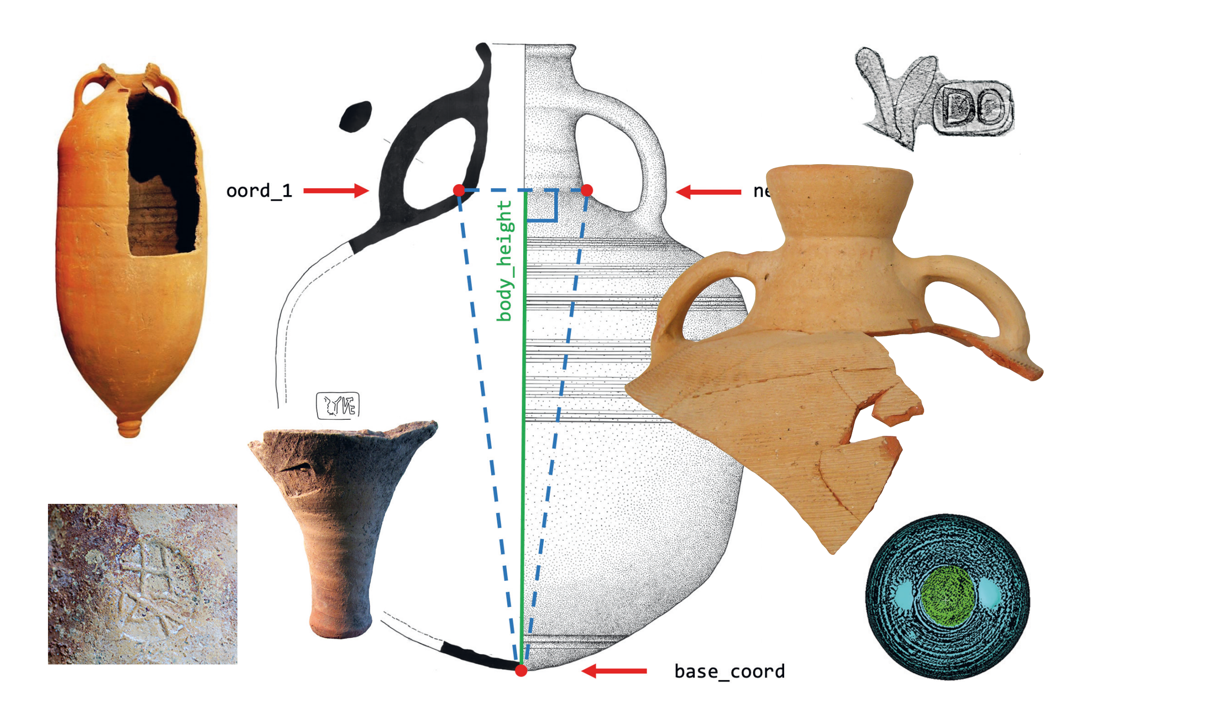
Horacio González Cesteros – Justin Leidwanger (eds.)

Regional Economies in Action

Standardization of Transport Amphorae in the Roman and Byzantine Mediterranean



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PREFACE

The origins of this book lie in some friendly bickering in a café in Santa Monica, California. One of us (Justin) was down from the Bay Area for professional society meetings and the other (Horacio) was spending a period researching and writing in Los Angeles. Nick Rauh, knowing both of us were working on Roman and Byzantine amphoras and happened to be on the US west coast, facilitated a critical connection that led to provocative conversation on amphora standardization that day in November 2016, generating a workshop on the topic and, in turn, the present volume. We owe a debt to Nick for that serendipitous moment, the first of many exciting discussions and collaborations now spanning years.

Our deep thanks go to all those who helped make a success of the workshop »Regional Convergences: Mass Production and the Development of Roman and Byzantine Amphora Standardization« (16–18 October 2017), especially Sabine Ladstätter for her steadfast support. The financial and institutional assistance of the Austrian Academy of Sciences, the Austrian Science Fund Lise Meitner Grants, and Stanford University's Omar and Althea Dwyer Hoskins Faculty Scholarship and Hellman Faculty Fellowship helped bring the group of scholars together. We were kindly hosted by the Austrian Archaeological Institute of the Austrian Academy of Sciences in Athens and the Danish Institute at Athens, where thanks are owed to Georg Ladstätter and Kristina Winther-Jacobsen. The ongoing resources of Stanford University, the Austrian Archaeological Institute and the Complutense University of Madrid were key to seeing the project through to completion, especially a grant from the Austrian Science Fund (FWF) that facilitated the volume's production and open access. We thank Sarah Parker and Sarah Cormack for their editorial assistance, the anonymous peer reviewers for their careful critiques, and Barbara Beck-Brandt for editorial guidance and professional support that have greatly enhanced the volume.

Throughout this process, we have benefitted immensely from the remarkable international community of scholarly colleagues who came together around our shared interests and focused theme, especially those who contributed their insights in the pages that follow but also those who unfortunately could not participate in the volume: Caroline Autret, Patrick Monsieur, and Chavdar Tzochev. We regret that a long time has passed since the workshop in late 2017 – and with it came various pandemic-related delays – but we hope that the thoughtful revisions and ideas that came with the years have made a still timely topic that much richer.

Justin Leidwanger – Horacio González Cesteros
Stanford and Madrid, March 6th 2023

JUSTIN LEIDWANGER – HORACIO GONZÁLEZ CESTEROS

FROM SHAPES AND SIZES TO REGIONAL ECONOMIC HISTORIES

STANDARDIZATION OF ROMAN AND BYZANTINE AMPHORAE[1]

Abstract
The standardization of transport amphorae provides a window into the scales, organizations, and technological practices behind ancient Mediterranean production, and thus also the coordination and complexity of past economic systems. As our greatest archaeological evidence for the packaging and distribution of bulk agricultural goods over long distances, transport amphorae represent a fundamental technology that responded to and influenced logistics and processes of Mediterranean exchange. This contribution sets forth the volume's overall intellectual questions for interrogating transport amphorae along with a framework – definitions, parameters, and contexts – through which standardization (and variation) may be explored analytically, in the process introducing the individual case study chapters that follow and their broader economic questions and intersections.

Approaching this material evidence requires a careful definition, and here we emphasize the concept of standardization as not a specific state of being but rather a process – i.e., a process of ›standardizing‹ – and related closely in turn to the process of diversification. From an archaeological perspective, standardization can be reflected in different aspects, such as formal features, volumetric homogeneity, production volumes and the related numbers and structures of workshops, or the presence of epigraphic evidence. However, we also discuss the economic, social, political, and other contexts in which different forms of standardized production may have appeared, as well as the parameters behind and mechanisms that facilitated it. After introducing each of the case studies, which range from pre-Roman to late Byzantine and from western Iberia to the Black Sea and Levant, we draw together certain themes and questions that link the volume's intellectual agenda and historical implications.

We examine the distinctly regional settings and shared production traditions that gave rise to different standard shapes and sizes, as well as the coordination and mutual influence across regions that are particularly evident in the Roman period. Questions emerge regarding how such containers communicated information and for what audiences; how concerns over transmitting information intersected with practical logistics of container handling, shipment, and exchange; what level of precision potters and merchants were able to (and cared to) achieve in controlling linear dimensions and capacities; and what mechanisms were available to transmit techniques and knowledge of standardized production across regions and generations. No less important are questions surrounding how the standardization of amphorae reflected the potential standardization of products – or origins and styles of products – they contained.

The chapter ends by exploring the broader questions of ancient economic history to which such analyses might contribute, including complicating scholarly assumptions regarding singular notions of ›efficiency‹ in production and exchange. Much work remains to be done in exploring the finer contours of potential links between standardization and scales of economic activity, ranging from small producers and local trade to the mass production and interregional shipment for large urban markets that characterized the Roman and Byzantine worlds. By identifying at least some fundamental questions that remain among these chapters – not least the relative roles of institutions like state and military supply versus market-based exchange in driving the different trajectories toward standardization and diversification – we hope to highlight the wide range of productive questions and analytical paths open for future work.

APPROACHING STANDARDIZATION IN TRANSPORT AMPHORAE

Prudence Rice describes standardization from an archaeological perspective on ceramics as »the relative degree of homogeneity or reduction in variability in the characteristics of the pottery, or

[1] We are grateful to Elizabeth S. Greene for sharing her insights on earlier drafts of this introduction, and to Susan Katzev of the Kyrenia Ship Project, and the Rheinisches Landesmuseum Trier and its photographer Thomas Zühmer for permission to include the images used here.

the process of achieving that relative homogeneity«[2]. This fundamental definition can be qualified in several ways to provide a baseline for the approaches that link this collection of studies. First, the volume focuses on transport amphorae, the sturdy and long-lived ceramic containers that primarily hauled processed liquid or semi-liquid staples – especially oil, wine, and fish products – across the Mediterranean and beyond. The production of these containers offers crucial evidence for not only the mobilization, marketing, and distribution of the goods but also for the specialization and scales achieved by some of the most important economic sectors in antiquity. Second, it embraces chronologically the height of amphora production and exchange under the Roman empire, and the varied trajectories that ensued in Late Antiquity and the Byzantine eastern Mediterranean. This approach allows us to examine economic change and associated institutions and practices over the *longue durée*. Third, it takes an explicitly regional view by examining questions of space and scale, which foreground the distinctly ecological context of ancient interaction and facilitate comparative views of economic developments alongside the varying political and social processes to which they were tied[3].

Rice's succinct definition emphasizes several key points, including that standardization reflects a relative, rather than absolute, concept. Describing a transport amphora as ›standardized‹ places it along a continuum. Fundamental to the technological and economic worlds of pottery production in the Romano-Byzantine Mediterranean was an inherent lack of absolute uniformity. Like any other ancient or traditional craft, this phenomenon must be distinguished from the modern concept, where standardization is integrally linked to industrialization, extreme specialization, and mass production[4]. Standardized pottery has often been used in anthropological work to index specialization and other features of complex systems of production in past and traditional societies[5]. For ancient Mediterranean potters, the production of amphorae often involved a highly specialized and repetitive skill set, yet the jars were also man-made[6]. Even with careful control over clay resources and firing as well as tools to help minimize variability, some measure of difference was unavoidable. At the same time, standardization would seem to imply more than just the broad similarity that can be attributed to routinization of technical processes; rather, it suggests reference to some ideal ›standard‹. That target might be achieved through replication of specific formal attributes signaling origin or contents, and/or through a particular volume of product. The potential relationship between a set content and its container is prominently underscored by the shared use of the term ›amphora‹ for both the generic two-handled ceramic jar and a particular unit of volume in the Roman world; at ca. 26 liters, this *amphora* unit – most concretely manifested in an example ›standard‹ said to have been kept at the Capitoline – was quite close to the capacities of some of the most common jars used for transport (especially of wine)[7]. Treating each instance of standardization of amphorae not as a binary but rather as a matter of degree that served a specific end allows examination of its relative level and different mechanisms to shed light on the broader economic systems at work among its producers, merchants, and consumers[8].

The description by Rice draws attention to the multiple characteristics involved in standardization and, by extension, the systematic and multifaceted approaches that are required for their study. Since standardization can manifest itself in different ways in transport amphorae, we must consider the many processes and contexts in which features of jars can be standardized[9]. These

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2 Rice 1991, 268.
3 On the ecological context of ancient economic life, see generally Horden – Purcell 2000.
4 Kotsonas 2014.
5 E.g., Benco 1988; Costin 1991; Arnold – Nieves 1992; Blackman et al. 1993; Orton – Hughes 2013, 144–149.
6 Peacock 1982, 75–128; Peacock – Williams 1986, 44–53; Demesticha 1998; see also more generally Schreiber 1999 for a potter's analysis of ancient vessels.
7 *De ponderibus* 61. See important early work in Grace 1949; see also Lund, infra, chap. 2. Note that we have distinguished throughout this volume between amphora (no italics) for the container and *amphora* (with italics) for the unit of capacity.
8 E.g., see discussion of conical cups in Berg 2004; Knappett – Hilditch 2015.
9 See generally Peña 2007.

include shape, volume, surface treatment, material composition, and manufacturing techniques. Shape can be defined through dimensions and formal attributes but should not be conflated with or limited to constructs of ›type‹ that reflect a modern classificatory scheme[10]. Volume is linked to form and dimensions but provides a functional feature that is particular to amphorae and worthy of consideration in relation to ancient units of measure[11]. Surface treatments might include decorative patterning, slipping, and epigraphy (stamping, inscriptions, various kinds of *dipinti* in red or black ink), each of which might signal, at different points in the life cycle, similar or distinct contents, producers, owners, etc.[12]. Finally, material choices and manufacturing techniques during production, from clay and temper selection to forming and firing practices, speak to technological and social networks and a broadly distributed *chaîne opératoire*[13].

These aspects of standardization must be treated as interrelated but not necessarily parallel. For example, convergence on a common shape may necessitate more carefully controlled techniques for forming or clay mixing. Visual signals of smaller or larger volume gradations might depend on altering not only size and fabric recipe but certain elements for easy recognition, while other practical aspects (rim diameter, etc.) were better left unchanged. Bulk producers of a standardized form might rely on minor formal deviations (handle sections, surface treatment patterns, etc.) to differentiate their own products from those of others within a workshop or area, even before the application of epigraphy or other mechanisms to distinguish contents beyond the workshop or area. Olivier P. Gosselain reminds us, however, that »[f]ar from being mere procedures, transmitted and reproduced mechanically from one generation to the next, the components of technical repertoires are meaningful and deeply invested in daily experience«[14]. Explicitly asking in what precise ways an amphora was standardized, and through what features and processes, may help us to identify purposeful standardization – particularly in the generally fragmentary archaeological record – against a backdrop of many objects that looked similar within the contexts of widespread production and circulation. These features are key to systematic evaluation and comparison that rely, where possible, on specific metrics (e.g., coefficient of variation, quantification of archaeometric variation)[15]. Such details facilitate exploration of where, how, and why these economic practices were accomplished by the various agents of production, whether individual potters, workshop and estate owners, merchants and shippers, or administrative officials[16].

Standardization emerges, in this definition, not as a state but as a process that unfolds across geographical and temporal scales and merits examination through context and comparison. It calls us to look comparatively across space, from the amphorae within a single assemblage or workshop to those amphorae shared across workshops or regions and even sometimes between disparate areas of the Mediterranean. How did standardization unfold over the distinctive political landscapes, socioeconomic topographies, and transportation geographies that comprised the highly interconnected Roman and Byzantine worlds? Temporal specificity and a longitudinal view of change become fundamental as well, prompting us to consider both broadly contemporaneous assemblages (a single firing in a workshop, a single cargo component from a shipwreck) as well as variability over time, whether from one day to the next with a single potter, or the cumulative change – in fits and starts – over many generations of producers and products. Beneath these spatial and temporal scales are different scales of production, with standardization processes in

10 See, e.g., critique in Reynolds 2008.
11 Greene – Lawall 2015; for specific units, see, e.g., discussion in Ramon 1991, 129; Kletter 2009; Zapassky et al. 2009; see also more generally Kruit – Worp 1999.
12 For epigraphy on amphorae, see Manacorda – Panella 1993.
13 Hagstrum 1985; Frankel 1988; Sinopoli 1988; Arnold 2000; Sillar – Tite 2000; Roux 2016; on amphorae, see Ceccarelli 2017.
14 Gosselain 2011, 223.
15 Metric variation is most commonly used for analysis: see Frankel 1988; Longacre 1999; for analysis of compositional standardization, see Blackman et al. 1993. See also below, p. 20.
16 See also Gallimore 2010; Burkhalter 2013.

particular relying on mechanisms of knowledge transmission from tools and techniques to social networks that could hardly have been uniform across the vast economies of the pre-modern Mediterranean world. If there need not be a single linear evolution toward greater standardization, then where and when we see relative disinterest in its particular forms should likewise be recognized and investigated. Since ancient potters clearly *could* create highly standardized jars, where and when they *chose not* to standardize may be just as revealing.

By foregrounding these different features and contexts of standardization, the present collection seeks to build new, regional, long-term histories of Roman and Byzantine economies using the same specialized transport containers that have long served as proxy economic evidence but in new ways. Our goal should be to understand the meaning and function of standardized containers within their specific economic, social, and political settings. While a truly emic perspective may be impossible, a rich set of deeply contextualized case studies can still offer many opportunities to recognize standardization's different manifestations and trajectories, and ultimately to interrogate its many underlying motivations and practices. How might we distinguish between some producers, merchants, or institutions who demanded only broad overall equivalency and consistency in their amphorae from others who required jars that clearly signaled a more or less specific size (e.g., 1 *amphora*, 41 *sextarii*, ›half-size‹) or content (e.g., wine, best quality wine, Gaulish wine, or wine in a ›Gaulish style‹) and still others whose primary requirement was for containers that fit best certain qualitative functional requirements (e.g., portable by one person, easily and securely stackable in a ship of a certain size, flexible for terrestrial as well as for riverine and/or maritime transport)? Meeting such different requirements might entail different levels of precision and accuracy and necessitate attention to different features. The different contexts in which the same product moved might variously demand convergence or divergence in forms of containers, complicating any unilinear or pan-Mediterranean explanations. Through a situational approach invoking many of the diverse regional economies and amphora traditions across the Roman and Byzantine worlds, the many actors and institutions driving and sustaining production, distribution, and consumption of these jars and their contents might become more visible and measurable, from the individual agricultural producer or commercial entrepreneur to the agents mobilizing bulk transfers of military and state supplies.

CASE STUDIES FROM THE ROMAN AND BYZANTINE WORLDS

The chapters in this book arise from a workshop on amphora standardization held at the Austrian Archaeological Institute and the Danish Institute in Athens, 16–18 October 2017. Like the present work, the Athens event featured broad chronological and geographical coverage – from the 1st millennium B.C. to the 15th century A.D., and from Lusitania to the Black Sea – that should be fundamental to the contextualized and comparative view outlined above. The studies balance west and east, with six chapters dedicated to each. In addition to four Late Antique or Byzantine case studies, others explore the long and varied trajectories of Roman amphorae well into later centuries, providing a broad diachronic view rather than a mere postscript. The strong representation of certain regions in particular periods is notable – for example, Roman Iberia and the early Byzantine Aegean – but perhaps also unsurprising in light of scholarly traditions of fieldwork and amphora-based research as well as the broader shift in economic centrality from Roman west to Byzantine east over the long period of interest here. A few workshop participants who were not able to contribute to the present volume would have helped to provide additional context for the pre-Roman east and to fill certain gaps in coverage, perhaps most notably for the Italian peninsula.

By ambitiously tying together broad ›global‹ observations on amphora volumes, their possible capacity standardization and connections to the jars' forms and the goods they held, John Lund sets the stage for the collection. His suggestion of 8–10 % variation in volume among amphorae belonging to a general class/type and only certain loose correlations between contents and shape point to specialized knowledge and external information as well as opacity in the distribution chain that would likely have been mitigated through bulk shipments and individual remeasurement at the point of consumer sale. Alongside certain broad physical correlations – like the typically larger sizes of oil versus wine amphorae, likely related to concerns of storage and spoilage – oblique glimpses at the underlying differences of goods, agents, scales, and regions involved underscore how context becomes fundamental to reading the motivation and mechanisms behind standardization. In this way, Lund's synoptic view of prominent Hellenistic through Late Antique amphorae offers important background and a comparative framework against which the individual case studies in the chapters that follow can be situated and unfold diachronically. We must emphasize therefore not only his call for the kinds of in-depth regional analyses at the heart of the present collection but also his challenge to undertake more studies focusing specifically on volumetric questions.

Four chapters focus on case studies from the major amphora-producing regions of the Iberian Peninsula, the first two of which are situated in its south. Antonio M. Sáez et al. immediately underscore the far-flung Mediterranean maritime connections in amphora standardization, linking western and eastern shores through exploration of the long tradition of amphora manufacture and use within the context of Phoenician and Punic hegemony and the rise of Rome at Gadir/Gades. Building on the remarkable recent growth in data for the region, including their own careful analysis and digital modeling of amphorae and workshops, the authors suggest a deep history of formal and volumetric standardization guided by increasingly controlled production sequences for local manufacture. They demonstrate that these jars were not only influenced by formal models from the Levantine cultural orbit but also followed Levantine volumetric standards until an abrupt shift that followed the conquest of the area in the late 3rd century B.C., after which Roman capacity standards reigned for both newly introduced Roman shapes as well as ongoing Phoenician-Punic forms. This adaptation to a shifting commercial and political landscape continued in the area as the Roman province of Baetica became one of the empire's greatest producers of oil for state and military supply. Darío Bernal-Casasola et al. offer a synopsis of this strongly standardized production that took hold in southern Spain from the early imperial era, typified in the famous Dressel 20 amphorae. In response to massive demand and elaborate state mechanisms of distribution, this amphora soon settled into an optimized shape and features even as its size grew to more than 75 liters at the height of production. The reversal of this trajectory, which the authors chart from the early 3rd century A.D. onward, brought greater diversification and both larger and smaller types that may, by contrast, be linked to the collapse of the major state apparatus interacting with Baetica and the adjacent private commercial opportunities it generated.

Chapters on production in Lusitania and Tarraconensis help to balance the Iberian picture often dominated by amphorae from the peninsula's south. That the trajectory outlined by Catarina Viegas et al. for Lusitanian amphorae in many ways runs parallel to that of Baetica thus becomes a critical point for understanding broader trends in the imperial and Late Antique west. Lusitanian forms seem generally to have followed or otherwise been influenced by those from Baetica, yet the region's exports centered on salted fish products that moved by normal commercial mechanisms rather than state drivers. The shift toward greater diversity of amphora forms and contents from around the latter 2nd or early 3rd century may make sense in light of the overall disruption of the *annona* system, which had nonetheless long allowed Lusitania, through its close connections to southern Iberia, incidental access to wider Mediterranean markets even though the province itself was not directly implicated. It does, however, simultaneously reveal the resilience of local producers and merchants in adapting to this new economic reality. Across the peninsula to the northeast, Horacio González Cesteros et al. provide a synthetic view of regional standardization linked to emerging Roman control of the consolidation of territory and trade in Tarraconensis between the 1st century B.C. and the 1st century A.D. The archaeological, historical, and epigraphic data set here reveals how standardization developed at the intersection of provincial socioeconomic structures and broader Roman economic systems. This case study demonstrates the influence of external demand – not necessarily linked to the state – on the production of agricultural commodities and their transport containers, driving the introduction of foreign amphora forms and the gradual abandonment of local ones. Reaching nearly an industrial scale through the involvement of provincial and imperial elites, the wine industry and its important commercial links to Gaul and Italy can be analyzed through the long history of regional amphora production, which peaked with standardized formal features, fabrics, epigraphic system, and volumes, through its decline once importers found alternative suppliers.

Comparative views from Gaul and North Africa round out the western Mediterranean case studies. Fanette Laubenheimer situates the widely distributed and standardized amphorae typed today as Gauloise 4 against a backdrop of earlier and more varied forms that had circulated only locally or within the region. The increased volume-to-weight ratio of these jars reflected local adaptation to meet the need for bulk maritime transport of wine for a growing empire in Italy and beyond. Careful attention to formal aspects and production sequences of both ancient and contemporary potters reveals the ergonomic challenges of producing larger jars that likely established routine practical limits to standardization in their overall linear and volumetric measurements (the latter falling at ±10 %). From the booming economy across the sea in North Africa, Michel Bonifay et al. explore amphora production for export that supported both state and commercial demand on a Mediterranean-wide scale. The authors track production traditions as they shifted variously back and forth between greater formal and volumetric standardization and periods characterized by more diversification. Yet the North African pattern represents more than a simple ebb and flow of the same model of standardization. Its different manifestations in each period – and even the different forms it took between the coastal and inland areas in the same period – underscore how integration into larger Mediterranean economies could prompt a variety of standardizations that reflect the intersection of diverse systems of production and distribution.

The eastern Mediterranean world, along with the Aegean and adjacent Black Sea, provide especially strong case studies in the later Roman and Byzantine economic histories of amphora standardization. Dominique Kassab Tezgör's view from Sinope on the northern Anatolian shore integrates the Black Sea into the story of standardization, and especially the role of the state in these trajectories with the dramatic Late Antique rise in the region's (probably wine-based) export economy. Among the production of several distinct formal groups, the fact that some jars followed broad linear standards that ensured a consistent capacity while others appear similar but unstandardized speaks to the complex motivations and mechanisms behind the dynamics of a single production center. Even if the fiscal movement of goods – for the civilian supply of nearby Constantinople and the military – was a major driver behind standardization, these jars naturally also found a place within the church economy as well as private commercial ventures. Paramount among the many concerns of production and packaging to which potters, merchants, and officials here attended were easy handling, stacking, and individual distribution, to which the author points as probable explanation for their small and attenuated shapes.

State and related mechanisms of supply are examined in detail by Frederick H. van Doorninck et al. using the well-preserved cargo assemblage from the 7th-century Yassıada shipwreck. The multianalytical approach draws on 3D point clouds and likely manufacturing sequences to evaluate the shapes of jars and their degree of standardization in an effort to understand the mechanics of production. They argue that the demanding capacity standards behind some late LR2-derived amphorae were grounded in a basic but precisely controlled linear dimension and simplified spherical concept that generated consistent volumes. The cargo's military destination signals state participation in this standardization trajectory, in this case also entangling another major economic institution, the church, in its assembly and shipping. That other amphorae – some older and reused – in the cargo may not follow this same system raises the prospect of a new phase in state-driven standardization around this time. Looking at this same broad region of the Aegean islands, specifically amphora workshops on Cos and Paros, Charikleia Diamanti presents strong evidence for the wavering Late Antique agricultural economy of the mid-6th century as well as its reorganization in service of the state. The author connects the simultaneous production, in the same workshop centers, of both late LR1 and LR2c (or LR13) forms with the emergence of imperial control evident in stamps newly introduced on these amphorae by the *quaestura exercitus*. This careful attention to form, fabric, and stamping practices leaves little doubt about the extent of official intervention, eclipsing even that from previous periods (e.g., Roman Baetica and North Africa). Over the course of the 7th century, features from these two forms merged into a single new standard, the ›Byzantine globular‹ form that would dominate the Byzantine territories from the late 7th or early 8th century onward.

This globular amphora, which seems to have largely replaced the more varied later Roman amphora forms within the Aegean, is picked up by Anastasia Yangaki's case study from Crete. Here local production reflects a shift also from the more diverse Roman types across the island toward a broadly standardized singular Aegean form but effected on a limited scale and with specific local choices in minor morphological features (e.g., rim profile). Such looser coordination – at least in comparison with some more tightly standardized case studies presented in other chapters – permitted greater variation in linear dimensions (and presumably volumes), as might be expected given the economic downturn that generally marked the 7th and 8th century. A trend toward smaller jars in this late period is also notable in this regard, but the type's wide functionality as local domestic and storage containers rather than solely market-driven transport amphorae may also help to explain some degree of this variation in linear measurements. The dwindling of Byzantine territories into the later medieval centuries saw an accelerating decline in the Mediterranean's reliance on its traditional amphorae, making the analysis by Joanita Vroom and Mink W. van IJzendoorn particularly helpful for understanding the persistence of such container technologies in certain regional contexts. The authors examine small ovoid amphorae found commonly around the southern Peloponnese and perhaps used for oil, which seems to have emerged as part of an opportunistic strategy on the part of producers to capitalize on Venetian ships sailing back into the Adriatic during the latter 13th and earlier 14th century. This so-called Last Byzantine Amphora allowed easy overland shipment to stopover ports, where they were added into Venetian holds more accustomed to hauling barrels. The specialized and externally generated market and its associated shipping technologies that had pushed barrels into a more dominant role had, inadvertently, created a new (if short-lived) niche for the venerable ceramic amphora.

AMPHORA PRODUCTION AND REGIONAL DYNAMICS

Despite long-standing interest in amphorae as quantifiable markers of ancient economies and interaction, and focused research on the institutions that helped to drive their movement, the multifaceted technologies represented by the containers themselves have rarely been considered[17]. Decades of research into amphora typologies and systems of production have laid the foundation for critical analysis of the roles their standardized shapes and sizes played throughout the transactions of their contents within the context of large-scale economies that characterized the Roman and Byzantine worlds. The present set of contributions aims to interrogate such standardization through detailed spatially and historically contextualized case studies. As is often the situation with collected studies that push a data-rich field in new directions, the chapters are opportunistic rather than comprehensive and tend to raise more questions than they answer. Yet through this collection, we hope to reveal the potential of such work that depends on – but also looks beyond – typology and chronology toward containers as information technologies within ancient economies. The diverse perspectives employed by the contributors to examine these jars already reflect the varied trajectories through which standardization took hold in these regions and periods. The stories here certainly do not reveal a unilinear march toward greater systematization or even one evolution punctuated by fits and starts. Rather, the overall picture is one of shifts and countershifts toward greater homogeneity or more diversity – or sometimes both simultaneously – within distinctly regional settings. Holistic synthesis must await many more studies, but a few preliminary observations on amphora standardization and the dynamics of regional economies might help to

[17] See, however, Bevan 2014, with responses by several amphora experts.

reveal some promising questions for further research and, we hope, inspire sustained analytical and comparative work for the future.

What aspects of Roman and Byzantine amphorae were standardized? Shape, specifically a shared regional ›style‹, emerges as an important marker throughout these contributions and a key indicator of strong economic regionalization. The many different ceramic container shapes that characterized ancient economies were all solutions to the same problem of (usually maritime) distribution of the same bulk products across the same waters, making it clear that participation in a specific regional style was a choice that yielded some benefit. The Gauloise 4 jars present one such case. These were first produced to meet demand internally within Gaul and across northwestern Europe and were well-suited to the boats that supported such riverine distribution. However, the particular shape was soon also chosen as the vehicle for accessing external wine markets extending throughout the Mediterranean. Dozens of producers coordinated to converge on this shape by drawing together characteristic features from their shared repertoire of locally circulating containers and adapting them to the challenges of maritime transport[18]. They were joined in turn by many more producers who specialized in only Gauloise 4. Yet the container collectively produced – an egg-shaped body terminating in a low ring base – contrasts with the more elongated jars typical at the time in the Mediterranean. It was perhaps an unconventional strategy, then, for breaking into new markets since the early Gaulish amphorae on which the Gauloise 4 shape was based were rare outside Gaul and therefore unlikely to have been visually familiar to prospective customers. The success of this regionally standardized shape is nonetheless demonstrated by the extensive distribution it achieved and also by the many imitations – which archaeologists generally collect as the Dressel 30 type – that arose elsewhere in the western Mediterranean and as far afield as Cilicia[19].

What information and to whom, then, did such regionally standardized shapes communicate? In the case of Gauloise 4, the standardized form was explicitly aimed at destinations outside the region. At marketplaces in Rome or in other parts of the Mediterranean, the distinctive shape would eventually mark these jars as coming broadly from Gaul[20]. Their imitations surely signaled products, presumably wine, in the regional style of Gaul; otherwise, the choice to replicate this specific form rather than more widely recognizable options in a far-removed context like Cilicia, would make little sense[21]. That Gauloise 4 and Cilician imitations were discovered together with several other regional Cilician/north Syrian types in the cargo of a shipwreck off the southeast coast of Cyprus makes it clear that the two containers were in dialog. Despite their recognizably similar shapes, the two could hardly have been confused when placed side by side, suggesting ›real‹ and ›imitation‹ here may have been alternatives for well-informed (and not unwitting) retailers, if not also consumers[22]. In a similar way, well-known imitations of southern Iberian fish-sauce amphorae at Lyon exhibit *dipinti* that mention products made seemingly according to Spanish, Antipolitan, and Pompeian recipes[23]. Such generally standardized shapes, however, may have functioned and been perceived rather differently within their own regional contexts. The Lusitanian amphorae which today share a typology together as Almagro 50 were produced throughout the Tagus and Sado Valleys and the Algarve; these different workshops and areas show minor variations in certain nonfunctional aspects of their shared shape that could have facilitated distinc-

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[18] See infra, chap. 7, p. 201 f.; see also Laubenheimer 1985, and recently Bigot 2020.

[19] Naciri et al. 1986; Aranegui – Gisbert 1992; Bonifay 2004, 148–151; Tremoleda – Járrega 2016: Bernal-Casasola 2009; Bernal-Casasola 2016; Fabião 1998; Quaresma – Raposo 2016. On the complex phenomenon of imitation amphoras, see Lawall 2011; for Roman amphorae, Moore 2011; for Cilician imitations, Rauh 2004.

[20] For the Greek world, cf. Lawall 2018. On jar names and knowledge of origins, see Kruit – Worp 2000.

[21] On the type, see Reynolds 2008, 71 fig. 3 p. q.; 72; Opaiţ 2010, 1016. 1018 fig. 4 a. b.

[22] Leidwanger 2013a.

[23] The *tituli picti* on Lyon 3 amphorae have been interpreted by some scholars as evidence of repacking for further riverine shipment of the same product from southern Iberia; cf. González – Berni 2018, 41–47, who link these imitations with a southern Gaulish product locally made but following Spanish, Antipolitan, and Pompeian recipes.

tions among producers (and distributors) in the know but would have been imperceptible – or at least unimportant – to an external market that knew them only collectively as carriers for western Iberian salted fish[24]. Laubenheimer relates how two late 20th-century potters in the same workshop could easily distinguish their own jars that were otherwise standardized for practical purposes and identical in the eye of the typical consumer (and the archaeologist)[25].

Standardization and variation work productively together and depend on each other, in this case communicating different basic or detailed information to different users. The same might be said of later Roman and Byzantine amphorae shared across large parts of the Mediterranean. The replacement of many regional styles with new forms linked to a general ›Byzantine *koiné*‹ of supraregional production from the 7th century onward probably meant that minor internal distinctions were only meaningful among local producers and to a select few distributors or customers in the know[26]. For example, among the many workshops producing LR2-derived forms, the spiral combing that marked one group of otherwise identical jars at Yassıada would have been meaningless to most eyes[27]. The one particular Cretan interpretation, outside a local context, would have been largely indistinguishable from other groups within the broadly shared globular Byzantine amphora family[28].

If such standardized shapes were in part bound up with the recognition of regionally specific products on a Mediterranean-wide market, they also responded to more functional considerations[29]. Maritime transportation, labor, and clay resources were all relatively inexpensive, but effective shapes of containers – those that could carry more volume of product for the weight/space of the container itself – still offered a clear advantage. The occasional adoption of more spherical shapes that maximized the ratio of volume to surface area, as with Baetican Dressel 20 and the later LR2 series, may reflect this interest[30]. The thinner the jar, too, the greater amount of product per container weight, although a thicker jar that was less likely to break could have been advantageous during longer or multistage journeys where a higher rate of breakage would have quickly eroded any such gains. A spherical jar lacking a toe, however, is not as easily handled as certain other shapes, so logistics that might favor certain sizes that were easily manipulated and carried by a single person – or in some cases a pair of individuals – should be considered. It is surely not surprising that weights of around 25–35 kg became most common not only for jars (and the *amphora* as a unit of volume at ca. 26.2 l) but also for the various other goods handled in large numbers by porters (e.g., metal ingots, sacks)[31]. The representation of two laborers carrying a Dressel 2–4 in the corner of the Via degli Augustali and Via del Foro in Pompeii (fig. 1), and a larger and more challenging Dressel 20 amphora in a wall painting in Augst, can be read in this same light[32].

The other container of relevance, though, was the ship. The close link between standardized jars and ship design and cargo organization is apparent in the term ›amphora‹ having become a preferred unit for estimating vessel tonnage[33]. Filling the geometrically complicated shape of a hold with minimal loss of space was no doubt important and could at times dictate trajectories of container development[34]. From the sole perspective of maximizing space on board, larger con-

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[24] See infra, chap. 5, 134–137. For variation in rims as personal expression of different potters among otherwise standardized forms, see Roux 2003, 777.

[25] See infra, chap. 7, 200; cf. Laubenheimer – Gisbert 2001.

[26] See also Zanini 2010; Gelichi – Molinari 2018.

[27] See infra, chap. 10, 251 f. 262 f.

[28] On this broad family of forms, see also Zanini 2010; Arthur 2018.

[29] E.g., Hein – Kilikoglou 2020.

[30] Cf. Berni (forthcoming); Zapassky et al. 2012.

[31] Bevan 2010, 25. 28. 31. On standardized weights of sacks, see Virlouvet 1995, 84; Mindau 2004, 454 f.; cf. Mayerson 1998.

[32] Martin-Kilcher 1994, 514–524.

[33] For this unit and its relationship to others pertaining to tonnage, see generally Nantet 2016, 45–48.

[34] Levinson 2006.

1 Laborers carrying a Dressel 2–4 amphora, from the corner of the Via degli Augustali and Via del Foro, Pompeii (photo © authors)

tainers were perhaps more appealing even if smaller ones were more easily manipulated[35]. The ability to pack jars easily and securely for transport depended on standardizing height and diameter along with broad shape[36]. The Madrague de Giens wreck, among many examples, demonstrates vividly this careful stacking and embedding of layer upon layer of amphorae[37]. This was no easy feat, as the investigators of the early Hellenistic Kyrenia ship learned in attempting to fit the archaeologically attested cargo within the replica ship's dimensions based on the preserved hull remains (fig. 2)[38]. Too much variation in heights or diameters would have disrupted this organizational system, although jars of complementary – generally smaller – sizes and shapes could be beneficial on some limited basis: the approximately 100 varied LR1 jars from Yassıada may have rested on their sides, tucked conveniently under the deck timbers between the necks of the top row of the 700+ LR2-related jars that formed the main cargo[39]. Slender spatheia were well-suited to capitalize on these sorts of spaces, particularly among cargos that involved larger amphorae like those from North Africa, as demonstrated in the 5th-century Dramont E wreck[40]. The Cabrera III shipwreck (Mallorca, Spain), dated to the third quarter of the 3rd century, offers a good example of how such shapes were carefully arranged to maximize any available space: the tubular Africana IIC and IID amphorae and Baetican Keay XVI jars were placed on their sides, while the globular late Dressel 20 jars that contained the main cargo were stacked between, and the smaller and slender Tejarillo 1, Keay XIX, and Beltrán 72 amphorae were used to fill any remaining gaps[41]. The sculptural representation of one set of carefully stacked and padded Gaulosie 4 jars, today reconstructed in the Rheinisches Landesmuseum Trier, offers some additional clues to this planning and to the suspected but often unattested use of organic materials as dunnage and for wrapping the individual jars (fig. 3)[42].

Tightly controlling linear dimensions was also a practical means to another end: standardization of volumes[43]. For ceramics in which capacity was a paramount concern, a skilled potter could reliably and quickly control the diameter of the major parts on a wheel with only simple tools and guides[44]; projecting this key diameter measurement through a given height of a largely cylindrical vessel body would have in turn ensured a rudimentary level of volumetric uniformity across pro-

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35 See also the experiment of ships filled with *dolia*: Marlier 2008; Dell'Amico – Pallarés 2011; Heslin 2011. Note too that the longer shelf life of oil lent it to large amphorae, as Lund has noted, in contrast to the smaller containers – at around 25+ kg – more often used primarily for wine: see infra, chap. 2, 49 f.

36 E.g., Hein et al. 2008; infra, chap. 10, 266–268.

37 Tchernia et al. 1978.

38 Katzev 2008, 77 f.

39 van Doorninck 2015b, 206; on the LR1 amphorae more generally, see van Alfen 1996.

40 Santamaria 1995, 117 f. See also infra, chap. 8, 216.

41 Bost et al. 1992, 28–33 fig. 6.

42 See also Laubenheimer 1985, 263 fig. 118.

43 E.g., Zapassky et al. 2009; Finkelstein et al. 2011; cf. Greene – Lawall 2015, 9.

44 See generally Schreiber 1999.

2 Attempting to load early Hellenistic amphoras on board the replica Kyrenia II ship in Cyprus (© Courtesy of Susan Katzev and the Kyrenia Ship Project)

3 Reconstructed stack of Gauloise 4 amphoras as part of a monument in the Rheinisches Landesmuseum Trier (© GDKE/Rheinisches Landesmuseum Trier, photo: T. Zühmer)

duction. This is presumably one major reason that archaeologists have often detected, by contrast, greater variation within features of amphorae not connected to volume, such as handles, toes, and sometimes necks[45].

What level of formal standardization was achieved? We should reiterate here that standardization was a relative concept, particularly for handmade ceramics even when produced on a massive scale. ›Closed packages‹ of techniques were not inherited and transmitted mechanically across generations but rather continually evolved within the daily experience of the potters charged with production[46]. Perhaps the better questions, then, ask what amounts and types of variation were accepted within a group of containers standardized to some particular end and within a certain context, and how demanding were these levels to meet? Answering these questions from the archaeological record presents challenges, most notably due to the relative lack of large numbers of sufficiently intact jars from appropriate contexts. Shipwrecks therefore become a prime source of data for testing standardization. In most instances, though, amphorae are too fragmentary to yield a full range of dimensions along with volumes, although 3D approaches to extracting capacities

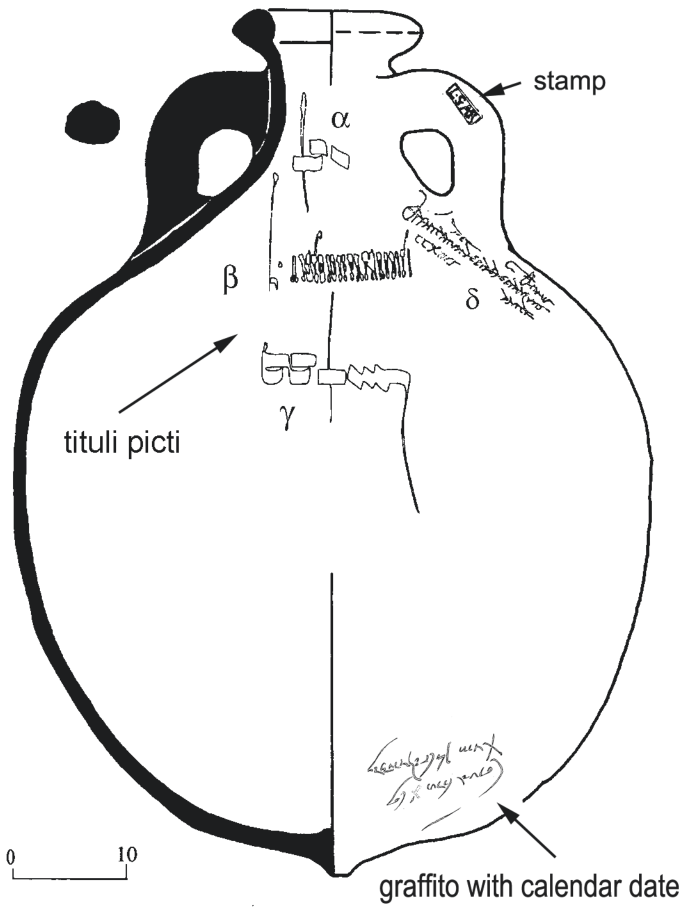
45 E.g., Laubenheimer – Gisbert 2001, 36 fig. 4; chap. 10, 262 f.
46 See generally Gosselain 2011; Gosselain 2016.

based on largely preserved profiles are becoming rather widespread[47]. Even if the margin of error in these approaches – which assume perfect symmetry and often uniform wall thickness – may necessarily be higher in comparison with direct measurements[48], these methods offer cautious hope of increasing sample sizes for certain key questions. Alternatively, one can focus usefully on just one of the more consistently preserved parts, as Yangaki does here with rims of Byzantine jars from Crete[49]. When working with a group of amphorae spanning many production events and often many years, though, higher variation may be expected than from a single firing, a single potter, or even a single season[50]. Certain differences perceived by archaeologists as variation may also be intentional rather than accidental if the standards themselves shift over time.

Even so, the case studies of standardized amphorae examined here yield key recurring figures: ±5 % variation in linear dimensions like maximum diameter and overall height and ±10 % variation in volume. The greater variation is unsurprising for volume, which represents a more complex aspect to control through several already inherently variable linear measures. These basic figures seem to hold where reasonable sample sizes are at hand, although even the best data tends to be limited to basic measurement ranges for a particular set of amphorae that can include multiple contexts. In his exploration of Roman and Late Antique amphora volumes, Lund reaches a similar general figure of 8–10 % or more variation within what he considers as a class[51]. Many more systematic studies are needed to measure these aspects in a statistically rigorous way that allows comparison, for example, using the coefficient of variation (CV), a measure that represents the ratio of standard deviation to mean, expressed as a percent[52]. Some of the most rigorous numbers for a Roman case study can be seen in the Gauloise 4 jars, which typify this pattern: a group of 15 standardized jars within this type range 38.4–42.4 cm in maximum diameter, 61.5–67.2 cm in overall height, and 29.9–37.7 liters in capacity[53]. These figures translate to CV values of 2.5 % (maximum diameter), 3.4 % (height), and 6.8 % (volume). Similar figures were achieved for the wine amphorae of Tarraconensis during the early imperial period[54].

As a closed assemblage of amphorae produced in the same workshops and in circulation together, the 7th-century Yassıada cargo provides our best statistically significant sample for Late Antiquity or the early Byzantine era. Although in this case the figures for what is considered a single volume group probably reflect the extreme of what was possible – rather than what was typical – for pottery production, the CV values are helpful for context: 0.55 % (maximum diameter), 2.16 % (body height), and 2.26 % (volume). The small Yassıada sample is not ideal for some of these figures like volume, but the more robust set of diameter measurements reveals a striking level of standardization[55]. Particularly helpful would be a detailed analysis of these values for the highly standardized olive oil amphora production of south Spain during the 1st–3rd century A.D. Most of the Dressel 20 amphorae found in Monte Testaccio still bear the marks of their ›standardized system‹ in their ink inscriptions, which offer the best evidence for strong governmental control of the oil supply (fig. 4). These inscriptions mention the weights of the amphora while empty and then after filling, a value that is consistently around 70 kg[56]. The fact that the Roman authorities cared to control this capacity, and that many *tituli picti/dipinti* with capacity information have been found (not only on Dressel 20 but on a large number of other types too),

[47] Cateloy 2016. See also discussions in Greene – Lawall 2015, 8; infra, chap. 3, 67–69.
[48] E.g., Vo-Phamhi – Leidwanger 2020.
[49] See infra, chap. 12, 305 f.
[50] Blackman et al. 1993, 74; Roux 2003, 780 f.
[51] See infra, chap. 2, 50. For a discussion of the complexity of classificatory schemes, including what archaeologists deem to reflect a ›class‹, see Reynolds 2008.
[52] See generally Longacre et al. 1988; Rice 1991, 269; Stark 1995; Costin – Hagstrum 1995; Eerkens – Bettinger 2001; Roux 2003, 772; Orton – Hughes 2013, 147 f.
[53] See infra, chap. 7, 203. 205 tab. 1.
[54] See infra, chap. 6, 178 f.
[55] See infra, chap. 10, 265.
[56] See infra, chap. 4, 106 f.



4 Epigraphic system on the Dressel 20 amphora from south Spain (from: Berni 1998)

illustrates that both the state and individuals were well aware that a high level of formal standardization did not necessarily go hand-in-hand with or directly imply volumetric standardization, since weight and capacity were the factors that most varied.

How good was this degree of standardization? The answer would seem to be rather good, at least as good as might reasonably be expected given pre-industrial technologies. A useful baseline is offered by the so-called Weber fraction, which defines the minimum amount of difference between two objects that is perceptible to humans: i.e., 3 % for line length and 2 % for weight[57]. Anthropological studies of traditional craft production systems offer the best comparanda when combined using specific metrics like the CV. Through studies of contemporary potters working within different systems in India and Spain, Valentine Roux has suggested that large-scale production (approximately 14,000 or more pieces per year) can typically yield CV values for many dimensions that fall under 3 %[58]. Experiments by Jelmer W. Eerkens have shown that groups of producers replicating a simple shape could achieve consistent linear dimensions to CV values of 5 %[59]. Ethnographic study has also demonstrated that larger pieces tend to be characterized by higher variation, a result of either the particular challenges of this work – due to materials and ergonomics – or simply the less frequent demand for (and therefore less frequent practice with)

57 Eerkens – Bettinger 2001.
58 Roux 2003; see also Benco 1988, 68.
59 Eerkens 2000; see also Zapassky et al. 2009; Li 2020, 135 f.

larger forms[60]. For ancient ceramics, including transport amphorae, around 40 cm in diameter and height seems to represent a common threshold, after which practical challenges increase considerably[61]. That some of the smaller amphorae, such as those at Sinope, were standardized to only the same general level as much larger amphorae, though, underscores how serial replication may never have been easy[62]. CV values specifically for volumes are only rarely provided, but in the case of smaller closed forms, they also tend to be significantly higher than values for basic linear dimensions on the same pots[63]. Amphorae should certainly count as larger and more challenging ceramics to standardize than unmolded wheel-made plates, cups, or bowls, and the organization and output of their workshops in the Roman and Byzantine periods would place them in this category of large-scale and specialized production systems. Some of the amphora groups that appear less standardized are, unsurprisingly, from contexts where production scales were probably smaller: e.g., the earlier Roman regional production in the Iberian Peninsula or the Last Byzantine Amphora[64]. The relative nature of standardization should again be emphasized since time and effort spent meeting high standards of accuracy in volumes (or formal features) may not have been deemed worth the reduced output it entailed, depending on the circumstances.

How these levels of standardization were consistently achieved and technically propagated remains less clear. A certain amount of unavoidable ›copying error‹ can over time shift the standard slightly during different forms of transmission[65]. Fortunately, much work has focused on the ways in which technological processes and skill sets, especially those surrounding pottery manufacture, were communicated within past (and contemporary) societies through such institutions as apprenticeship[66]. Yet the broader social context of learning through practice generated variation and individualization of skills and techniques rather than pure replication of prescribed skill sets[67]. While internal forces of tradition and external forces of demand might push for greater continuity, formal and otherwise, shifting labor organization and individualization of technical practices could simultaneously drive change, especially over generations of producers. Important for any understanding of regional standardization, therefore, are both temporal and spatial scale[68]. To what extent and in what ways were mechanisms for the successful transmission of knowledge sustained not only within workshops over shorter time periods and across generations but also across the larger communities of potters and greater distances typical of shared production zones for the amphorae studied here[69]? These conditions meant new challenges of coordination, from more complex social networks of potters to more diverse resource landscapes of production. Standardization could demand communication of certain basic schematics, general description of details, and specific measurements. We might imagine a potter in southern Gaul instructing another through demonstration of a new shape that is broadly similar in its body to a well-known local vessel but with different linear dimensions and articulated thereafter with different formal features (base, neck) by each producer. Roux has elucidated how the distributors of the pots, rather than the potters, may have played a key role in the verbal transfer of information that leads to standardization[70].

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60 Benco 1988, 67 fig. 7; Roux 2003, 778. Laubenheimer also draws attention to the ergonomic challenges of working with vessels of the size of Gauloise 4: see infra, chap. 7, 201.

61 On such challenges in ancient pottery, see Schreiber 1999, 20; see also infra, chap. 7, 203.

62 See infra, chap. 9.

63 Roux 2003, 779 tab. 7. See also, for example, Riley 1979/1980.

64 García et al. 2019; see also infra, various chapters on early Iberian amphorae, and chap. 13, for the Latest Byzantine Amphora. See also infra, chap. 12, 309–313, for Byzantine Crete.

65 Eerkens – Lipo 2005.

66 E.g., Crown 2011; Melko 2017.

67 See generally Gosselain 2011; Gosselain 2016; see also Bleed 1997.

68 Gosselain 2000; Knappett – Kiriatzi 2017, 12–14.

69 Costin 1991; see also Li 2020.

70 Roux 2015, 7.

Should we also envision moving physical standards (a measurement gauge [?]) or full prototypes (a physical model [?]) as well as the associated tools to reproduce it, in a similar fashion to mechanisms noted for the exchange of architectural design in the Roman world[71]? Were moving potters, whether experts or learners, also part of the system? The mobility of potters has long been theorized as part of the production model in certain economic contexts and for some specialized products, like *dolia*, and has been asserted as likely, on the basis of stamps, for the transplantation of sigillata manufacture across the Roman Mediterranean[72]. Such mobility would seem likely given the extensive and dispersed landholdings of some larger producers and the organization of enslaved and other dependent labor under both Rome and the Byzantine Empire. Examples can be found among those amphorae produced in a period when the use of enslaved manpower was at its peak, such as during the late 2nd century B.C. in the northern Peloponnese and among Brindisian production, where the same stamps have been found on similar forms[73]. Augustan Tarraconensis provides another context where stamps bearing the name of the same enslaved worker have been found attached to supervisors in different workshops, sometimes across distances of more than 55 km[74]. Verbal guidance from mobile distributors, as Roux has suggested, also offers a context for adoption between communities of certain formal standardization even without direct transfer[75], and the portability of tools and physical standards would lend this model support. But the successful adoption and redeployment of the associated technologies and practices to support such high degrees of standardization – for instance, of capacities – often may have demanded more technical guidance than a voice passing through or a one-time demonstration. The varied social networks of potters are surely key to understanding the modes and mechanisms by which standardization became rooted[76]. Behind different facets of standardization were sustained interactions on both the small scale of individual learning and also across regions over the long term.

STANDARD PRODUCTS?

Standardizing jars themselves was thus one distinct challenge, but ultimately it was the processed liquid and semi-liquid foodstuffs they carried that mattered in the eyes of a producer and a consumer. This reality raises a key question that is hinted at various times above but merits more focused discussion: namely, the link between standardization of the container and of its contents. Even if it can be argued that some amphora types carried different products or products of a different nature and that reuse routinely took place in some contexts, it is generally accepted that most vessels were produced for the packaging of one specific product or a predetermined and defined group of products. The variability within a contemporaneous amphora form produced within the geographical limits of a small region or even a workshop can thus be seen as signaling either a lack of standardization (as suggested for the early provincial repertoire in the Iberian Peninsula) or massive production of several discrete (and possibly more standardized) commodities across an agriculturally vibrant region. In such cases, statistical approaches extending beyond CV values for formal variation within the broad group might offer an opportunity to help distinguish between the range of possible interpretive options.

Nevertheless, many regions specialized in the production of a single or just a narrow range of products, a development that increased with the emergence of the large estates typical of the late

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71 E.g., Loertscher 1989.

72 On Italian sigillata branches in general, see Zabehlicky-Scheffenegger 2003; for Lyon, Desbat – Génin 1996; for ESB, Bes 2015, 16 f. For *dolia*, see London 1989; Blitzer 1990; for stamps on ›opus doliare‹, Mayet 1986; Steinby 1993. See also more generally Heitz – Stapfer 2017.

73 Filis 2019.

74 Berni – Miró 2013, 80 f.; infra, chap. 6.

75 Roux 2015.

76 Roux 2020. On social network modeling of potters, see Hasaki – Harris Cline 2020.

5 Wasters and other ceramic debris from the massive production center for Dressel 20 amphoras of Sotillo (Almodovar del Río, Córdoba) (photos © authors)

Republican and imperial periods[77]. In areas such as the southern Spanish Guadalquivir and Genil Valleys, this trajectory resulted in an economy centered on an export-driven monoculture during the 2nd and 3rd century A.D. The Dressel 20, highly standardized and produced in massive quantities in this period, offers the best example of this economic specialization toward monoculture, in this case related to olive oil (fig. 5). There are many others, however, including the Dressel 1 form in 1st-century B.C. Tyrrhenian Italy and the Gauloise 4 jar during the 1st and 2nd century A.D. in southern France. At the same time, this apparent homogeneity of regional agricultural production extending over several thousands of square kilometers each may conceal important diversity in contents. One should acknowledge, for example, small climatic and/or soil conditions as well as different economic and cultural habits underlying a general production of ›Baetican‹ olive oil or ›Gaulish‹ wine that would have resulted in variations in taste and other related features.

On the other hand, descriptions of ancient agronomists and archaeological remains of wine and oil presses seem not to emphasize significant differences in production within the geographical limits of regions[78]. Authors such as Pliny tell us about preferences for and perceived adequacy of certain varieties of olive trees and especially vines depending on region[79]. Since scientific trace analyses of contents like wines and oils remain rare, the ink markings on the amphorae themselves still offer the most important clues regarding the products they transported. Such epigraphy's presence by itself could suggest that it was necessary to communicate the exact nature of the product even when the origin was known from the form. For example, the *tituli picti* mentioned above on amphorae at Lyon reveal a fish product created following a special recipe or imported style[80], information also transmitted by Cato in his discussion of how to produce ›Coan wine‹ in Campania[81]. As indicated above, it is quite likely that many ›imitations‹ of regional amphora forms were intended – certainly in their early stages but likely also later – to be read as containing products made in the same ›style‹ as those from the original producer region[82].

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77 Carandini 1989. Several ancient authors, ranging from Republican to Late Antique in date, suggest the preference for not having an excessively large estate: e.g., Cato agr. 2; Colum. 1, 3; Plin. nat 18, 32; Pall. agric. 16, 7. Horden – Purcell (2000, 201–204) suggest problems associated with the complete specialization of regions in large-scale monoculture when major markets decline, but this seems to have been a constant feature throughout different periods in important olive-oil- and wine-producing regions such as inland Baetica, Tripolitania, and the coastal region of Tuscany. For the Late Antique period, examples of large estates and monoculture, mainly centered on wine and oil, can be found in Banaji 2016.

78 For a general view about the different provinces, see Brun 2004.

79 For different wines related to different provinces, see Tchernia 1986; Komar 2020.

80 González – Berni 2018, 41–47.

81 Cato agr. 112.

82 See above, p. 17 f.

A different rationale can be found in the rich epigraphical system of the highly standardized Dressel 20 amphorae of the Flavian and Severan periods, during which time almost no mention is made of the specific contents[83], suggesting they were perfectly clear to the parties involved and always the same, even if the locations where fiscal control was conducted are generally noted. Dressel 20 jars are linked to supply of the army and the city of Rome, both contexts in which the state would presumably have demanded a consistent product and quality. Such a powerful state demand may have promoted standardization of the agricultural product alongside its container. While Dressel 20 *tituli picti* generally concern administrative notation rather than indicating contents, the situation appears different for its later relative, Dressel 23. Some examples in CIL XV seem to mention not olive oil but olives. Furthermore, a recent underwater discovery of Dressel 23 amphorae with black epigraphic lettering in Begur (Girona, Spain) indicates a kind of sweet olive[84]. Could the loosening of their monopoly over western imperial markets during the 3rd century have pushed Baetican producers to develop new commercial strategies that involved new products relying on the same olive trees? Whatever the case, this instance of diversification would seem to underscore the ability of Baetican agricultural estates to shift toward different varieties of olive products that relied on the same natural resources as well as the same container used to package the more common and traditional local oil.

Even if the regional microecologies that were key to ancient Mediterranean socioeconomic life ensured some variation[85], a certain level of standardization may also be apparent in taste and consumption, at least among the privileged social classes of the Roman and Late Antique periods but likely also extending to broader sectors of society with limited disposable resources[86]. This homogeneity centered on the shared consumption of widespread bulk products like wine, oil, or fish sauces, but their qualities, quantities, and varieties were no doubt quite different depending on the particular social and economic status of the consumer. In one sense, the situation was therefore probably not very different from the contemporary era, with producers offering widely varying qualities as well as types of wines (red, white, young, aged, reserve, etc.), olives, and other foodstuffs, but simultaneously catering to certain massive consumer forces, such as the state here, that demanded a specific and homogeneous product. Once again, the best evidence comes from the epigraphy on amphorae. While the Dressel 20 *tituli picti* do not mention content or quality, regular references not only to the specific product but also to its quality and/or the years since it was produced can be found on amphorae for wine and fish products[87]. The early imperial Baetican fish-product amphorae, however, present a difficult dilemma. The massive contemporaneous production of different types of amphorae along Cádiz Bay may be linked to the packaging of different qualities and products of fish[88]. This seems to be the case for the contents of the Dressel 12 amphora, a form never produced in large quantities and used mainly for the packaging of expensive products, especially *garum scomber*[89]. However, *garum scomber* was not the only content packed in Dressel 12, as there are *tituli picti* on these jars mentioning other products, while on other amphora types of this period and region, various products are mentioned[90]. Even if a close relationship existed between content and container – and the standardization of one is somehow linked to standardization of the other – and both trajectories of standardization are driven by related factors of trade and consumption, we should again recall Rice's assertion that standardization is a relative rather than absolute concept.

83 Rodríguez 1972; Rodríguez 1980; Remesal 1989; Aguilera 2007.

84 Thanks to J. Mayoral and R. Geli for sharing this information; cf. Derda 1992; van Doorninck 2015a, 50 (Yassıada).

85 See generally Horden – Purcell 2000.

86 E.g., Hingley 2005; and various contributions in Pitts – Versluys 2014; Van Oyen – Pitts 2017.

87 Amphorae for fish products often mention the quality, normally excellent, in *tituli picti*, while indications of the years of the product, even if not uncommon for jars carrying fish products, are more typical on wine amphorae.

88 García 1998.

89 González 2012.

90 For the *tituli picti* on fish-sauce amphorae, see Martínez 2000; Martin-Kilcher 2004; Lagóstena 2004; García et al. 2018.

TOWARD ECONOMIC HISTORIES

The parameters behind amphora standardization explored above – from regions converging on broadly shared styles to specific mechanisms for serial control over volumes and the social coordination of producers who enacted them – offer a first step in moving beyond the basic fact (the ›what‹) of standardized production toward a greater appreciation of its place in linking production, distribution, and consumption in past Mediterranean economies. There is no doubt that the technical capacity to achieve high levels of formal and volumetric standardization in these jars was at hand throughout the period under examination, yet the case studies here reveal varied trajectories and in turn the varied interests and motivations behind them. Rather than attempt to outline a singular history, we can focus then on assembling different and complementary regional histories from across a fuller temporal and spatial breadth of the ancient Mediterranean. This is in part a concession to the state of knowledge since we are limited in how synthetic a vision such disparate glimpses can offer. But more importantly, it is a matter of being sensitive to the complexity of where, when, and how developments of standardization (and variation) intersected with growing and diversifying economic scales, shifting political structures, and of course the rise and eventual eclipse of the amphora as the transport container of choice. Such regional and long-term historical approaches are therefore also key to understanding ultimately the ›why‹ behind standardization. To this end, a few preliminary connections and trends can be hypothesized that might inform future study.

One crucial consideration centers on the relationship between scales of demand, mass production, and standardization. Could standardization take hold without mass production? To what extent and in what ways was mass production tied to demand? How did scales of demand affect different manifestations of standardization? The multiple trajectories of standardization tied to mass demand for foodstuffs is illustrated by the different regions of the Iberian Peninsula, especially Baetica and Tarraconensis during the late Republican and early imperial periods[91]. Both regions featured important pre-Roman amphora traditions which were transformed by the Roman conquest. The arrival of settlers from the Italian Peninsula changed broadly the local social and economic landscape, affecting agricultural production and the subsidiary production industry of ceramic vessels for the transport and trade of liquid or semi-liquid commodities. Even if pre-Roman pottery and agricultural traditions remained active for a time[92], the production of foodstuffs was quickly reoriented toward meeting the emerging demand of new populations settled across the peninsula, especially the Roman army and administrative staff. This process affected particularly wine production, but the olive oil and fish product industries were also impacted. The Italian population that settled in Spain demanded wines that were similar to those made in Italy and transported in vessel shapes traditionally associated with those wines. The earliest Roman amphora production in Tarraconensis is thus characterized by precise replication of the Dressel 1 shape, the most important Italian amphora of the 2nd and 1st centuries B.C. In their formal (and probably also volumetric) features, these copies are perfectly standardized to the originals; they used techniques that followed precisely the Italian prototypes of the period, from which they are differentiated only by their fabrics[93]. The new provincial economies, however, soon developed different types of amphorae that did not follow these Italian standards. Amphorae of the middle quarters of the 1st century B.C. in northeast and south Spain were thus characterized by heterogeneity and an acute lack of formal and volumetric standardization. It is in this ›disorderly‹ phase of production, though, that we can see the foundations for the highly

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[91] See infra, chap. 4; chap. 6.

[92] The length of the pre-Roman tradition and its contribution to the later provincial repertoires of the late 1st cent. B.C. differ depending on the geographical area. One example of this transformation and the remains of pre-Roman tradition in techniques and formal features can be found in chap. 3, 83 f.

[93] Whether the content might also be distinguished from the original Italian content remains an open question. See infra, chap. 6, 161–164.

standardized regional production of the imperial period, the best example of which comes from the olive oil amphorae of the Guadalquivir Valley[94]. A shift took hold over the next half century, if not longer, from heterogeneity and lack of standardization to a more homogeneous production of highly standardized vessels, a shift that was directly motivated not so much by local community taste as by growing external demand over the last part of the 1st century B.C. and 1st century A.D.

Underlying these and other trajectories described in the case studies here are implicit or explicit appeals to ›efficiency‹ as an underlying driver behind amphora standardization, namely that tightly controlling certain attributes offered practical benefits that made such amphorae more effective as containers. Yet any abstract singular ›efficiency‹ is hardly a sufficient explanation any more than an abstract singular ›economy‹ reflects the need behind it. For several decades, economic historians and sociologists have recognized that thriving economic institutions, both efficient and inefficient, are invariably socially and culturally contingent[95]. Here, the efficiencies behind standardized jars are dependent on the different economic agents and forces that intersected in their use and context. Already we have emphasized the many different aspects and modes of standardization that might yield benefits in one or another context of production, distribution, or consumption. At times the particular economic and logistical conditions of transport could favor larger or different specialized containers – including containers other than amphorae – as well as repackaging for various legs of journeys, as Peña has argued for multistage transit of North African oil from inland locations toward ports and from those ports to far-flung markets[96]. Containers that could move most seamlessly across the various transactions that connected producers and consumers offered potential labor savings and therefore a possible economic advantage. The time and effort needed to verify (and remeasure or even repackage) contents could be saved through standardization. Systems designed to reduce such transaction costs – costs of doing business – required widespread agreement and some investment to implement, as well as mechanisms that could help foster trust and increase transparency among participants in the sometimes-opaque information environments that characterized Mediterranean interaction[97]. For the major products that were crossing the Mediterranean in containers, streamlining communication and ensuring reliable information regarding contents – their type, origin, or amount – could yield benefits at each stage along an economic chain.

Many could have benefitted from various efficiencies enabled by standardization, but greater dividends were typically accrued by those operating at larger economic scales. If a shipment of just one form of standardized jar offered advantages of space and easy loading over cargos composed of many different containers, that system could potentially – if indirectly – favor agents capable of large-scale uniform movements of single bulk products over smaller operators assembling mixed cargos. The answer to this unevenness would seem to be reflected in the assembly of cargos in standardized jars but belonging to many producers or merchants, allowing a broader group to capitalize on such a system[98]. Standard volumes presumably benefitted economic chains by removing some of the opacity of transactions and reducing logistical burdens like routine measurement[99]. In practice, though, such an initiative to standardize volumes may have been a greater concern to individuals or institutions in control of both more products and more stages of the transactions that moved them. No doubt those same economic players also had greater power to bring about and then to enforce standards effectively. And no single

94 García et al. 2011, 228–242.
95 See generally Ogilvie 2007; Verboven 2015.
96 Peña 1998. See also Marlière – Torres 2007.
97 On trust and transparency (or lack thereof) in ancient economic interaction, see generally Bang 2008; Johnstone 2011; Verboven 2002; Verboven 2012.
98 See, e.g., Rathbone 2003; Boetto 2012; Rice 2016. For a special case concerning Dressel 20 amphorae, see Colls et al. 1977.
99 Greene – Lawall 2015.

institution exerted a stronger influence on the distribution of goods in amphorae than the state, to which many of the authors here attribute, explicitly or implicitly, the major initiative toward standardization.

It is easy to imagine a link between greater standardization and fiscal transfers of goods for urban and military supply; it is hard not to see the state at work behind standardized Dressel 20 jars that are so strongly connected to the movement of oil to both the metropolis and Rome's military outposts in the provincial northwest[100]. Sáez et al. trace the shift from Punic to Roman units of volume to the years following the conquest of the Iberian peninsula by Rome[101]. This ceramic evidence provides productive paths to explore whether change was driven by the state or through strategic local calculations that recognized the commercial utility of Roman units amid a new western Mediterranean economic order. Even in the case of Dressel 20 amphorae, goods were moved on behalf of the state by private entrepreneurs who stood to gain from any such systems put in place[102]. The mixed commercial and state contexts in which North African amphorae circulated point to similarly complex dynamics and may help account for the seemingly varied trajectories identified by Bonifay et al. within certain periods[103]. For example, the massive cylindrical African shapes with tucked-in handles were perhaps more conveniently rolled – akin to barrels – than carried; doing so, however, required specific logistical infrastructure at ports and elsewhere along the way, infrastructure that was more readily anticipated in state contexts of urban and military provisioning[104]. By contrast, Michael McCormick has noted that the small conical Kapitän 2 jar – for which no state context of distribution has been suggested – was easily manipulated using its high looping handles; this ergonomic advantage was especially useful in contexts where the jars needed to be passed by hand from ship to shore without such port infrastructure as at any beachside anchorage where small-scale private commercial exchange rather than state supply was probably the norm[105].

What benefits (and costs) of amphora standardization might we envision, then, for the sorts of small-scale and often local interactions that were equally fundamental to Mediterranean connectivity[106]? Within such contexts of circulation, transactions between producer and distributor – or even directly from producer to consumer – need not always have been ›containerized‹ with amphorae; those that were, though, may have gained little advantage through standardization in an economic setting where face-to-face relations were the norm. Here, the successful transaction of goods was grounded strongly in social networks and shared customs. The anonymization of products in such jars may, in fact, run counter to the socially embedded nature of much highly localized exchange, especially on smaller scales, which drew trust from long-term relationships among known parties. The suggestion, by Elizabeth S. Greene and Mark L. Lawall, for how non-standardized amphorae may have functioned in the Archaic and Classical periods is worth consideration here: any tasting and testing of products that accompanied verification at the point of transaction for unstandardized amphorae served to build trust and promote future relationships within closely connected communities[107]. On the other hand, standardized amphorae offered the individual producers an opportunity to enter the broader bulk Mediterranean market for such

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[100] See infra, chap. 4, 107 f.; also Remesal 1997; Berni 2008; González 2014; González – Berni 2018; García et al. 2011, 235–237.

[101] See infra, chap. 3, 83 f.

[102] In some cases, state activity likely offered new possibilities for private enterprise, as has been suggested to explain the appearance at Alexandria of African and especially south Spanish olive oil amphorae, which are interpreted to represent return cargos in exchange for Egyptian grain delivered to Rome: see Mattingly 1988; Tchernia 2008. A similar system has been proposed for the diffusion of African Red Slip Ware in Egypt: see Bonifay – Tchernia 2012.

[103] See infra, chap. 8.

[104] For barrels and infrastructure, see Unger 2006; on barrel logistics, see also Marlière 2002, 190; Bevan 2014, 402.

[105] McCormick 2012, 61–64. On such low-profile sites and their trade, see Leidwanger 2013b.

[106] E.g., Nieto 1997; Horden – Purcell 2000, 137–143.

[107] Greene – Lawall 2015, 11.

goods, anonymizing their contents alongside those of others. From this perspective, standardized amphorae could offer advantages for certain types of small-scale transactions and relationships, but in other contexts they behaved no differently than any other container.

If those involved in bulk transactions throughout the distribution process stood to gain most, then surely the political context in which amphora standardization took hold cannot be overlooked. The state played a critical role not only in coordinating certain economic activities but in conditioning the transfer and uptake of associated technologies and practices across space[108]. The Black Sea situation, for example, would seem to imply that the late Roman Empire's combined metropolitan and military needs could foster standardization, in this case through small Sinopean jars that Kassab Tezgör proposes were expediently distributed as rations[109]. The extensive circulation these small amphorae achieved beyond state-directed flows, however, indicates their adaptability to commercial mechanisms that grew in tandem with the scaling up of regional economic activity in the capital's extended hinterlands[110]. The reduction in formal variability of amphorae more generally toward the end of Late Antiquity surely indicates that commercial merchants and the many individual smaller-scale producers working over more limited geographies were also relying on the same shapes and sizes of amphorae as the state. The military provisioning behind the Yassıada cargo underscores this state connection, in this instance coordinated by the church, another massive agent involved in standardization from Late Antiquity onward. In the 4th and 5th centuries A.D., the church emerged as a powerful economic institution that covered a range of economic interactions spanning the production, transport, and trade of agricultural commodities, with bishops and monasteries driving the creation and delivery of ceramic goods which included the amphorae used for their transport[111]. If the late Roman and Byzantine state was invested in such standardization, might it help to explain the staying power of ceramic amphorae in the east even as other areas came to adopt alternative containers like barrels? That is, could the state have created a situation in which private market settings could also benefit from lower transaction costs[112]? This may have combined with a sort of ›path dependence‹ on the part of workshops and distributors, for whom it was easier to continue making the same jars[113]. The dwindling range of forms starting in the 6th century would make sense in this context[114].

The re-emergence of selective stamping on certain regionally standardized Aegean forms from the late 6th century, this time clearly connected to imperial office and supply, likewise highlights the state's role[115]. Yet it is worth noting that the jars which provide the strongest evidence for standardization of volumes within the Yassıada assemblage bear no such stamps even as another amphora from a much smaller group in the same cargo does[116]. We should recall here too that some of the most extensive epigraphic accounting systems emerged in contexts of more – rather than less – formally standardized jars: Dressel 20 amphorae are the most obvious case, but we should add here the Aegean LR2-derived forms for which the epigraphic record is gaining new

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108 Blake 2016.

109 See infra, chap. 9, 241. 243 f.

110 E.g., Empereur – Picon 1989, 232 f.; Kassab Tezgör 2010.

111 Bernal-Casasola 2010 highlights the special case of unguentaria produced by the church. So-called Ephesian unguentaria were produced at Ephesos in the same workshops as LR3 amphorae and probably the ampullae of Saint John: for Ephesian unguentaria, see Metaxas 2005; for ampullae, see Pülz 2012. Epigraphical evidence on Late Antique amphorae allows Derda 1992 to link monasteries to the production of amphorae and their contents. Fournet – Pieri 2008 are more cautious about this association regarding some *spatheia* of the 6th and early 7th cent. found at Antinoopolis.

112 See especially Lo Cascio 2003; Lo Cascio 2006.

113 For path dependence, see Levi 1997.

114 For an exploration of this phenomenon within the evolution of Levantine and Cilician amphorae, see Reynolds 2005; see also infra, chap. 11 and 12.

115 See infra, chap. 12, 282–286; see also Diamanti 2012; Opaiţ – Diamanti 2014. For the role of amphorae in state supply more generally during Late Antiquity, see Karagiorgou 2001; Pieri 2007; Diamanti 2019.

116 van Doorninck 1989, 249 figs. 1. 2; 250.

scholarly attention[117]. Do these parallel developments undermine the assertion that standardized jars provided a more efficient alternative to such tedious individual accounting at every stage of transaction? We do not yet know with precision the relative chronology – or the earlier or later trajectories – to understand whether and how jars of a set volume may have eventually replaced aspects of individual accounting of their contents[118]. Nor do we know whether such extensive formal standardization across the Aegean was accompanied by similarly universal volumetric standardization[119]; not all workshops or production series need have been standardized volumetrically – or at least to the same accuracy – given the broader commercial interests that often shared the same regional container forms as the state[120]. Even with similar volumetric standardization, this stamping practice may not reflect redundancy but rather different levels of trust and bureaucratization depending on the circulation context. We should not be surprised if imperial bureaucracy meant to ensure supply collided with other mechanisms of the entrepreneurial commercial agents who were generally charged with its production and transport. Increasing state control could manifest itself in several ways simultaneously. Moreover, the movement of vital imperial provisions involved high stakes, in which security of the shipment may have been the greater official concern than the transport of maximum product for minimum cost, a goal we generally assume for private commerce.

On the other hand, clear instances of commercial drivers behind some amphora standardization are easily detected. For example, while several regional Gaulish products, especially grain and cheap wine transported in barrels, were mobilized for military supply on the Rhine frontier[121], Gauloise 4 amphorae appear to represent a wholly different phenomenon. There is little to suggest that standardization around the Gauloise 4 shape would have taken hold without the imposition of external market forces. Rather local agents might have continued using other forms as they did for internal circulation even alongside the exported Gauloise 4. The same might be said for Lusitanian amphorae, which show aspects of formal and volumetric standardization even in the absence of direct state intervention[122], or the emergence of the Last Byzantine Amphora in the Peloponnese[123]. The widespread and rather different distribution of Lusitanian amphorae indicates a commercial success that was independent of, but clearly stimulated by, trajectories of the nearby (and heavily state-tied) Baetican economy[124]. Such standardization likely entailed important socioeconomic reorganization within communities of potters[125]. But whether the market by itself was enough to generate this shift toward standardization in the absence of state economic controls is another matter entirely. Even in cases such as the large-scale production of Tarraconensis, without the environment of relative peace and provincial and economic unity – and the generally universal currency and shared measures these brought – would similar aspects of economic organization have been achieved? What seems clear enough is that through this combination of both direct and indirect mechanisms, the Roman and Byzantine state pro-

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117 Opaiţ – Diamanti 2014; Diamanti 2019; González 2019; in the last LRCW conference at Valencia (October 2019), B. Yener-Marksteiner, Ch. Diamanti and H. González Cesteros presented a new stamp found in a 7th-cent. context at Limyra (south Turkey).

118 Important work is being done tracing standardization in the later Byzantine period by van Doorninck, Günsenin, and others: e.g., van Doorninck 2015a; van Doorninck (forthcoming); Günsenin 2019.

119 E.g., see infra, chap. 12, for the participation of Crete in regional Aegean standardization.

120 See, e.g., Costin 1996.

121 Gauloise 4 jars are well represented in military camps of the German border from the second quarter of the 1st cent. A.D. and seem to have been sporadically copied in the Rhine workshop of Ladenburg, see Baudoux et al. 1998.

122 See infra, chap. 5.

123 See infra, chap. 13.

124 E.g., at Beirut: Reynolds 2008, 80. See more generally the various contributions in Part III of Vaz Pinto et al. 2016. For the general absence of Lusitanian amphorae in state supply systems for the army in northwest Europe, see Almeida – González 2017.

125 Roux 2015. For the ground-level transformation of production associated with Gaulish amphorae, see Laubenheimer 2001; Bigot 2020 (with new evidence).

vided the broad framework underpinning efforts at standardization that clearly went beyond its own systems of taxation and fiscal movement of goods. Trajectories of standardization reveal the intersection of broad institutions and specific technological achievements to which historians and archaeologists have variously attributed economic growth and development in antiquity[126].

Regional perspectives become particularly relevant in evaluating any potential relationship between standardization – or diversification – of amphorae and long-term economic growth. Did economic agents in times of growth see benefits to greater organization and therefore push toward standardized containers? Or did flourishing economies and interaction bring new opportunities for different amphora forms to enter the market? Instances of both situations can be found in the studies collected here, and certainly some of the best cases of standardization emerged in periods and regions we associate with economic boom, including early imperial Baetica and North Africa in the high empire. But how should we interpret the burst of standardization within Aegean production during the latter 6th and early 7th century, a period more generally associated with decline in the wake of imperial overexpansion, waves of plague, and emerging external threats? Shipwreck numbers suggest that this otherwise economically tumultuous period may in fact have been one of the busiest in terms of maritime interaction over the entire course of the 1st millennium in this part of the Mediterranean[127]. Perhaps we can then examine whether amphora standardization may correlate not with generic economic growth but rather more specifically with intensifying distribution and seaborne interaction[128]. If so, the standardization of amphora forms and volumes, when analyzed alongside other indicators, could offer new and finer insights into the development of ancient economies that can help us look past singular trajectories of ›growth‹ or ›decline‹ toward the many complex contours of production, distribution, and consumption; ultimately, we might hope to find the many socioeconomically diverse agents implicated in such systems and for whom abstract concepts of growth and decline were ground-level lived experiences of change[129]. Examining the transfers of technology and techniques behind standardized production across spaces and communities – and situating these alongside related developments in production and consumption[130] – may help us understand how such broader economic trends intersected with the localized social processes to which all ancient economies were intimately tied. To do so, however, will require sustained research that foregrounds the different facets of standardization and variation, analyzing them systematically and comparatively across scales, regions, and periods.

In his exploration of the *longue durée* of ›Mediterranean containerization‹, Andrew Bevan noted the Mediterranean's place as »a uniquely privileged case study of such transport packaging behavior« and issued a call for »a more strongly comparative and evolutionary assessment of transport containers as carefully designed, mass-produced, widely disseminated, and highly iconic objects«[131]. This chapter and the analyses that follow raise more questions than can presently be answered, but we hope the volume serves to demonstrate the rich economic histories waiting to be written through the lens of standardization.

126 E.g., Lo Cascio 2006; Scheidel 2011; Wilson 2011; Erdkamp 2020.
127 Leidwanger 2020, 114–122.
128 For the early emergence of standard containers alongside growing Mediterranean connectivity in the Bronze Age and Early Iron Age, see Knapp – Demesticha 2019.
129 E.g., Bowes 2021.
130 E.g., Lewit 2020.
131 Bevan 2014, 387.

BIBLIOGRAPHY

Aguilera 2007 — A. Aguilera Martín, Evolución de los tituli picti delta de las ánforas Dressel 20 entre mediados del siglo I y mediados del siglo III, Acta XII Congressus Internationalis Epigraphiae Graecae et Latinae, Monografies de la Secció Històrico-Arqueològica 10 (Barcelona 2007) 15–22.

Almeida – González 2017 — R. R. de Almeida – H. González Cesteros, Las ánforas lusitanas en los origenes del mundo romano septentrional, in: C. Carreras – J. van den Berg (eds.), Amphorae from the Kops Plateau (Nijmegen): Trade and Supply to the Lower Rhineland from the Augustan Period to AD 69/70, Archeopress Roman Archaeology 20 (Oxford 2017) 87–91.

Aranegui – Gisbert 1992 — C. Aranegui Gascó – J. A. Gisbert Santonja, Les amphores à fond plat de la Péninsule Ibérique, in: F. Laubenheimer (ed.), Les amphores en Gaule. Production et circulation. Table ronde international (Besançon 1992) 101–111.

Arnold 2000 — D. E. Arnold, Does the Standardization of Ceramic Pastes Really Mean Specialization?, Journal of Archaeological Method and Theory 7, 4, 2000, 333–375.

Arnold – Nieves 1992 — D. E. Arnold – A. L. Nieves, Factors Affecting Ceramic Standardization, in: G. Bey – C. Pool (eds.), Ceramic Production and Distribution: An Integrated Approach (Boulder 1992) 93–113.

Arthur 2018 — P. Arthur, Byzantine »Globular Amphorae« and the Early Middle Ages: Attempting to Shed Light on a Dark-Age Enigma, in: S. Gelichi – A. Molinari (eds.), I contenitori da trasporto altomedievali e medievali (VIII–XII secolo) nel Mediterraneo. Centri produttori, contenuti, reti di scambio. In Memoria di Fabiola Ardizzone. Archeologia Medievale 45 (Florence 2018) 281–287.

Bang 2008 — P. F. Bang, The Roman Bazaar: A Comparative Study of Trade and Markets in a Tributary Empire (Cambridge 2008).

Banaji 2016 — J. Banaji, The Economic Trajectories of Late Antiquity, in: J. Banaji (ed.), Exploring the Economy of Late Antiquity (Cambridge 2016) 61–88.

Badoux et al. 1998 — J. Baudoux – A. J. Bocquet – R. A. Brulet – F. Laubenheimer – E. Marlière – F. Vilvorder, La production des amphores dans l'Est et le Nord des Gaules. Typologie et caractérisation physico-chimique, in: F. Laubenheimer (ed.), Les amphores en Gaule II. Production et circulation. Table ronde international (Paris 1998) 39–42.

Benco 1988 — N. L. Benco, Morphological Standardization: An Approach to the Study of Craft Specialization, in: C. C. Kolb – L. M. Lackey (eds.), A Pot for All Reasons: Ceramic Ecology Revisited, Laboratory for Anthropology, Temple University (Philadelphia, PA 1988) 57–72.

Berg 2004 — I. Berg, The Meanings of Standardization: Conical Cups in the Late Bronze Age Aegean, Antiquity 78, 2004, 74–85.

Bernal-Casasola 2009 — D. Bernal-Casasola, Ánforas y vino en la Antigüedad Tardía. El ejemplo de la Hispania meriodional, in: J. Blánquez Pérez – S. Celestino Pérez, El vino en época taroantigua y medieval (Madrid 2009) 33–60.

Bernal-Casasola 2010 — D. Bernal-Casasola, Iglesia, producción y comercio en el Mediterráneo tardoantiguo. De las ánforas a los talleres eclesiásticos, in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3. Third International Conference on Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean, Archaeology and Archaeometry, Archaeopress, BARIntSer 2185 (I) (Oxford 2010) 19–31.

Bernal-Casasola 2016 — D. Bernal-Casasola, Dressel 30 (Baetican coast), Amphora ex Hispania. Landscapes of production and consumption <http://amphorae.icac.cat/amphora/dressel-30-baetica-coastal> (09. 07. 2016).

Berni 1998 — P. Berni Millet, Las ánforas de aceite de la Bética y su presencia en la Cataluña romana, Instrumenta 4 (Barcelona 1998).

Berni 2008 — P. Berni Millet, Epigrafía anfórica de la Bética. Nuevas formas de análisis, Instrumenta 29 (Barcelona 2008).

Berni 2021 — P. Berni Millet, Producción anfórica en Hispania. La evidencia de la epigrafía, in: W. Broekaert – A. Delattre – E. Dupraz – M. J. Estarán Tolosa, Epigraphy on Ceramics: The Instrumentum domesticum, its textual genres and its functions in Ancient Societies (Geneva 2021) 19–46.

Berni (forthcoming) P. Berni Millet, Las otras ánforas del Monte Testaccio. La producción de aceite y de ánforas oleícolas en la Cuenca del Guadalquivir en época romana, Mesa redonda internacional, 29–30 de octubre 2015 (Madrid forthcoming).

Berni – Miró 2013 P. Berni Millet – J. Miró Canals, Dinámica socioeconómica en la Tarraconense oriental a finales de la República y comienzos del Imperio. El comercio del vino a través de la epigrafía anfórica, in: J. López Vilar (ed.), Tarraco Bienal. Actes del 1er congres Internacional d'Arqueologia i Món Antic (Tarragona 2013) 63–83.

Bes 2015 P. Bes, Once upon a Time in the East. The Chronological and Geographical Distribution of Terra Sigillata and Red Slip Ware in the Roman East, Roman and Late Antique Mediterranean Pottery 6 (Oxford 2015).

Bevan 2010 A. Bevan, Making and Marking Relationships: Bronze Age Brandings and Mediterranean Commodities, in: A. Bevan – D. Wengrow, Cultures of Commodity Branding (Walnut Creek 2010) 35–85.

Bevan 2014 A. Bevan, Mediterranean Containerization, Current Anthropology 55, 4, 2014, 387–418.

Bigot 2020 F. Bigot, Production et commerce des amphores gauloises sur le littoral et dans les ports de Narbonnaise (Montagnac 2020).

Blackman et al. 1993 M. J. Blackman – G. J. Stein – P. B. Vandiver, The Standardization Hypothesis and Ceramic Mass Production: Technological, Compositional, and Metric Indexes of Craft Specialization at Tell Leilan, Syria, American Antiquity 58, 1, 1993, 60–80.

Blake 2016 E. Blake, Commentary: States and Technological Mobility – A View from the West, in: E. Kiriatzi – C. Knappett, Human Mobility and Technology Transfer in the Prehistoric Mediterranean (Cambridge 2016) 181–192.

Bleed 1997 P. Bleed, Content as Variability, Result as Selection: Toward a Behavioral Definition of Technology, Archaeological Papers of the American Anthropological Association 7, 1, 1997, 95–104.

Blitzer 1990 H. Blitzer, Koroneika: Storage-Jar Production and Trade in the Traditional Aegean, Hesperia 59, 1990, 675–711.

Boetto 2012 G. Boetto, Les épaves comme sources pour l'étude de la navigation et des routes commerciales: Un approche méthodologique, in: S. Keay (ed.), Rome, Portus and the Mediterranean, Archaeological Monographs of the British School at Rome 21 (Rome 2012) 153–173.

Bonifay 2004 M. Bonifay, Etudes sur la céramique romaine tardive d'Afrique. BARIntSer 1301 (Oxford 2004).

Bonifay – Tchernia 2012 M. Bonifay – A. Tchernia, Les réseaux de la céramique africaine (Ier–Ve siècles), in: S. Keay (ed.), Rome, Portus and the Mediterranean, Archaeological Monographs of The British School at Rome 21 (Rome 2012) 315–333.

Bost et al. 1992 J. P. Bost – M. Campo – S. Colls – V. Guerrero – F. Mayet, L'épave Cabrera III (Majorque): Échanges commerciaux et circuits monétaires au milieu du IIIe siècle après Jésus-Christ (Paris 1992).

Bowes 2021 K. Bowes, When Kuznets Went to Rome: Roman Economic Well-Being and the Reframing of Roman History, Capitalism: A Journal of History and Economics 2, 1, 2021, 7–40.

Brun 2004 J.-P. Brun, Archéologie du vin et de l'huile dans l'Empire romain (Paris 2004).

Burkhalter 2013 F. Burkhalter, Les amphores vinaires dans la documentation papyrologique d'époque ptolémaïque: production, prix et capatité, in: A. Tsingarida – D. Viviers (eds.), Pottery Markets in the Ancient Greek World (8th–1st Centuries B.C.). Proceedings of the International Symposium held at the Université libre de Bruxelles, 19–21 June 2008, Études d'archéologie 5 (Brussels 2013) 251–271.

Carandini 1989 A. Carandini, La villa romana e la piantagione schiavistica, in: A. Schiavone (ed.), Storia di Roma IV. Caratteri e morfologie (Turin 1989) 101–200.

Cateloy 2016 C. Cateloy, La mesure de capacité des amphores. Question de méthodes, in: E. Nantet (ed.), Phortia: Le tonnage des navires de commerce en Méditerranée: du VIIIe siècle av. l'ère chrétienne au VIIe siècle de l'ère chrétienne (Rennes 2016) 89 f.

Ceccarelli 2017 L. Ceccarelli, Production and Trade in Central Italy in the Roman Period: The Amphora Workshop of Montelabate in Umbria, BSR 85, 2017, 109–141.

Colls et al. 1977 D. Colls – R. Étienne – R. Lequément – B. Liou – F. Mayet, L'épave Port-Vendres II et le commerce de la Bétique à l'époque de Claude, Archaeonautica 1 (Paris 1977).

Costin 1991 C. L. Costin, Craft Specialization: Issues in Defining, Documenting, and Explaining the Organization of Production, in: M. B. Schiffer (ed.), Archaeological Method and Theory III (Tucson, AZ 1991) 1–56.

Costin 1996 C. L. Costin, Craft Production and Mobilization Strategies in the Inka Empire, in: B. Wailes (ed.), Craft Specialization and Social Evolution. In Memory of V. Gordon Childe (Philadelphia, PA 1996) 211–255.

Costin – Hagstrum 1995 C. L. Costin – M. B. Hagstrum, Standardization, Labor Investment, Skill, and the Organization of Ceramic Production in Late Prehispanic Highland Peru, American Antiquity 60, 4, 1995, 619–639.

Crown 2001 P. L. Crown, Learning to Make Pottery in the Prehispanic American Southwest, Journal of Anthropological Research 57, 2001, 451–469.

Dell'Amico – Pallarés 2011 P. Dell'Amico – F. Pallarés, Appunti sui relitti a dolia, Archaeologia Maritima Mediterranea 8, 2011, 47–135.

Demesticha 1998 S. Demesticha, Experimenting on Amphora Manufacture, in: E. Karpodini-Dimitriadi (ed.), Ethnography of European Traditional Cultures: Arts, Crafts, Techniques of Heritage, Institute of Cultural Studies of Europe and the Mediterranean (Athens 1998) 139–149.

Derda 1992 T. Derda, Inscriptions with the Formula θεου χὰρις κὲρδος on Late Roman Amphora, ZPE 94, 1992, 135–152.

Desbat – Génin 1996 A. Desbat – M. Génin, Les ateliers précoces et leurs productions, Les productions des ateliers de poitiers antiques de Lyon, Gallia 53, 1996, 219–241.

Diamanti 2012 Ch. Diamanti, Byzantine Emperors on Stamped Late Roman/Early Byzantine Amphoras, ReiCretActa 42, 2012, 1–5.

Diamanti 2019 Ch. Diamanti, *Quastura exercitus*, the *Eparch* of the islands and the Late Roman/Early Byzantine Stamped Amphoras, in Ch. Diamanti – A. Vassiliou (eds.), Essays in Byzantine Material Culture and Society in Honour of Sophia Kalopissi-Verti (Oxford 2019) 205–216.

Eerkens 2000 J. W. Eerkens, Practice Makes Within 5% of Perfect: Visual Perception, Motor Skills, and Memory in Artifact Variation, Current Anthropology 41, 4, 2000, 663–668.

Eerkens – Bettinger 2001 J. W. Eerkens – R. L. Bettinger, Techniques for Assessing Standardization in Artifact Assemblages: Can We Scale Material Variability?, American Antiquity 66, 3, 2001, 493–504.

Eerkens – Lipo 2005 J. W. Eerkens – C. P. Lipo, Cultural Transmission, Copying Errors, and the Generation of Variation in Material Culture and the Archaeological Record, Journal of Anthropological Archaeology 24, 2005, 316–334.

Empereur – Picon 1989 J.-Y. Empereur – M. Picon, Les régions de production d'amphores impériales en Méditerranée orientale, Amphores romaines et histoire économique: Dix ans de recherche, CEFR 114 (Rome 1989) 223–248.

Erdkamp 2020 P. Erdkamp, Population, Technology, and Economic Growth in the Roman World, in: P. Erdkamp – K. Verboven – A. Zuiderhoek (eds.), Capital, Investment, and Innovation in the Roman World (Oxford 2020) 39–65.

Fabião 1998 C. Fabião, O vinho da Lusitânia. Reflexoes em torno de um problema arqueológico, Revista portuguesa de arqueologia, 1, 1, 1998, 169–198.

Filis 2019 K. Filis, The ovoid amphorae from Aigion, in the north-west Peloponnese. The connections with Corinth and the Brindisi area, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. M. Sáez Romero (eds.), The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 3–34.

Finkelstein et al. 2011 I. Finkelstein – E. Zapassky – Y. Gadot – D. M. Master – L. E. Stager – I. Benenson, Phoenician ›Torpedo‹ Amphoras and Egypt: Standardization of Volume Based on Linear Dimensions, AegLev 21, 2011, 249–259.

Fournet – Pieri 2008 J.-L. Fournet – D. Pieri, Les dipinti amphoriques d'Antinoopolis, in: R. Pintaudi, Antinoupolis 1. Scavi e materiali I, Instituto Papirologico »G. Vitelli« (Florence 2008) 175–216.

Frankel 1988 D. Frankel, Pottery Production in Prehistoric Bronze Age Cyprus: Assessing the Problem, JMedA 1, 2, 1988, 27–55.

Gallimore 2010 S. Gallimore, Amphora Production in the Roman World: A View from the Papyri, BAmSocP 47, 2010, 155–184.

García 1998 E. García Vargas, La producción de ánforas en la bahía de Cádiz en época romana (siglos II a.C.–IV d.C.) (Écija 1998).

García et al. 2011 E. García Vargas – R. R. de Almeida – H. González Cesteros, Los tipos anfóricos del Guadalquivir en el marco de los envases hispanos del siglo I a.C. Un universo heterogéneo entre la imitación y la estandarización, Spal 20, 2011, 185–283; DOI: 10.12795/spal.2011.i20.12

García et al. 2018 E. García Vargas – E. Roselló Izquierdo – D. Bernal-Casasola – A. Morales Muñiz, Salazones y salsas de pescado en la Antigüedad. Un primer acercamiento a las evidencias de paleocontenidos y depósitos primarios en el ámbito euro-mediterráneo, in: D. Bernal-Casasola – R. Jiménez Camino Álvarez (eds.), Las cetariae de Ivlia Tradvcta. Resultados de las excavaciones arqueológicas en la calle San Nicolás de Algeciras (2001–2006) (Cádiz 2018) 287–312.

García et al. 2019 E. García Vargas – H. González Cesteros – R. R. de Almeida, Ovoid amphorae as the first Roman provincial repertoire in *Hispania Ulterior* (the Guadalquivir Valley), in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. Sáez Romero (eds.), The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 62–111.

Gelichi – Molinari 2018 S. Gelichi – A. Molinari (eds.), I contenitori da trasporto altomedievali e medievali (VIII–XII secolo) nel Mediterraneo. Centri produttori, contenuti, reti di scambio, In Memoria di Fabiola Ardizzone, Archeologia Medievale 45 (Florence 2018).

González 2012 H. González Cesteros, *Scomber* gaditano en Éfeso. Una Dresel 12 con titulus encontrada en la »Casa Aterrazada 2« de Éfeso, DialA 38, 1, 2012, 111–124.

González 2014 H. González Cesteros, Ánforas hispanas en la Germania Inferior antes de la formación de la provincia (20 a.C. – 69 d.C.) (unpubl. doctoral dissertation Instituto Catalán de Arqueología Clásica Tarragona 2014).

González 2019 H. González Cesteros, Eastern Mediterranean Amphorae, in: T. Bezeczky (ed.), Amphora research in the Castrum Villa on Brijuni Island, DenkschrWien 509 = AForsch 29 (Vienna 2019) 67–90.

González – Berni 2018 H. González Cesteros – P. Berni Millet, Roman amphorae in Neuss. Augustan to Julio-Claudian contexts, Roman and Late Antique Mediterranean Pottery 12 (Oxford 2018).

Gosselain 2000 O. Gosselain, Materializing Identities: An African Perspective, Journal of Archaeological Method and Theory 7, 3, 2000, 187–217.

Gosselain 2011 O. Gosselain, Fine if I Do, Fine if I Don't. Dynamics of Technical Knowledge in Sub-Saharan Africa, in: B. W. Roberts – M. Vander Linden, Investigating Archaeological Cultures: Material Culture, Variability, and Transmission (New York 2011) 211–227.

Gosselain 2016 O. Gosselain, Commentary: On Fluxes, Connections and their Archaeological Manifestations, in: E. Kiriatzi – C. Knappett, Human Mobility and Technology Transfer in the Prehistoric Mediterranean (Cambridge 2016) 193–205.

Grace 1949 V. Grace, Standard Pottery Containers of the Ancient Greek World, Commemorative Studies in Honor of Theodore Leslie Shear, Hesperia Suppl. 8 (Princeton, NJ 1949) 175–189.

Greene – Lawall 2015 E. S. Greene – M. L. Lawall, Amphora Standardization and Economic Activity, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (College Station, TX 2015) 3–16.

Günsenin 2019 N. Günsenin, A Günsenin IV Amphora from Küçükyalı, Anatolia Antiqua 27, 2019, 279–284.

Hagstrum 1985 M. B. Hagstrum, Measuring Prehistoric Ceramic Craft Specialization: A Test Case in the American Southwest, JFieldA 12, 1, 1985, 65–75.

Hasaki – Harris Cline 2020 E. Hasaki – D. Harris Cline, Social Network Analysis and Connoisseurship in the Study of Athenian Potters' Communities, in: E. Hasaki – M. Bentz (eds.), Reconstructing Scales of Production in the Ancient Greek World. Producers, Processes, Products, People. Proceedings of the XIX Conference of Classical Archaeology, Archaeology and Economy in the Ancient World, Bonn 22–26 May 2018 (Heidelberg 2020) 59–80.

Hein et al. 2008 A. Hein – V. Georgopoulou – E. Nodarou – V. Kilikoglou, Koan Amphorae from Halasarna. Investigations in a Hellenistic Amphora Production Centre, JASc 35, 2008, 1049–1061.

Hein – Kilikoglou 2020 A. Hein – V. Kilikoglou, Digital Modeling of Function and Performance of Transport Amphorae, International Journal of Ceramic Engineering and Science 2, 4, 2020, 187–200.

Heitz – Stapfer 2017 C. Heitz – R. Stapfer (eds.), Mobility and Pottery Production. Archaeological and Anthropological Perspectives (Leiden 2017).

Heslin 2011 K. Heslin, Dolia Shipwrecks and the Wine Trade in the Roman Mediterranean, in: D. Robinson – A. Wilson, Maritime Archaeology and Ancient Trade in the Mediterranean, Oxford Centre for Maritime Archaeology (Oxford 2011) 157–168.

Hingley 2005 R. Hingley, Globalizing Roman Culture. Unity, diversity and empire (Abingdon 2005).

Horden – Purcell 2000 P. Horden – N. Purcell, The Corrupting Sea: A Study of Mediterranean History (Malden 2000).

Johnstone 2011 S. Johnstone, A History of Trust in Ancient Greece (Chicago 2011).

Karagiorgou 2001 O. Karagiorgou, LR2: A Container for the Military *annona* on the Danubian Border?, in: S. Kingsley – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity (Oxford 2001) 129–166.

Kassab Tezgör 2010 D. Kassab Tezgör, Le réseau commercial des amphores sinopéennes entre les II[e]–III[e] s. et le VI[e] s. de notre ère, in: D. Kassab Tezgör – N. Inaishvili (eds.), PATABS I. Production and Trade of Amphorae in the Black Sea. Actes de la Table Ronde internationale de Batoumi et Trabzon, 27–29 Avril 2006, Varia Anatolica 21 (Paris 2010) 167–173.

Katzev 2008 S. W. Katzev, The Kyrenia Ship: Her Recent Journey, Near Eastern Archaeology 71, 1–2, 2008, 7–81.

Kletter 2009 R. Kletter, Comment: Computational Intelligence, *Lmlk* Storage Jars and the *Bath* Unit in Iron Age Judah, Journal of Archaeological Method and Theory 16, 2009, 357–365.

Knapp – Demesticha 2019 A. B. Knapp – S. Demesticha, Mediterranean Connections: Maritime Transport Containers and Seaborne Trade in the Bronze and Early Iron Ages (London 2019).

Knappett – Hilditch 2015 C. Knappett – J. Hilditch, Colonial Cups? The Minoan Plain Handleless Cup as Icon and Index, in: C. Glatz (ed.), Plain Pottery Traditions of the Eastern Mediterranean and Near East. Production, Use, and Social Significance (London 2015) 91–113.

Knappett – Kiriatzi 2017 C. Knappett – E. Kiriatzi, Technological Mobilities: Perspectives from the Eastern Mediterranean. An Introduction, in: E. Kiriatzi – C. Knappett (eds.), Human Mobility and Technology Transfer in the Prehistoric Mediterranean (Cambridge 2017) 1–17.

Komar 2020 P. Komar, Eastern Wines on Western Tables: Consumption, Trade and Economy in Ancient Italy, Mnemosyne Suppl. 435 (Leiden 2020).

Kotsonas 2014 A. Kotsonas, Standardization, Variation, and the Study of Ceramics in the Mediterranean and Beyond, in: A. Kotsonas, Understanding Standardization and Variation in Mediterranean Ceramics: Mid 2[nd] to Late 1[st] Millennium BC (Leuven 2014) 7–23.

Kruit – Worp 1999 N. Kruit – K. A. Worp, Metrological Notes on Measures and Containers of Liquids in Graeco-Roman and Byzantine Egypt, ArchPF 45, 1, 1999, 96–127.

Kruit – Worp 2000 N. Kruit – K. A. Worp, Geographical Jar Names: Towards a Multi-Disciplinary Approach, ArchPF 46, 1, 2000, 65–146.

Lagóstena 2004 L. Lagóstena Barrios, Las ánforas salsarias de *Baetica*. Consideraciones sobre sus elementos epigráficos, in: J. Remesal Rodríguez (ed.), Epigrafía anfórica, Instrumenta 17, 2004, 197–219.

Lawall 2011 M. L. Lawall, Imitative Amphoras in the Greek World, MBAH 28, 2011, 45–88.

Lawall 2018 M. L. Lawall, Regional Styles of Transport Amphora Production in the Archaic Aegean, in: S. Handberg – A. Gadolou (eds.), Material Koinai in the Greek Early Iron Age and Archaic Period. Acts of an International Conference at the Danish Institute at Athens, Monographs of the Danish Institute at Athens 22 (Aarhus 2018) 289–311.

Laubenheimer 1985 F. Laubenheimer, La production des amphores en Gaule Narbonnaise sous le Haut-Empire, Annales littéraires de l'Université de Besançon 327 (Paris 1985).

Laubenheimer 2001 F. Laubenheimer, Le vin gaulois de Narbonnaise exporté dans le monde romain, sous le Haut-Empire, in: F. Laubenheimer (ed.), 20 ans de recherches à Sallèles d'Aude (Besançon 2001) 51–66.

Laubenheimer – Gisbert 2001 F. Laubenheimer – J. A. Gisbert Santonja, La standardisation des amphores Gauloise 4 des ateliers de Narbonnaise à la production de Denia (Espagne), in: F. Laubenheimer (ed.), 20 ans de recherches à Sallèles d'Aude (Besançon 2001) 33–50.

Leidwanger 2013a J. Leidwanger, Between Local and Long-Distance: A Roman Shipwreck at Fig Tree Bay off SE Cyprus, JRA 26, 2013, 191–208.

Leidwanger 2013b J. Leidwanger, Opportunistic Ports and Spaces of Exchange in Late Roman Cyprus, Journal of Maritime Archaeology 8, 2, 2013, 221–243.

Leidwanger 2020 J. Leidwanger, Roman Seas: A Maritime Archaeology of Eastern Mediterranean Economies (New York 2020).

Levi 1997 M. Levi, A Model, a Method, and a Map. Rational Choice in Comparative and Historical Analysis, in: M. Lichbach – A. Zuckerman (eds.), Comparative Politics. Rationality, Culture and Structure (Cambridge 1997) 19–41.

Levinson 2006 M. Levinson, The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger (Princeton, NJ 2006).

Lewit 2020 T. Lewit, Invention, Tinkering, or Transfer? Innovation in Oil and Wine Presses in the Roman Empire, in: P. Erdkamp – K. Verboven – A. Zuiderhoek (eds.), Capital, Investment, and Innovation in the Roman World (Oxford 2020) 307–353.

Li 2020 X. Li, Bronze Weapons of the Qin Terracotta Warriors: Standardisation, Craft Specialisation and Labour Organization, BARIntSer 2992 (Oxford 2020).

Lo Cascio 2003 E. Lo Cascio, Mercato libero e ›commercio amministrato‹ in età tardoantica, in: C. Zaccagnini (ed.), Mercanti e politica nel mondo antico (Rome 2003) 307–325.

Lo Cascio 2006 E. Lo Cascio (ed.), Innovazione tecnica e progresso economico nel mondo romano (Bari 2006).

Loertscher 1989 T. Loertscher, Voluta constructa: Zu einem kaiserzeitlichen Volutenkonstruktionsmodell aus Nordafrika, AntK 32, 2, 1989, 82–103.

London 1989 G. London, On Fig Leaves, Itinerant Potters, and Pottery Production Locations in Cyprus, in: P. E. McGovern – M. R. Notis, Cross-craft and Cross-Cultural Interactions in Ceramics, American Ceramics Society (Westerville, OH 1989) 65–80.

Longacre 1999 W. A. Longacre, Standardization and Specialization: What's the Link?, in: J. M. Skibo – S. J. Feinman (eds.), Pottery and People. A Dynamic Interaction (Salt Lake City, UT 1999) 44–58.

Longacre et al. 1988 W. A. Longacre – K. L. Kvamme – M. Kobayashi, Southwestern Pottery Standardization: An Ethnoarchaeological View from the Philippines, Kiva 53, 2, 1988, 101–112.

Manacorda – Panella 1993 D. Manacorda – C. Panella, Anfore, in: W. V. Harris (ed.), The inscribed economy. Production and distribution in the Roman empire in the light of instrumentum domesticum, JRA Suppl. 6 (Ann Arbor, MI 1993) 55–64.

Marlier 2008 S. Marlier, Architecture et espace de navigation des navires à dolia, Archaeonautica 15, 2008, 153–173.

Marlière 2002 E. Marlière, L'outre et le tonneau dans l'Occident Romain, Monographies Instrumentum 22 (Montagnac 2002).

Marlière – Torres 2007 E. Marlière – J. Torres Costa, Transport et stockage des denrées dans l'Afrique romaine: le rôle de l'outre et du tonneau, in: A. Mrabet – J. Remesal Rodríguez (eds.), In Africa et in Hispania: études sur l'huile africaine, Instrumenta 25 (Barcelona 2007) 85–106.

Martin-Kilcher 1994 S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte. II, Die Amphoren für Wein, Fischsauce, Südfrüchte (Gruppen 2–24) und Gesamtauswertung, FiA 7 (Augst 1994).

Martin-Kilcher 2004 S. Martin-Kilcher, Fischsaucen: Pinselaufschriften und römische Amphoren, in: J. Remesal Rodríguez (ed.), Epigrafía anfórica, Instrumenta 17 (Barcelona 2004) 245–257.

Martínez 2000 J. Martínez Maganto, Inscripciones sobre ánforas de salazón: interpretación sobre la estructura y significado comercial de los tituli picti, in: D. Bernal-Casasola – E. García Vargas (eds.) Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el Imperio Romano IV (Écija 2000) 1206–1220.

Mattingly 1988 D. J. Mattingly, Oil for export? A comparison of Libyan, Spanish and Tunisian olive oil production in the Roman empire, JRA 1, 1988, 33–56.

Mayerson 1998 P. Mayerson, The Sack (Cάκκος) Is the Artaba Writ Large, ZPE 122, 1998, 189–194.

Mayet 1986 F. Mayet, Les figlinae dans les marques d'amphores Dressel 20 de Bétique, Hommage à Robert Étienne, Publications du Centre Pierre Paris 17 = REA 88 (Paris 1986) 285–305.

McCormick 2012 M. McCormick, Movement and Markets in the First Millennium: Information, Containers, and Shipwrecks, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection (Washington, DC 2012) 51–98.

Melko 2017 N. Melko, Form Follows Fingers: Roman Pottery, the Producer's Perspective and the Mobility of Ideas, in: C. Heitz – R. Stapfer (eds.), Mobility and Pottery Production. Archaeological and Anthropological Perspectives (Leiden 2017) 213–228.

Metaxas 2005 S. Metaxas, Frühbyzantinische Ampullen und Amphoriskoi aus Ephesos, in: F. Krinzinger (ed.), Spätantike und mittelalterliche Keramik aus Ephesos, DenkschrWien 332 = AForsch 13 (Vienna 2005) 67–123.

Mindau 2004 G. Mindau, Regard sur la comptabilité antique romaine. La mosaïque de l'aula des mensores à Ostie, des doigts et des comptes, MEFRA 116, 1, 2004, 437–468.

Moore 2011 J. Moore, When Not Just Any Wine Will Do …? The Proliferation of Coan-Type Wine and Amphoras in the Greco-Roman World, MBAH 28, 2011, 89–122.

Naciri et al. 1986 A. Naciri – F. Widemann – A. Sabir, Distinction par analyse par activation neutronique des amphores gauloise 4 et de leurs imitations tardives en Maurétanie Césarienne. Les Dressel 30, AntAfr 22, 1986, 129–140.

Nantet 2016 E. Nantet, Phortia: Le tonnage des navires de commerce en Méditerranée: du VIII^e^ siècle av. l'ère chrétienne au VII^e^ siècle de l'ère chrétienne (Rennes 2016).

Nieto 1997 X. Nieto, Le commerce de cabotage et de distribution, in: P. Pomey (ed.), La navigation dans l'antiquité (Aix-en-Provence 1997) 146–158.

Ogilvie 2007 S. Ogilvie, ›Whatever Is, Is Right?‹ Economic Institutions in Pre-industrial Europe, Economic History Review 60, 2007, 649–684.

Opaiţ 2010 A. Opaiţ, On the Origin of the LR Amphora 1, in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3. Third International Conference on Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean, Archaeology and Archaeometry, BARIntSer 2185 (Oxford 2010) 1015–1022.

Opaiţ – Diamanti 2014 A. Opaiţ – Ch. Diamanti, Imperial Stamps on Early Byzantine Amphoras. The Athenian Agora Examples, ReiCretActa 43, 2014, 55–61.

Orton – Hughes 2013 C. Orton – M. Hughes, Pottery in Archaeology [2](Cambridge 2013).

Peacock 1982 D. P. S. Peacock, Pottery in the Roman World: An Ethnoarchaeological Approach (London 1982).

Peacock – Williams 1986 D. P. S. Peacock – D. F. Williams, Amphorae and the Roman Economy: An Introductory Guide (London 1986).

Peña 1998 J. T. Peña, The Mobilization of State Olive Oil in Roman Africa: The Evidence of Late 4th-c. Ostraca from Carthage, in: J. T. Peña – J. J. Rossiter – A. Wilson – C. M. Wells, Carthage Papers: The Early Colony's Economy, Water Supply, a Public Bath, and the Mobilization of State Olive Oil, JRA Suppl. 28 (Portsmouth, RI 1998) 117–238.

Peña 2007 J. T. Peña, Roman Pottery in the Archaeological Record (Cambridge 2007).

Pieri 2007 D. Pieri, Les centres de production d'amphores en Méditerranée orientale durant l'antiquité tardive: quelques remarques, in: M. Bonifay – J. C. Tréglia (eds.), LRCW 2. Late Roman coarse wares, cooking wares and amphorae in the Mediterranean: archaeology and archaeometry, BARIntSer 1642, I (Oxford 2007) 611–25.

Pitts – Versluys 2014 M. Pitts – M. J. Versluys, Globalisation and the Roman World: World History, Connectivity and Material Culture (Cambridge 2014).

Pülz 2012 A. Pülz, Archaeological evidence of Christian Pilgrimage in Ephesus, Herom 1, 2012, 225–260.

Quaresma – Raposo 2016 J. C. Quaresma – J. M. Raposo, Lusitana 3 (Western Lusitania), Amphorae ex Hispania. Landscapes of production and consumption <http://amphorae.icac.cat/amphora/lusitana-3-western-lusitania> (08. 07. 2016).

Ramon 1991 J. Ramon Torres, Las ánforas púnicas de Ibiza, Trabajos del Museo Arqueologico de Ibiza 23 (Ibiza 1991).

Rathbone 2003 D. Rathbone, The Financing of Maritime Commerce in the Roman Empire, I–II AD, in: E. Lo Cascio (ed.), Credito e moneta nel mondo romano (Bari 2003) 197–229.

Rauh 2004 N. K. Rauh, Pirated Knock-offs: Cilician Imitations of Internationally Traded Amphoras, in: J. Eiring – J. Lund (eds.), Transport Amphorae and Trade in the Eastern Mediterranean. Acts of the International Colloquium at the Danish Institute at Athens, September 26–29, 2002, Monographs of the Danish Institute at Athens 5 (Athens 2004) 329–336.

Remesal 1989 J. Remesal Rodríguez, Cuestiones en torno a la epigrafía anfórica de la Bética. Amphores romaines et histoire économique. Dix ans de recherche (Colloque Sienne, 1986), CEFR 114 (Rome 1989) 489–503.

Remesal 1997 J. Remesal Rodríguez, Heeresversorgung und die wirtschaftlichen Beziehungen zwischen der Baetica und Germanien, Corpus der in Deutschland gefundenen Stempel auf Amphoren Dr. 20 (Stuttgart 1997).

Reynolds 2005 P. Reynolds, Levantine Amphorae from Cilicia to Gaza: A Typology and analysis of regional production trends from the 1st to 7th centuries, in: J. M. Gurt Esparraguera − J. Buxeda Garrigós − M. Á. Cau Ontiveros (eds.), LRCW I. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry, BARIntSer 1340 (Oxford 2005) 563–611.

Reynolds 2008 P. Reynolds, Linear Typologies and Ceramic Evolution, FACTA. A Journal of Roman Material Culture Studies 2, 2008, 61–87.

Rice 1991 P. M. Rice, Specialization, Standardization, and Diversity. A Retrospective, in: R. L. Bishop – F. W. Lange (eds.), The Ceramic Legacy of Anna Shepard (Boulder 1991) 257–279.

Rice 2016 C. Rice, Shipwreck Cargoes in the Western Mediterranean and the Organization of Roman Maritime Trade, JRA 29, 1, 2016, 165–192.

Riley 1979/1980 J. Riley, Industrial Standardisation in Cyrenaica During the Second and Third Centuries A.D. The Evidence from Locally Manufactured Pottery, LibSt 11, 1979/1980, 73–78.

Rodríguez 1972 E. Rodríguez Almeida, Novedades de epigrafía anforaria del monte Testaccio. Recherches sur les amphores romaines (Colloque Rome, 1971), CEFR 10 (Rome 1972) 107–241.

Rodríguez 1980 E. Rodríguez Almeida, El monte Testaccio, hoy: Nuevos testimonios epigráficos, in: J. M. Blázquez Martínez (coord.), Producción y comercio del aceite en la Antigüedad. Primer Congreso Internacional (Madrid 1980) 57–102.

Roux 2003	V. Roux, Ceramic Standardization and Intensity of Production. Quantifying Degrees of Specialization, American Antiquity 68, 4, 2003, 768–782.
Roux 2015	V. Roux, Standardization of Ceramic Assemblages: Transmission Mechanisms and Diffusion of Morpho-Functional Traits across Social Boundaries, Journal of Anthropological Archaeology 40, 2015, 1–9.
Roux 2016	V. Roux, Ceramic Manufacture: The chaîne opératoire Approach, in: A. Hunt (ed.), The Oxford Handbook of Archaeological Ceramic Analysis (Oxford 2016) 101–113.
Roux 2020	V. Roux, Chaîne Opératoire, Technological Networks, and Sociological Interpretations, Cuadernos de prehistoria y arqueología de la Universidad de Granada 30, 2020, 15–34.
Santamaría 1995	C. Santamaría, L'épave Dramont E à Saint-Raphaël (V^e siècle ap. J.-C.), Archaeonautica 13 (Paris 1995) 11–198.
Scheidel 2011	W. Scheidel, A Comparative Perspective on the Determinants of the Scale and Productivity of Roman Maritime Trade in the Mediterranean, in: W. V. Harris – K. Iara (eds.), Maritime Technology in the Ancient Economy: Ship-Design and Navigation, JRA Suppl. 84 (Portsmouth, RI 2011) 21–37.
Schreiber 1999	T. Schreiber, Athenian Vase Construction: A Potter's Analysis (Malibu, CA 1999).
Sillar – Tite 2000	B. Sillar – M. S. Tite, The Challenge of ›Technological Choices‹ for Materials Science Approaches in Archaeology, Archaeometry 42, 1, 2000, 2–20.
Sinopoli 1988	C. Sinopoli, The Organization of Craft Production at Vijayanagara, South India, American Anthropologist 90, 3, 1988, 580–597.
Stark 1995	B. Stark, Problems in Analysis of Standardization and Specialization in Pottery, in: B. J. Mills – P. L. Crown, Ceramic Production in the American Southwest (Tucson, AZ 1995) 231–267.
Steinby 1993	M. Steinby, L'organizzazione produttiva dei laterizi: un modello interpretativo per l'instrumentum in genere?, in: W. V. Harris (ed.), The Inscribed Economy. Production and Distribution in the Roman Empire in the Light of Instrumentum Domesticum (Rome, 1992), JRA Suppl. 6 (Ann Arbor, MI 1993) 139–143.
Tchernia 1986	A. Tchernia, Le vin de l'Italie romaine. Essai d'histoire économique d'après les amphores, BEFAR 261 (Rome 1986).
Tchernia 2008	A. Tchernia, Entrepôt et cargaisons complémentaires sur la route du blé d'Alexandrie, in: J. Pérez Ballester – G. Pascual Berlanga (eds.), Comercio, redistribución y fondeaderos. La navegación a vela en el Mediterráneo (Valencia 2008) 57–64.
Tchernia et al.1978	A. Tchernia – P. Pomey – A. Hesnard, L'épave romaine de la Madrague de Giens (Var): Campagnes 1972–1975, Gallia Suppl. 34 (Paris 1978).
Tremoleda – Járrega 2016	J. Tremoleda – J. Járrega, Gauloise 4 (Tarraconensis northern coastal area), Amphora ex Hispania. Landscapes of production and consumption <http://amphorae.icac.cat/amphora/gauloise-4-tarraconensis-northern-coastal-area> (10. 07. 2016).
Unger 2006	R. W. Unger, Investment and Risk: Ship Design and Investment in Port Infrastructure, 1200–1800, in: S. Cavaciocchi (ed.), Ricchezza del mare, ricchezza dal mare, secc. XIII–XVIII; atti delle »Settimane di Studi«, 11–15 aprile 2005, Le Monnier (Prato 2006) 317–342.
van Alfen 1996	P. G. van Alfen, New Light on the 7^th-c. Yassi Ada Shipwreck: Capacities and Standard Sizes of LRA1 Amphoras, JRA 9, 1996, 189–213.
van Doorninck 1989	F. H. van Doorninck, Jr., The Cargo Amphoras on the 7^th Century Yassi Ada and 11^th Century Serçe Limani Shipwrecks: Two Examples of a Reuse of Byzantine Amphoras as Transport Jars, in: V. Déroche – J.-M. Spieser, Recherches sur la céramique byzantine, BCH Suppl. 18 (Athens 1989) 247–257.
van Doorninck 2015a	F. H. van Doorninck, Jr., The Metrology of the Piriform Amphoras from the Eleventh-Century Byzantine Ship at Serçe Limanı: New Designs but an Old System, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (College Station, TX 2015) 35–54.

van Doorninck 2015b F. H. van Doorninck, Jr., The Seventh-Century Byzantine Ship at Yassıada and Her Final Voyage: Present Thoughts, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (College Station, TX 2015) 205–216.

van Doorninck (forthcoming) F. H. van Doorninck, Jr., The Cargo Amphoras on the 7th Century Yassıada and the 11th Century Serçe Limanı Shipwrecks: a Progress Report, TINA Maritime Archaeology Periodical (forthcoming).

Van Oyen – Pitts 2017 A. Van Oyen – M. Pitts (eds.), Materialising Roman Histories (Oxford 2017).

Vaz Pinto et al. 2016 I. Vaz Pinto – R. R. de Almeida – A. Martin (eds.), Lusitanian Amphorae: Production and Distribution, Roman and Late Antique Mediterranean Pottery 10 (Oxford 2016).

Verboven 2002 K. Verboven, The Economy of Friends. Economic Aspects of Amicitia and Patronage in the Late Republic (Bruxelles 2002).

Verboven 2012 K. Verboven, City and Reciprocity: The Role of Cultural Beliefs in the Roman Economy, AnnHistScSoc 67, 4, 2012, 599–627.

Verboven 2015 K. Verboven, The Knights Who Say NIE: Can Neo-institutional Economics Live up to Its Expectation in Ancient History Research?, in: K. Verboven – P. Erdkamp, Structure and Performance in the Roman Economy. Models, Methods and Case Studies, Latomus (Brussels 2015) 33–57.

Virlouvet 1995 C. Virlouvet, Tessera frumentaria: les procédures de distribution du blé public à Rome à la fin de la République et au début de l'empire, BEFAR 296 (Rome 1995).

Vo-Phamhi – Leidwanger 2020 J. Vo-Phamhi – J. Leidwanger, A New Computational Method to Quantify Morphological Standardization and Diversity within Ceramic Assemblages, Archeologia e Calcolatori 31, 1, 2020, 55–76.

Wilson 2011 A. Wilson, The Economic Influence of Developments in Maritime Technology in Antiquity, in: W. V. Harris – K. Iara, Maritime Technology in the Ancient Economy: Ship-Design and Navigation, JRA Suppl. 84 (Portsmouth, RI 2011) 211–233.

Zabehlicky-Scheffenegger 2003 S. Zabehlicky-Scheffenegger, C. Sentius and his commercial Connections, in: C. Abadie-Reynal (ed.), Les céramiques en Anatolie aux époques hellénistiques et romaines. Actes de la Table Ronde d'Istanbul, Varia Anatolica 15 (Istanbul 2003) 117–119.

Zanini 2010 E. Zanini, Forma delle anfore e forme del commercio tardoantico: spunti per una riflessione, in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3. Third International Conference on Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean, Archaeology and Archaeometry, BARIntSer 2185, I (Oxford 2010) 139–148.

Zapassky et al. 2009 E. Zapassky – I. Finkelstein – I. Benenson, Computing Abilities in Antiquity: The Royal Judahite Storage Jars as a Case-Study, Journal of Archaeological Method and Theory 16, 2009, 51–67.

Zapassky et al. 2012 E. Zapassky – Y. Gadot – I. Finkelstein – I. Benenson, An Ancient Relation between Units of Length and Volume Based on a Sphere, PLoS ONE 7.3, 2012, e33895.

John Lund

SPEAKING VOLUMES

ON THE CAPACITIES OF TRANSPORT AMPHORAE FROM THE HELLENISTIC PERIOD THROUGH LATE ANTIQUITY*

Abstract
A good deal of scholarly attention has in recent years been given to the shapes and contents of transport amphorae, but the same cannot be said with regard to their volumes. The aim of the paper is to attempt to remedy this by presenting an overview of the holding capacity of a selection of Roman and Late Antique amphora types as a basis for a discussion of the following issues: 1) How standardized were Greek and Roman amphora capacities?; 2) Did the shape of an amphora reflect its contents?; 3) Was there a correlation between the primary contents of an amphora class and its capacity? It will be argued that ancient amphora capacities were not standardized to the degree that a modern consumer would expect and that it is doubtful that the contents – whether wine or oil – can be reliably deduced from the amphora shape, which rather seems to reflect certain regional patterns in the areas of production. However, the topic is admittedly so fraught with difficulties of a methodological and practical nature that these conclusions may only be regarded as preliminary.

INTRODUCTION

The purpose of this paper is to raise three questions related to the capacities of ancient transport amphorae: 1) How standardized were Greek and Roman amphora capacities?; 2) Did the shape of an amphora reflect its contents?; and 3) Was there a correlation between the primary contents of an amphora class and its capacity? My main focus will be on the Hellenistic, Roman and Late Antique periods, but some earlier evidence will also be touched upon[1].

Each question is fraught with difficulties of a methodological and practical nature, not least concerning the identification of the contents of the ancient amphora classes, even if Tania Panagou, Dario Bernal-Casasola, Michel Bonifay, and others have put our knowledge about this thorny issue on a firmer footing in recent years[2]. It is, moreover, still an open question whether transport amphorae were originally intended for one kind of primary contents or were multipurpose vessels, as suggested by some scholars[3]. The not uncommon reuse of amphorae, in particular at the local level[4], does not make things easier, since scientific residue analyses can rarely if ever distinguish between primary and secondary use. Still, Mark Lawall concluded in his discussion of the »Socio-Economic Conditions and the Contents of Amphorae« that »the primary contents model

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* I wish to thank the editors for astute comments and bibliographical reference and Kathleen W. Slane for information about Late Roman 1 amphorae from Corinth. I am also grateful to Stephen Lumsden for having expertly corrected my English. After the manuscript was submitted, Jaime Molina Vidal and Daniel Mateo Corredor published a study on »The Roman Amphorae Average Capacity«, which comprises calculations of the supposed average capacity of no less than 265 amphora classes including subtypes (Molina – Mateo 2018, 303–308 tab. 1). The authors deal with some of the same issues as this paper, but from a different perspective. Hence, the two contributions complement each other.

1 Only the basic literature is cited for each amphora class. Comprehensive bibliographies may be found in several recent publications, e.g., Bezeczky 2013 and Dobreva 2017, or in the »Roman amphorae: a digital resource« database: <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/> (01. 04. 2023). The fractional versions of transport amphorae are not discussed in this paper.

2 Lund 2004; Bernal-Casasola 2015; Panagou 2016a. See now also Bernal-Casasola et al. 2021.

3 Lawall 2011 with references; Greene – Lawall 2015, 6 f.

4 Lawall 2011, 30–33; Abdelhamid 2013; Peña 2021.

does seem appropriate for the primary use of amphorae from the large scale producers whether in the Greek or in the Roman worlds«[5]. This paper will therefore concentrate on amphorae from some of these ›large-scale producers‹ for which there is scholarly consensus of sorts about their primary contents, in particular on those classes that probably contained wine and olive oil.

STANDARDIZATION OF LIQUID MEASUREMENTS IN CLASSICAL ANTIQUITY

In recent years, scholarly interest in standardization in antiquity has surged[6]. The term has many connotations, as demonstrated by Justin Leidwanger and Horacio González Cesteros in their introduction to this volume. This contribution deals with some of the volumetric aspects of amphora standardization.

The Greek word μετρετές designated »a liquid measure, ʽαμφορεύς«[7], which according to Mabel Lang corresponded to 39.312 liters[8]. But other scholars have converted this measurement to 39.4[9] or 38.8356 liters[10]. We are not better off with the Roman ›quadrantal/amphora‹ measure[11], which Stephanie Martin-Kilcher correlates to 26.0928 liters[12], while others put it at 25.50[13], 26.26[14], or 26.196 liters[15]. Things are not made easier by the possibility that standards could vary from one place to the other and also over time[16], Malcolm Wallace thus observed that the mean capacity of Rhodian amphorae decreased from 27.3 liters between 230 and 200 B.C. to 26.2 liters about 200 B.C. and 25.4 liters about 187 B.C.[17]. The size of some Roman and Late Antique amphora classes also changed over time. Indeed, a new concerted study of the various kinds of evidence (archaeological, inscriptional, and philological) is called for if the discussion about standard liquid measures in antiquity is to be put on a firmer footing, but such an attempt is outside the scope of this contribution.

STANDARD AMPHORA CAPACITIES?

Danish archaeologist Peter Oluf Brøndsted was one of the first scholars to address the issue of how to measure amphora capacities in his pamphlet on Panathenaic amphorae from 1832[18]. His solution was to fill two completely preserved amphorae with grain, which is now usually substituted by sand, rice, lentils, water, or polystyrene beads, the latter of which seems to be most common now. Since we do not know if ancient amphorae were filled all the way to the rim or not, it is important to measure both their ›body capacity‹ and their ›full capacity‹. When both measurements are not included in publications, as is often the case, an element of uncertainty is added. It is, however, not always possible, for practical reasons, to measure the capacity of transport amphorae in this manner, which is why other approaches have been developed[19], based, for instance, on 3D models. The latter have been discussed by Victor Martínez in a paper

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5 Lawall 2011, 32.
6 See, for instance, Wilson 2008; Kotsonas 2014; Greene – Lawall 2015; Lund 2015, 214; van Oyen – Pitts 2017.
7 Liddell – Scott – Jones 1122 s. v. μετρετές. See also Liddell – Scott – Jones 95 s. v. ʽαμφορεύς. See further Mlasowsky 1996; Bentz 1998, 34 f.; Lawall 2000, 10–12; Schulzki 2000; Tiverios 2007, 15 f.
8 Lang 1964, 58; Desantis 2001, 106 fig. 63; Tiverios 2007, 15 n. 92.
9 Schulzki 2000; Ault 2007, 264; Wikander 2008, 762 f. tab. 30. 2.
10 Darton – Clark 1994, 11 s. v. amphora.
11 Lewis – Short 1966, 109 f. s. v. amphora.
12 Martin-Kilcher 1987, 152.
13 Wikander 2008, 763 tab. 30. 2.
14 <http://intarch.ac.uk/journal/issue1/tyers/intro.html> (01. 04. 2023).
15 Darton – Clark 1994, 9 s. v. amphora.
16 As was also the case with weight standards, cf. Tekin 2016, 19–24.
17 Wallace 2004, 430.
18 Brøndsted 1832.
19 For a recent overview of such methods, see Greene – Lawall 2015, 8; Cateloy 2016, 45–47.

on »Volumetric Calculations of Lusitanian Amphora Types« and by Stella Demesticha in her discussion of »Volumetric Analysis and Capacity Measurements of Selected Maritime Transport Containers«[20]. She demonstrates that this method has an element of error of about 5 %[21].

Martin Bentz has observed that the Panathenaic amphorae had a mean capacity of 26.33 liters with a variation of about 8–9 % on either side of this figure[22], and Malcolm Wallace's study of »Standardisation of Greek Amphora Capacities« from 2004 yielded a similar result[23]. He measured a number of Rhodian amphorae and found that the capacities of »twenty-six of these, made by five fabricants in the term of the eponym Pausanias« – i.e., between c. 230 and 200 B.C. – »measured with polystyrene beads, ranged from 25.4 to 29.1 liters (or less than ±8 %)«[24]. He found similar variations in other Hellenistic amphora classes and concluded that »Buying a single jar would take the risk of its being more than 3.5 per cent under standard size about one time in three and being more than 7.0 per cent under about one time in twenty (though as many jars would be over standard)«[25]. Víctor Martínez similarly found great variation in the capacities of 28 Lusitanian Dressel 14 amphorae; their capacities ranged from 23.4 to 49.8 liters with a mean of 34.1 liters. He arrived at a similar range of variation for the Almagro 51C/Keay 23 amphorae[26].

Moving on to Late Antiquity, Peter van Alfen distributed the Late Roman 1 (LR1) amphorae from the 7th-century A.D. Yassıada shipwreck into 11 types[27], of which many had subtypes of their own. He divided the most popular type (I), which accounted for 39 of the 71 amphorae measured, into three subtypes (Ia, Ib, and Ic), each with a different capacity ranging from c. 6.1 (Ia) and c. 7.1 (Ib) to c. 8.2 (Ic) liters. The capacities of the other types clustered around c. 8.3 (Types II–VII) and c. 8.5 liters (Types IIIa–VI) with a »looser grouping of Type IIIb-c jars of c. 9.5 l«[28]. According to van Alfen, this variation does not exclude the possibility that a system of amphora standardization for specific commodities was in place, but he admits that »there is no guarantee that it was always adhered to in using the jars«[29]. He concludes that »the great variety of sizes and capacities in LRA1 amphoras is not easily explained by state regulation or need«, suggesting cautiously that they were due to »consumer-driven marketing practices«[30]. The Late Roman 1 amphorae from the Yassıada wreck are smaller and have a smaller holding capacity than many other Late Roman 1 amphorae. I am grateful to Kathleen Slane for having drawn my attention to five examples from Corinth with capacities between >18 and 36 liters[31]. At Nea Paphos in Cyprus, Late Roman 1 amphorae were produced in three sizes[32].

The evidence thus suggests that the capacities of ancient amphora classes were not standardized to the strict degree that modern consumers would expect[33], though this may have changed

20 Martínez 2016; Demesticha 2017.

21 Demesticha 2017, 174 f. Of the 36 amphorae mainly from the Bronze and Iron Ages thus analyzed, 17 have a capacity below 15 liters, 6 between 15 and 30 liters, and 9 between 30 and 62 liters, cf. Demesticha 2017, 175–182 tab. A.

22 Bentz 1998, 32–34.

23 Wallace 2004.

24 Wallace 2004, 430.

25 Greene – Lawall 2015, 8–12 discuss an even greater range of variation in the capacities of 28 intact amphorae from a wreck at Pabuç Burnu dated to the second quarter of the 6th cent. B.C. For the Thasian amphorae, see now also Tzochev 2016a, 234 f.

26 Martínez 2016, 130–133 fig. 2. In both cases, however, the calculations contain outliers, and the result should be taken with a grain of salt.

27 For the Late Roman 1 type, see Peacock – Williams 1986, 185–187 Class 44; Pieri 2005, 69–84; Bezeczky 2013, 158–160 Type 52; Şenol 2018, 507–509.

28 van Alfen 1996, 192 f. 203. Cf. however, Pieri 2005, 70.

29 See now also van Alfen 2015, 18.

30 van Alfen 1996, 212 f.

31 Personal communication; Bonifay 1986, 300 quotes a figure of 26 liters.

32 Demesticha 2000, 549 f.

33 Thus also Laubenheimer – Gisbert 2001, 39 f; also Laubenheimer in this volume infra, chap. 7; Monachov – Kuznetsova 2017. The same seems to have been the case with the Levantine trade amphorae from the Bronze Age,

in the Late Roman period. In a study that focused on the globular (LR2-type) jars from the same wreck, van Alfen concluded that »it is possible that a conceptual turning point for standardization can be found shortly before the ship sank, which could account for both standardized and non-standardized jars being on the same ship«[34]. Still, approximate standards no doubt existed in the Hellenistic and Roman periods, and Wallace astutely observed that if you acquired a batch of amphorae, the different capacities would largely be evened out because the mean variation of a batch of 100 amphorae »should range on the order of ± one percent«[35]. As observed by Stefanie Martin-Kilcher, few ancient consumers would probably have acquired a whole amphora of wine[36], barring exceptional circumstances[37], and Dyfri Williams has demonstrated that this was also the case in Athens in the Late Archaic and Early Classical periods[38]. Indeed, σηκώματα, stone tables with standard measures of liquids, have been preserved from the ancient world. Such tables were presumably also used as standard measures for wine, although some of the quantities involved are so small that other liquids must have been involved[39]. This leads me to believe that the approximate capacity standards witnessed in, say, Rhodian amphorae may have originated from a desire on the part of the Rhodian state to impose a tax on its wine producers because a standardized measure would be necessary to ensure that they were all treated equally. Indeed, the stamping itself probably also had a fiscal character, according to Yvon Garlan[40].

DID THE SHAPE OF AN AMPHORA CLASS REFLECT ITS CONTENTS?

Andrei Opaiţ has proposed that there was a »link between the amphora shape and its contents,« suggesting that »a vessel with a shorter neck and ovoid or globular body was probably used for olive oil.« He also noted that »an amphora intended specifically for a fish product would either have no neck or a larger truncated conical neck that would not impede the filling and emptying of the vessel with fish sauce or salted fish. Wine amphorae on the contrary seem to have had a narrow and rather longer neck«[41]. Tania Panagou concluded that these assumptions »if used with caution and as a complementary tool, can offer reasonable indications«[42]. It may be observed in passing that some fish amphorae identified by Opaiţ have a wide mouth and hardly any neck[43], but the focus of this contribution is on oil and wine amphorae, and I shall therefore proceed to examine Opaiţ's suggestion that »a vessel with a shorter neck and ovoid or globular body was probably used for olive oil.«

An early example of a globular or ovoid jar is the Corinthian A amphora, which first appeared in the early 7th century B.C. and continued in production until about 300 B.C. Its body is more or less spherical; the neck is broad and flat, and the handles are heavy[44]. Most scholars agree that such amphorae contained olive oil, mainly because they have no resinous coating on the interior,

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cf. Cateloy 2016, in particular 47–52 figs. 4. 5.

34 van Alfen 2015, 30 f. For the 11th cent. A.D., see van Doorninck 2015.

35 Wallace 2004, 430 f.

36 One should not forget, though, that consumers could also acquire smaller quantities of wine in wineskins, Immerwahr 1992, and in the Hellenistic Period in coarse lagynoi, a shape favoured by individual drinkers, cf. Rotroff 1996, 22 and Rotroff 2006, 83–85.

37 Martin-Kilcher 1994, 539 f; Finkielsztejn 2010, 201; Badoud 2017, 10.

38 Williams 2018, 80–83.

39 See, e.g., Finkielsztejn 2010; Cioffi 2014. For the use of the term in papyri, see Mayerson 1998; Mayerson 2001.

40 Garlan 2000, 167–171. The rationale behind the stamping is debated, but the case for the fiscal character is well argued by Badoud, who concludes that it is »certain that the stamping reflected a tax on the production of amphoras«: Badoud 2017, 22. It seems more likely to me, however, that the taxation was directed at the agricultural produce contained in the amphorae, cf. Palaczyk 2017, 237; Börker 2019, 81 f.; Lund 2018.

41 Opaiţ 2007, 101 f.

42 Panagou 2016a, 315.

43 Opaiţ 2007, 102–117.

44 C. G. Koehler, A Brief Typology and Chronology of Corinthian Transport Amphoras <http://projects.chass.utoronto.ca/amphoras/corab92.htm> (30. 12. 2018).

and also because they are manufactured in a fabric similar to blisterware, which is associated with vessels used for oil in Corinth[45].

Corinthian B amphorae were first made about 525 B.C., and production continued into the 2nd century B.C. on Corfu and perhaps also at Corinth. Their shape changed over the centuries. At first it was nearly globular, but by the middle of the 5th century the body became ovoid[46], and it developed into a piriform shape by the 3rd century B.C. Corinthian B amphorae are thought to have primarily contained wine, mainly due to the fact that many are coated on the interior with a resinous substance[47].

The Massaliote amphorae are characterized by a spherical or ovoid body, a short neck, and heavy handles. The earliest examples, i.e., Types 1 to 3 in Guy Bertucchi's classification from 1992, were produced from the second half of the 6th into the 4th century B.C. Wine is thought to have been their primary contents. The resinous coating frequently found on their interior is used as an argument in favor of this theory, together with residue in an amphora found in the Bourse at Marseille. On the other hand, several examples were found to contain olives[48].

The shape of the Brindisi amphorae varied from nearly circular to ovoid. They were produced from the second half of the 2nd century B.C. through the early 1st century A.D. at several places on the south Adriatic coast, of which the best known are the Apani and Giancola workshops in the Brindisi area[49]. Some scholars think that olive oil was the primary contents, but others hold that they could also be used for the transportation of wine[50].

There is little doubt about the contents of the Dressel 20 amphorae that were made in workshops along the Guadalquivir Valley in Andalusia in southern Spain from before the middle of the 1st century A.D. into the middle of the 3rd century. It is generally agreed that this amphora class was exclusively used for olive oil. It has a large globular body with sharply bent or oval handles and a short neck[51].

The Gauloise 4 amphora was produced in Gallia Narbonensis between about A.D. 50 and the end of the 3rd century. It has a small ring base, an ovoid body, a bead rim, and grooved handles. Amphorae of this type are often coated internally, and they carry *dipinti*, which always refer to various kinds of wine (*Aminneum, Picatum, Passum*), and it is therefore generally agreed that they carried wine[52].

Moving on to Late Antiquity, the Late Roman 2 (LR2) amphora type has a broad-bellied, near-globular shape with a short neck and a cup-shaped mouth[53]. It was produced in the Argolid at Kanoupi, between Porto Cheli (ancient Halieis) and Hermioni between the 4th and 7th centu-

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45 Whitbread 1995, 256 f. and passim; Göransson 2007, 82 f.; Sacchetti 2012, 16–24; Pratt 2016, 98–208; Knapp – Demesticha 2017, 140–142; Şenol 2018, 367; <https://amphoras.artsci.utoronto.ca/corab92.htm> (01. 04. 2023).

46 C. G. Koehler, A Brief Typology and Chronology of Corinthian Transport Amphoras; <http://projects.chass.utoronto.ca/amphoras/corab92.htm> (30. 12. 2018).

47 Whitbread 1995, 258–261 and passim; Göransson 2007, 88–114; Sacchetti 2012, 32–38; Knapp – Demesticha 2017, 140–142; Şenol 2018, 367; <https://amphoras.artsci.utoronto.ca/corab92.htm> (01. 04. 2023).

48 Bertucchi 1992, 37–67. 185–191 and passim; Sacchetti 2012, 43–48.

49 Manacorda – Pallecchi 2012; Palazzo 2013; González – Berni 2018, 71–73; Şenol 2018, 260.

50 Peacock – Williams 1986, 82 f. Class 1; Bezeczky 2013, 110–114 Type 28; Carre et al. 2014, 422 n. 20; Carreras et al. 2016; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=51&CFID=0cbafef0-5362-4d13-9247-6d590777103f&CFTOKEN=0> (01. 04. 2023).

51 Peacock – Williams 1986, 136–140 Class 25; Martin-Kilcher 1987; Peña 1999, 86–88; Berni 2008; Bezeczky 2013, 139–142 Type 39; Kingsley et al. 2014; González – Almeida 2017, 55–58; González – Berni 2018, 21–29; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=83&CFID=0cbafef0-5362-4d13-9247-6d590777103f&CFTOKEN=0 (01. 04. 2023).

52 Laubenheimer 1985; Peacock – Williams 1986, 142 f. Class 27; Martin-Kilcher 1994, 358–376 (in part); Bezeczky 2013, 134 f. Type 34; Delbey et al. 2015; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=136> (01. 04. 2023).

53 Munn 1985; Pieri 2005, 90 f.; Diamanti 2010, 75–80; Bădescu 2012, 316–322; Gerousi 2014, 195; Heath et al. 2015; Şenol 2018, 425.

ries A.D.[54]. Dressel 24 *similis* amphorae, which were probably a typological predecessor to the LR2 amphora, were manufactured in kilns at Chios and Erythrai[55], but the latter type was not apparently made here, and other reported kiln sites do not stand up to closer scrutiny[56]. *Tituli picti* show that the Dressel 24 *similis* amphorae were oil containers[57], and Olga Karagiorgou concluded that the available evidence »strongly favours olive oil or olives as the primary content of LR2 [amphorae]« pointing among other things to the fact that LR2 kilns identified in the Peloponnese are situated in an area ideal for the cultivation of olives[58].

Wine amphorae, on the other hand, seem according to Andrei Opaiţ »to have had a narrow and rather longer neck,« longer than that of oil and fish amphorae. This holds true for many Classical and Hellenistic wine amphorae of the Aegean, such as those from Thasos, Chios, Cos, Knidos, and Rhodes[59], as well as for some other classes (Schöne-Mau XXXV, Pseudo-Dressel 2/4, Dressel 30) but not all[60]. Among exceptions to this ›rule‹ are the Gauloise 4, the Late Roman 4 (LR4, ›Gaza‹) amphorae, manufactured on the Palestinian coast[61], and the North African ›amphore globulaire.‹[62]. Dominique Piéri has argued that wine was probably also the principal contents of the bag-shaped Late Roman 5 (LR5) amphorae[63].

This review suggests that some oil amphorae (Corinthian A, Brindisi, Dressel 20, LR2) were indeed globular or ovoid but so were some wine amphorae (Corinthian B, Massaliote, Gauloise 4, and the amphore globulaire). Moreover, other oil amphorae did not have this shape, for example the Tripolitana I and III and the Africana I amphorae, which, according to Michel Bonifay, most likely contained olive oil[64]. Mark Lawall rightly observed that »what is striking about his results is the fact that the Africana types, despite different contents, all share the same general shape and the same basic forms of toe, mouth and rim«[65]. The tentative conclusion to be drawn from this evidence is that making assumptions about the contents of a given amphora class merely based on its shape is hazardous[66].

IS IT POSSIBLE TO ESTABLISH A CORRELATION BETWEEN THE CAPACITY OF AN AMPHORA CLASS AND ITS PRIMARY CONTENTS?

The capacities of the oil and wine amphora classes reviewed above are a natural first step towards investigating whether there was a correlation between the volume of an amphora class and its primary contents.

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54 Munn 1985.

55 Opaiţ – Tsaravopoulos 2011.

56 Reports of production of LR2 amphorae at Reşadıye in the Knidian Peninsula seem in fact to refer to the LR1 type, cf. Tuna et al. 1987, 49, and an alleged kiln site in Chios produced amphorae of the subtype Zeest 70 according to Opaiţ 2004, 11.

57 Opaiţ – Tsaravopoulos 2011.

58 Riley 1981, 117 f. 122; Peacock – Williams 1986, 182–184 Class 43; Karagiorgou 2001; Bezeczky 2013, 153; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/details.cfm?id=239> (01. 04. 2023). However, Pieri 2005, 92 f. opts for wine as the principal contents.

59 Şenol 2018, 357. 359. 369 f. 395 f. 408.

60 For these, see Bonifay 2004, 87–155; Bonifay 2007.

61 Riley 1981, 117 f. 120; Peacock – Williams 1986, 198 f. Class 49; Majcherek 1995; Pieri 2005, 101–114; Freed 2009, 155; Bezeczky 2013, 170–172 Type 57; Şenol 2018, 445 f.; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=16> (01. 04. 2023). Lawall 2011, 23 f. notes that papyrological finds show that LR4 amphorae »are frequently attested as containing not only imported wine, but also imported grapes, olive oil, nuts, olives, honey, cheese, pickles fish products, fruit and meat.«

62 Bonifay – Capelli 2018, 68.

63 Riley 1981, 117 f. 121; Peacock – Williams 1986, 191 Class 46; Lund 1993, 133–135; Pieri 2005, 114–127; Freed 2009, 155; Bezeczky 2013, 171.

64 Bonifay 2007, 87–155. The conclusion is based on the location of the amphora workshops and the absence of an internal resinous coating. See also Woodworth et al. 2015.

65 Lawall 2011, 25.

66 Lawall 2011, 33 is likewise critical of the notion of ›oil shapes‹ and ›wine shapes.‹

As far as oil amphorae are concerned, Carolyn Koehler stated that Corinthian A amphorae »are on the whole much larger than those of other Greek amphora series; in all periods they held various amounts, the smallest about 18 litres, the largest 70, and the majority above 40«[67]. This accords with the recently quoted average capacity of 46.2 liters[68]. A Brindisi amphora found at Ashkelon in Israel holds 54.25 liters, and one in Alexandria has a capacity of 64.36 liters[69]. The measured capacity of the Dressel 20 amphorae varies between 58.50 and 80.50 liters, with a mean of about 69.51 liters[70]. The capacity probably varied over time, and they could – according to *tituli* – contain between 59 and 191 liters »with a plurality receiving 215–16 pounds of oil (ca 78–79 l)«[71]. The capacity of the Tripolitana II–III amphorae is 80–85 liters[72], that of the Africana I class is 35–40 liters[73], and LR2 amphorae contained about 40–45 liters[74]. When the average capacities of these oil amphorae are combined, it emerges that they contained a mean of 56.3 liters, a figure that should of course be taken with a grain of salt due to the many uncertainties involved.

Wine amphorae present a somewhat different picture. The capacity of the Corinthian B amphorae fluctuated between 19.3 and 27.6 liters, but Carolyn Koehler notes that a »certain intended size« of about 25 liters was attained by the early 3rd century B.C.[75]. The capacity of the Massaliote 2b and 3 amphorae varied between c. 15.5 and 28.3 liters, with a mean of 22.4 liters[76]. The Thasian amphorae of types Ia and Ib each held an average of 6.3 and 11.1 liters[77], and the Rhodian ones contained between 25.4 and 27.3 liters[78]. For Knidian amphorae, capacities between 25.2 and 39.95 liters have been reported, with a mean at 34.4 liters[79]. The completely preserved Gauloise 4 amphorae from the kiln site at Sallèles d'Aude had a capacity between 29.9 and 37 liters, with a mean of 33.9 liters[80]. LR4 (Gaza) amphorae of the 5th and early 6th centuries (Pieri type 4B) contained between 24 and 26 liters[81], and the Late Roman 5 amphorae have a standard capacity

67 <https://amphoras.artsci.utoronto.ca/corab92.htm> (01. 04. 2023).

68 Knapp – Demesticha 2017, 141.

69 Barako 2008, 455 Amphora 25; Şenol 2018, 261 no. 220; 262–264 nos. 221–223 have capacities between 35.52 and 43.66 liters.

70 Based on Peacock – Williams 1986, 51–53 tab. 1 with the omission of two small amphorae holding 39 and 45.95 liters each, and Kingsley et al. 2014, 3. According to »Roman Amphorae: a digital resource,« the average capacity is 70–75 liters; <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/index.cfm> (01. 04. 2023).

71 Martin-Kilcher 1987, 54–58. 152–157; Bezeczky 2013, 139–142; van den Berg 2015, 447 with references. The quotation is from Peña 1999, 86. For this issue, see Rodríguez 1984; Rodríguez 1990; Rodríguez 2000; Berni 2008; Aguilera 2012.

72 <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=306> (01. 04. 2023).

73 <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=1> (01. 04. 2023). Auriemma 2000, 27 n. 4 quotes a figure of 43–44 liters; Şenol 2018, 220 no. 185 has a capacity of 37.15 liters.

74 <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=239> (01. 04. 2023) quotes a figure of 40–45 liters. Karagiorgou 2001, 149 states that their capacity is »mainly about 40 litres,« but she also (142) refers to examples at 30 liters.

75 <https://amphoras.artsci.utoronto.ca/corab92.htm> (01. 04. 2023).

76 Bertucchi 1992, 39. 54. 58 f. 62. 64 f.

77 Cf. Bon – Bon 1957, 17–19; Brašinskij 1984, 180–182; Panagou 2016b, 210 and n. 3. See also Tzochev 2016a, 234 f.; Tzochev 2016b.

78 Wallace 2004, 430. The mean capacity for the 11 examples quoted by Brašinskij 1984, 199 f. is 27 liters (disregarding 7 fractional amphorae). See also Monachov 2005, 88–91 and passim.

79 Alpözen et al. 1995, 86. 88 f.; Şenol 2003, 33–38; Şenol 2009, 126–129; Panagou 2016b, 229 n. 3; Şenol 2018, 397 f. According to Dündar 2013, 167: »The capacity of Cnidian amphorae in the 3rd century B.C., of approximately 40 litres, decreases by the end of the 2nd century B.C. to 3 litres, and in the Roman Imperial period, during the 1st–2nd century A.D. was further reduced in capacity to 17 litres.« Cf. <https://amphoras.artsci.utoronto.ca/corab92.htm> (01. 04. 2023).

80 Laubenheimer – Gisbert 2001, 37.

81 Pieri 2005, 105. The earlier type A held between 13 and 16 liters. According to »The Roman Amphorae« website, their capacity was 20–25 liters: <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=16> (01. 04. 2023).

between 20 and 25 liters[82]. The average capacities of these wine amphorae thus varied between 8.3 and 34.4 liters. However, Coan amphorae make up an exception to this ›rule,‹ with a capacity varying between 40.6 and 51 liters and a mean of 44.5 liters[83]. Still, the average capacity for all of the wine amphorae under discussion – including the Coan ones – amounts to only 28.2 liters, about half of the corresponding figure for the oil amphorae. The very same difference is illustrated graphically by the oil and wine amphorae from North Africa, as identified by Michel Bonifay, who did not, I think, factor in the size of the amphorae when he determined their contents[84].

This is not to suggest that all wine amphorae were smaller than all oil amphorae throughout the ancient world and for all periods. The sample analyzed here is evidently too small to allow for such a sweeping conclusion. Other factors may have been involved. For instance, it has been suggested that the capacity of an amphora was determined by the value of its contents; that is, a more valuable commodity would be shipped in a smaller container than a less valuable one[85]. Still, if future research confirms that the capacity of ancient olive oil amphorae was, generally speaking, greater than that of those containing wine, then this may perhaps be explained with reference to olive oil's relatively long ›shelf life‹, a suggestion originally put forward by Olga Karagiorgou in her study of the LR2 amphorae. She observed that »the detrimental impact of oxygen on the flavour and body of the wine« meant that a wine amphora had to be emptied reasonably quickly once its seal had been broken, in contrast to those containing olive oil[86].

CONCLUSION

Ancient amphora capacities were not standardized to the degree that a modern consumer would expect: the capacities within a single class varied between 8 and 10 % or more. However, this inconsistency could be evened out by acquiring a large batch of amphorae, as pointed out by Malcolm Wallace, and it would not be a problem for the everyday consumer who probably bought a carefully measured smaller amount of wine or oil from a retailer. The evidence suggests that oil amphorae did, on the whole, have a larger carrying capacity than wine amphorae[87], which may have had something to do with the longer shelf life of olive oil over wine, once the seal was broken. But it is hard to maintain the notion that the contents – whether wine or oil – of an amphora can be reliably deduced from its shape. It rather seems that this reflected certain regional patterns[88]. Many Archaic East Greek amphorae thus shared a somewhat similar shape[89], and the same holds true for the Hellenistic wine amphorae from the Aegean and also for most of the amphorae produced in Roman North Africa, regardless of their contents[90]. A buyer far from the production area of the amphora would probably not have been aware of such regional patterns, which incidentally supports the notion that the trade in amphorae (or rather their contents) was highly organized and carried out on a well-informed basis.

Due to the many uncertainties involved, these conclusions should all be regarded as preliminary. The only certainty to emerge from this study is that more – indeed many more – volumetric studies of transport amphorae are in order. This contribution has tried to cover most of the Mediterranean over an extended period of time, but the best way to arrive at clearer answers is presumably to abandon a global view in favor of studying the issues at a regional and even local level, which is to a large extent precisely what the present publication is all about.

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82 <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/character.cfm?id=267> (01. 04. 2023).
83 Brašinskij 1984, 201; Alpözen et al. 1995, 96 f.; Şenol 2003, 42 f.; Şenol 2009, 130–132; Panagou 2016b, 210 n. 3.
84 Bonifay 2007 fig. 1.
85 Steckner 1989, 69 f.
86 Karagiorgou 2001, 148 f.
87 Thus, also Molina – Mateo 2018, 308.
88 For examples, see Lawall 2017 and Philis 2019.
89 See Pierre Dupont in: Cook – Dupont 1998, 142–191.
90 See Bonifay 2007, fig. 1.

BIBLIOGRAPHY

Abdelhamid 2013 S. Abdelhamid, Against the throw-away-mentality: The reuse of amphoras in ancient maritime transport, in: H. P. Hahn – H. Weiss (eds.), Mobility, Meaning & Transformations of Things: shifting contexts of material culture through time and space (Oxford 2013) 91–106.

Aguilera 2012 A. Aguilera Martín, La normalisation de l'épigraphie amphorique. Les tituli picti des amphores Dressel 20, in: M. E. Fuchs – R. Sylvestre – C. Schmidt Heidenreich (eds.), Inscriptions mineures. Nouveautés et réflexions. Actes du premier colloque Ductus (19–20 juin 2008, Université de Lausanne) (Bern 2012) 135–143.

Alpözen et al. 1995 T. O. Alpözen – A. H. Özdaz – B. Berkaya, Commercial Amphoras of the Bodrum Museum of Underwater Archaeology. Maritime trade of the Mediterranean in ancient times (Bodrum 1995).

Ault 2007 B. A. Ault, Oikos and Oikonomia: Greek houses, households and the domestic economy, in: R. C. Westgate – N. Fischer – J. Whitley (eds.), Building Communities. House, Settlement and Society in the Aegean and Beyond. Proceedings of a Conference held at Cardiff University, 17–21 April 2001, BSA Studies 15 (London 2007) 259–265.

Auriemma 2000 R. Auriemma, Le anfore del relitto di Grado e il loro contenuto, MEFRA Antiquité 112, 2000, 27–51.

Bădescu 2012 A. Bădescu, Oriental amphorae type LRA 1 and LRA 2 discovered at Histria (the basilica extra muros sector), Pontica 45, 2012, 311–328.

Badoud 2017 N. Badoud, Deciphering Greek Amphora Stamps, CHS Research Bulletin 5, no. 2 <http://research-bulletin.chs.harvard.edu/2017/09/11/amphora-stamps> (01. 04. 2023).

Barako 2008 T. J. Barako, Amphoras Through the Ages, in: L-E. Stager – J. D. Scholoen – D. Ben-Shlomo (eds.), Askhalon 1. Introduction and Overview (1985–2006) (Winona Lake, IN 2008) 429–461.

Bentz 1998 M. Bentz, Panathenäische Preisamphoren. Eine athenische Vasengattung und ihre Funktion vom 6.–4. Jahrhundert v. Chr, AntK Beih. 18 (Basel 1998).

Bernal-Casasola 2015 D. Bernal-Casasola, What Contents Do We Characterise in Roman Amphorae? Methodological and Archaeological Thoughts on a ›Trending Topic‹, in: C. Oliveira – R. Morais – A. Morillo (eds.), Archaeoanalytics. Chromatography and DNA analysis in archaeology. International Symposium (Porto 2015) 61–83.

Bernal-Casasola 2021 D. Bernal-Casasola – M. Bonifay – M. Pecci et al. (eds.), Roman Amphora Contents. Reflecting on the Maritime Trade of Foodstuffs in Antiquity. In Honour of Miguel Beltrán Lloris. Proceedings of the Roman Amphora Contents International Interactive Conference (RACIIC) (Cadiz, 5–7 October 2015), Roman and Late Antique Mediterranean Pottery 17 (Oxford 2021).

Berni 2008 P. Berni Millet, Epigrafía anfórica de la Bética. Nuevas formas de análisis, Instrumenta 29 (Barcelona 2008).

Bertucchi 1992 G. Bertucchi, Les amphores et le vin de Marseille VI^{e} s. avant J.-C.-II^{e} s. après J.-C., RANarb Suppl. 25 (Paris 1992).

Bezeczky 2013 T. Bezeczky, The Amphorae of Roman Ephesus, FiE 15, 1 (Vienna 2013).

Börker 2019 C. Börker, Der ΕΡΓΑΣΤΗΡΙΑΡΧΗΣ und die rhodischen Amphorenstempel, ZPE 209, 2018, 78–90.

Bon – Bon 1957 A.-M. Bon – A. Bon, Les timbres amphoriques de Thasos, Études thasiennes 4 (Paris 1957).

Bonifay 1986 M. Bonifay, Observations sur les amphores tardives à Marseille d'après les fouilles de la Bourse (1980–1984), RANarb 19, 1986, 269–301.

Bonifay 2004 M. Bonifay, Etudes sur la céramique romaine tardive d'Afrique, BARIntSer 1301 (Oxford 2004).

Bonifay 2007 M. Bonifay, Que transportaient donc les amphores africaines? Annexe: Analyse du contenu d'amphores africaines, in: E. Papi (ed.), Supplying Rome and the empire. The Proceedings of an international seminar held at Siena-Certosa di Pontignano on May 2–4, 2004 on Rome, the provinces, production and distribution, JRS Suppl. 69 (Portsmouth, RI 2007) 8–31.

Bonifay – Capelli 2018	M. Bonifay – C. Capelli, Observations archéologiques et archéométriques sur les amphores globulaires de l'Afrique byzantine, in: R. M. Carra Bonacasa – E.Vitale (eds.), Studi in memoria di Fabiola Ardizzone 3. Ceramica, Quaderni Digitali di Archeologia Postclassica (Palermo 2018) 61–74.
Brašinskij 1984	I. B. Brašinskij, Metody issledovanija antičnoj torgovli na primere severnogo Pričernomor'ja (Leningrad 1984).
Brøndsted 1832	P. O. Brøndsted, On Panathenaic Vases and on the Holy Oil Contained in Them; with Particular Reference to some Vases of that Description now in London: Letter Addressed to W. R. Hamilton, Esq. (London 1832).
Carlson et al. 2015	D. N. Carlson – J. Leidwanger – S. M. Kampbell (eds.), Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey, Ed Rachal Foundation Nautical Archaeology Series (College Station 2015).
Carre et al. 2014	M.-B. Carre – P. Monsieur – S. P. Mattioli, Transport amphorae Lamboglia 2 and Dressel 6A: Italy and/or Dalmatia? Some clarifications, JRA 27, 2014, 417–428.
Carreras et al. 2016	C. Carreras Monfort – A. Martín Menéndez – J. Pera Isern – E. Rodrigo Requena, Las Ánforas de Brindisi en La Hispania Citerior. Pautas de Distribución y Consumo Brindisi/Amphorae in the Hispania Citerior Province. Patterns of Distribution and Consumption, Saguntum 48, 2016, 103–121.
Cateloy 2016	C. Cateloy, Trade and capacity studies in the eastern Mediterranean: the first Levantine trade amphorae, in: Demesticha – Knapp 2016, 30–55.
Cioffi 2014	C. Cioffi, Documenting, measuring and integrating sekomata. An example from Naxos, in: La mesure et ses usages dans l'antiquité. La documentation archéologique, Journée d'études de la Société française d'archéologie classique, 17 mars 2012 (Besançon 2014) 41–56.
Cook – Dupont 1998	R. M. Cook – P. Dupont, East Greek Pottery (London 1998).
Darton – Clark 1994	M. Darton – J. Clark, The Dent Dictionary of Measurement. A unique dictionary of units, quantification and measurement (London 1994).
Delbey et al. 2015	T. Delbey – A. Quevedo – F. Laubenheimer, Amphores vinaires Gauloise 4 de Narbonnaise (France) exportées à Carthagène (Espagne)? Analyse statistique exploratoire multidimensionnelle de données géochimiques, ArcheoSciences, RArcheom 39, 2015, 185–199.
Demesticha 2000	S. Demesticha, The Paphos Kiln: Manufacturing Techniques of LR1 Amphoras, ReiCretActa 36, 2000, 549–554.
Demesticha 2017	S. Demesticha, Appendix: Volumetric Analysis and Capacity Measurements of Selected MTCs, in: Knapp – Demesticha 2017, 172–184.
Demesticha – Knapp 2016	S. Demesticha – A. B. Knapp (eds.), Maritime Transport Containers in the Bronze–Iron Age Aegean and Eastern Mediterranean, SIMA 183 (Uppsala 2016).
Desantis 2001	P. Desantis, Le anfore commerciali e le misure di capacità in Etruria Padana, in: G. Luppi (ed.), Pondera. Pesi e Misure nell'Antichità. Campogalliano (Modena 2001) 103–110.
Diamanti 2010	C. Diamanti, Local Production and Import of Amphoras at Halasarna of Kos Island (5^{th}–7^{th} c.) (Athens 2010).
Dobreva 2017	D. Dobreva, Tra oriente e occidente. Dinamiche commerciali in Moesia Inferior e Thracia in epoca romana: i dati delle anfore, Antenor Quaderni 42 (Rome 2017).
Dündar 2013	E. Dündar, Remarks on the Possible Uses of a Late Cnidian Stamped Amphora from Patara, Adalya 16, 2013, 167–175.
Finkielsztejn 2010	G. Finkielsztejn, The *Sekoma*: A Volume Standard for Liquids, in: A. Kloner – E. Eshel – H. B. Korzakova – G. Finkielsztejn (eds.), Maresha Excavations Final report III. Epigraphic finds from the 1989–2000 Seasons, IAA Reports 45 (Jerusalem 2010) 193–203.
Freed 2009	J. Freed, The burial amphoras, in: S. T. Stevens – M. B. Garrison – J. Freed, A Cemetery of Vandalic Date at Carthage, JRA Suppl. 75 (Porthsmouth, RI 2009) 127–172.

Garlan 2000 — Y. Garlan, Amphores et timbres amphoriques grecs: entre érudition et idéologie (Paris 2000).

Gerousi 2014 — E. Gerousi, A Late Roman Workshop at Dilesi in Boeotia, in: N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4: Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean Archaeology and archaeometry The Mediterranean: a market without frontiers Volume I, BARIntSer 2616 (Oxford 2014) 193–202.

González – Berni 2018 — H. González Cesteros – P. Berni Millet, Roman Amphorae in Neuss. Augustan to Julio-Claudian Contexts, Roman and Late Antique Mediterranean Pottery 12 (Oxford 2018).

González – Almeida 2017 — H. González Cesteros – R. R. de Almeida, Las ánforas de aceite de oliva béticas. De las Oberaden 83 hasta las Dressel 20 en el Kops Plateau de Nimega, in: C. Carreras Monfort – J. van den Berg (eds.), Amphorae from the Kops Plateau (Nijmegen). Trade and supply to the lower-Rhineland from the Augustan period to A.D. 69–70, Archaeopress Roman Archaeology 20 (Oxford 2017) 47–60.

Göransson 2007 — K. Göransson, The Transport Amphorae from Euesperides. The maritime trade of a Cyrenaican city 400–250 BC (Lund 2007).

Greene – Lawall 2015 — E. S. Greene – M. L. Lawall, Amphora standardization and economic activity, in: Carlson et al. 2015, 1–16.

Heath et al. 2015 — S. Heath – J. L. Rife – J. J. Bravo III – G. Blasdel, Preliminary Report on Early Byzantine Pottery from a Building Complex at Kenchreai (Greece), ISAW Papers 10; DOI: 2333.1/q83bk6k7; <http://dlib.nyu.edu/awdl/isaw/isaw-papers/10/> (01. 04. 2023).

Immerwahr 1992 — H. R. Immerwahr, New Wine in Ancient Wineskins: The Evidence from Attic Vases, Hesperia 61, 1992, 121–132.

Karagiorgou 2001 — O. Karagiorgou, LR2: a Container for the Military *annona* on the Danubian Border?, in: S. Kingsley – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity. Proceedings of a Conference at Sommerville College, Oxford, 29th May, 1999 (Oxford 2001) 129–166.

Kingsley et al. 2014 — S. A. Kingsley – M. J. Decker – E. Gerth, Rome in Spain, Spain in the Americas: Amphoras, Olive Jars & the Economics of Long-Distance Trade, Odyssey Papers 42 (London 2014).

Knapp – Demesticha 2017 — A. B. Knapp – S. Demesticha, Mediterranean Connections. Maritime Transport Containers and Seaborne Trade in the Bronze and Early Iron Ages (New York 2017).

Kotsonas 2014 — E. Kotsonas (ed.), Understanding Standardization and Variation in Mediterranean Ceramics Mid 2nd to Late 1st Millennium BC, BABesch Suppl. 25 (Leuven 2014).

Lang 1964 — M. Lang, Weights and Measures, in: M. Lang – M. Crosby, Weights, Measures and Tokens, Agora 10 (Princeton, NJ 1964) vi–68.

Laubenheimer 1985 — F. Laubenheimer, La production des amphores en Gaule Narbonnaise sous le Haut-Empire, Annales littéraires de l'Université de Besançon 327 (Paris 1985).

Laubenheimer – Gisbert 2001 — F. Laubenheimer – J. A. Gisbert Santonja, La standardisation des amphores Gauloise 4 des ateliers de Narbonnaise à la production de Denia (Espagne), in: F. Laubenheimer (ed.), 20 ans de recherches à Sallèles d'Aude (Besançon 2001) 33–50.

Lawall 2000 — M. L. Lawall, Graffiti, Wine Selling, and the Reuse of Amphoras in the Athenian Agora, ca. 430 to 400 B.C., Hesperia 69, 2000, 3–90.

Lawall 2011 — M. L. Lawall, Socio-Economic Conditions and the Contents of Amphorae, in: C. Tzochev – T. Stoyanov – A. Bozkova (eds.), PATABS II. Production and Trade of Amphorae in the Black Sea, Acts of the International Round Table held in Kiten, Nessebar and Sredetz, September 26–30, 2007 (Sofia 2011) 23–33.

Lawall 2017 — M. Lawall, Regional Styles of Transport Amphora Production in The Archaic Aegean, in: S. Handberg – A. Gadolou (eds.), Material Koinai in the Greek Early Iron Age and Archaic Period. Acts of an International Conference at the Danish Institute at Athens, 30 January – 1 February 2015, Monographs of the Danish Institute at Athens (Athens 2017) 289–311.

Lewis – Short 1966 — C. T. Lewis – C. Short, A Latin Dictionary Founded on Andrew's Edition of Freund's Latin Dictionary (Oxford 1966).

Lund 1993 J. Lund, Pottery of the Classical, Hellenistic and Roman Periods, in: L. Wriedt Sørensen – D. W. Rupp (eds.), The Land of the Paphian Aphrodite II. The Canadian Palaipaphos Survey Project Artifact and Ecofactual Studies, SIMA 104, 2 (Göteborg 1993) 79–155.

Lund 2004 J. Lund, Oil on the Waters? Reflections on the Contents of Hellenistic Transport Amphorae from the Aegean, in: J. Eiring – J. Lund (eds.), Transport Amphorae and Trade in the Eastern Mediterranean. Acts of the International Colloquium at the Danish Institute at Athens, September 26–29, Monographs of the Danish Institute at Athens 5 (Aarhus 2004) 211–216.

Lund 2015 J. Lund, A Study of the Circulation of Pottery in Cyprus from the 3rd century BC to the 3rd century AD, Gösta Enbom Monograph Series 5 (Copenhagen 2015).

Lund 2018 J. Lund, A note on the so-called fabricants of Knidian amphorae, Skyllis 18, 2018, 79–84.

Majcherek 1995 G. Majcherek, Gazan Amphorae: Typology Reconsidered, in: H. Meyza – J. Młynarczyk (eds.), Hellenistic and Roman Pottery in the Eastern Mediterranean. Advances in Scientific Studies, Acts of the II Nieborów Pottery Workshop. Nieborów, 18–20 December 1993 (Warsaw 1995) 163–178.

Manacorda – Pallecchi 2012 D. Manacorda – S. Pallecchi, Le fornaci romane di Giancola (Brindisi), Bibliotheca archaeologica. Collana di archeologia 27 (Bari 2012).

Martin-Kilcher 1987 S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte, I. Die südspanischen Ölamphoren (Gruppe 1), FiA 7, 1 (Augst 1987).

Martin-Kilcher 1994 S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte, II. Die Amphoren für Wein, Fischsauce, Südfrüchte (Gruppen 2–24) und Gesamtauswertung, FiA 7, 2 (Augst 1994).

Martinez 2016 V. Martinez, Do We Have the Capacity to Understand the Economy of Lusitanian Commodities? Volumetric Calculations of Lusitanian Amphora Types, in: I. Vaz Pinto – R. R. de Almeida – A. Martin (eds.), Lusitanian Amphorae: Production and Distribution, Roman and Late Antique Mediterranean Pottery 10 (Oxford 2016) 129–136.

Mayerson 1998 P. Mayerson, The Sack (Cάκκος) Is the Artaba Writ Large, ZPE 122, 1998, 189–194.

Mayerson 2001 P. Mayerson, Sekomata: Measures of Wine, not Jars, BAmSocP 38, 2001, 97–101.

Mlasowsky 1996 DNP I (1996) 626 s. v. Amphora [2, Hohlmaß] (A. Mlasowsky).

Molina – Mateo 2018 J. Molina Vidal – D. Mateo Corredor, The Roman Amphorae Average Capacity (AC), OxfJA 37, 2018, 299–311.

Monachov 2005 S. I. Monachov, Rhodian Amphoras. Developments in Form and Measurements, in: V. Stolba – L. Hannestad (eds.), Chronologies of the Black Sea Area in the Period c. 400–100 B.C., Black Sea Studies 3 (Aarhus 2005) 69–95.

Monachov – Kuznetsova 2017 S. I. Monachov – E. V. Kuznetsova, Overseas Trade in the Black Sea Region from the Archaic to the Hellenistic Period, in: V. Kozlovskaya (ed.), The Northern Black Sea in Antiquity. Networks, Connectivity, and Cultural Interactions (Cambridge 2017) 59–99.

Munn 1985 M. L. Z. Munn, A late Roman kiln site in Hermionid Greece, AJA 89, 1985, 342–343.

Oleson 2008 J. P. Oleson (ed.), The Oxford Handbook of Engeneering and Technology in the Classical World (Oxford 2008).

Opaiţ 2004 A. Opaiţ, Local and Imported Ceramics in the Roman Province of Scythia (4th–6th centuries AD), BARIntSer 1274 (Oxford 2004).

Opaiţ 2007 A. Opaiţ, Weighty Matter: Pontic Fish Amphorae, in: V. Gabrielsen – J. Lund (eds.), The Black Sea in Antiquity. Regional and Interregional Economic Exchanges, Black Sea Studies 6 (Aarhus 2007) 101–121.

Opaiţ – Tsaravopoulos 2011 A. Opaiţ – A. Tsaravopoulos, Amphorae of Dressel 24 similis type in the central Aegean area (Chios-Erythrai-Kyme), BSA 106, 2011, 275–326.

Palaczyk 2017	M. Palaczyk, Gab es Verbreitungsmuster der rhodischen »Fabrikantenstempel«?, in: L. Cappuccini – C. Leypold – M. Mohr (eds.), Fragmenta Mediterranea. Contatti, tradizioni, e innovazioni in Grecia, Magna Grecia e Etruria. Studi in onore di Christoph Reusser (Florence 2017) 231–240.
Palazzo 2013	P. Palazzo, Le anfore di Apana (Brindisi) (Rome 2013).
Panagou 2016a	T. Panagou, Transport Amphorae and their Contents, in: M. Giannopoulou – Ch. Kallini (eds.), ἠχάδιν: Τιμητικός τόμος για τη Στέλλα Δρούγου (Athens 2016) 312–334.
Panagou 2016b	T. Panagou, Patterns of Amphora Stamp Distribution: Tracking Down Export Tendencies, in: E. M. Harris – D. M. Lewis – M. Woolmer (eds.), The Ancient Greek Economy: Markets, Households and City-States (Cambridge 2016) 207–229.
Peacock – Williams 1986	D. P. S. Peacock – D. F. Williams, Amphorae and the Roman Economy: An Introductory Guide (London 1986).
Peña 1999	J. T. Peña, The Urban Economy during the Early Dominate, BARIntSer 784 (Oxford 1999).
Peña 2021	J. T. Peña, The reuse of transport amphoras as packaging containers in the Roman world: an overview, in: Bernal-Casasola 2021, 77–79.
Philis 2017	K. Philis, Τα τοπικά εργαστήρια και οι εισαγωγές εμπορικών αμφορέων στο Βόρειο Αιγαίο στους κλασικούς χρόνους. Εμπορικά δίκτυα και αγορές καταναλωτικών αγαθών, in: E. Manakidou – A. Avramidou (eds.), Classical Pottery of the Northern Aegean and its Periphery (480–323/300 BC). Proceedings of the International Archaeological Conference Thessaloniki, May 17–20, 2017 (Thessaloniki 2017) 243–261.
Pieri 2005	D. Pieri, Le commerce du vin oriental à l'époque byzantine (V^e^–VII^e^ siècles). Le témoignage des amphores en Gaule, Bibliothèque archèologique et historique 174 (Beyrouth 2005).
Pratt 2016	C. E. Pratt, Greek commodities moving west: comparing Corinthan and Athenian amphorae in early Archaic Sicily, in: Demesticha – Knapp 2016, 195–213.
Riley 1981	J. A. Riley, The Pottery from the Cisterns 1977.1, 1977.2 and 1977.3, in: J. H. Humphrey (ed.), Excavations at Carthage Conducted by the University of Michigan 6 (Ann Arbor, MI 1981) 85–124.
Rodríguez 1984	E. Rodríguez Almeida, Il Monte Testaccio: ambiente, storia, materiali (Rome 1984).
Rodríguez 1990	E. Rodríguez Almeida, Revisitando el Testaccio, Pact 27, 1990, 369–390.
Rodríguez 2000	E. Rodríguez Almeida, El Monte Testaccio, ayer, hoy y mañana, in: D. Bernal-Casasola – E. García Vargas (eds.), Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el imperio romano (Sevilla y Écija, 1998), Actas IV (Écija 2001) 1279–1302.
Rotroff 1996	S. I. Rotroff, The Missing Krater and the Hellenstic Symposium. Drinking in the Age of Alexander the Great, Broadhead Classical Lecture 7 (Christchurch 1996).
Rotroff 2006	S. I. Rotroff, Hellenistic Pottery, Athenian Agora 23 (Princeton, NJ 2006).
Sacchetti 2012	F. Saccheti, Les amphores grecques dans le nord de l'Italie. Échanges commerciaux entre les Apennins et les Alpes aux époques archaïque et classique, Bibliothèque d'Archéologie méditerranéenne et africaine 10 (Aix-en-Provence 2012).
Schulzki 2000	DNP VIII (2000) 109 s. v. Metretes (H. J. Schulzki).
Şenol 2003	A. K. Şenol, Marmaris Müzesi Ticari Amphoraları (Ankara 2003).
Şenol 2009	A. K. Şenol, Taşucu Arslan Eyce Amphora Müzesi (Silifke 2009).
Şenol 2018	A. K. Şenol, Commercial amphorae in the Graeco-Roman Museum of Alexandria, Études Alexandrines 44 (Alexandria 2018).
Steckner 1989	C. Steckner, Les amphores LR1 et LR2 en relation avec le pressoir du complexe ecclésiastique des thermes de Samos. Relation entre forme et fonction d'un vase en tant que récipient d'un contenu spécifique. Examen par ordinateur et expérimentation, in: V. Déroche – J.-M. Spieser (eds.), Recherches sur la céramique Byzantine, BCH Suppl. 18 (Athènes 1989) 57–71.

Tekin 2016 — O. Tekin, Balance Weights in the Aegean World. Classical and Hellenistic Periods (Istanbul 2016).

Tiverios 2007 — M. Tiverios, Panathenaic Amphoras, in: O. Palagia – O. Choremi-Spetsieri (eds.), The Panathenaic Games. Proceedings of an international conference held at the University of Athens, May 11–12, 2004 (Oxford 2007) 1–19.

Tuna et al. 1987 — N. Tuna – J.-Y. Empereur – M. Picon – E. Döger, Rapport préliminaire de la prospection archéologique Turco-Française des ateliers d'amphores de Reşadıye-Kılıseyani, sur la péninsule de Datça (15 Juillet–3 Août 1986), Anatolia Antiqua 6, 1987, 47–52.

Tzochev 2016a — C. Tzochev, Markets, amphora trade and wine industry, in: E. M. Harris – D. M. Lewis – M. Woolmer (eds.), The ancient Greek economy. Markets, households and city-states (Cambridge 2016) 230–253.

Tzochev 2016b — C. Tzochev, Amphora Stamps from Thasos, Agora 37 (Princeton, NJ 2016).

van Alfen 1996 — P. G. van Alfen, New light on the 7th-c. Yassi Ada shipwreck: capacities and standard sizes of LRA1 amphoras, JRA 9, 1996, 189–213.

van Alfen 2015 — P. G. van Alfen, The Restudy of the LR2 Amphoras from the Seventh-Century Yassıada Shipwreck Preliminary Evidence for Standardization, in: Carlson et al. 2015, 17–34.

van den Berg 2015 — J. van den Berg, An Amphora on a River Barge: a revised dating of Druten 1, Netherlands, IntJNautA 44, 2015, 446–450.

van Doorninck 2015 — F. H. van Doorninck, Jr., The Metrology of the Piriform Amphoras from the Eleventh-Century Byzantine Ship at Serçe Limanı: New Designs but an Old System, in: Carlson et al. 2015, 35–54.

van Oyen – Pitts 2017 — A. van Oyen – M. Pitts (eds.) Materialising Roman Histories (Oxford 2017).

Wallace 2004 — M. Wallace, Standardization in Greek Amphora Capacities, in: J. Eiring – J. Lund (eds.), Transport amphorae and trade in the eastern Mediterranean, Monographs of the Danish Institute at Athens 5 (Aarhus 2004) 429–431.

Whitbread 1995 — I. K. Whitbread, Greek Transport Amphorae. A Petrological and Archaeological Study, The British School at Athens Fitch Laboratory Occasional Paper 4 (Exeter 1995).

Wikander 2008 — C. Wikander, Technologies of Calculation, in: Oleson 2008, 759–769.

Williams 2018 — D. Williams, A Dourian *geustērion*: scenes of wine production and sale on Athenian vases, BABesch 93, 2018, 75–92.

Wilson 2008 — A. Wilson, Large-Scale Manufacturing, Standardization, and Trade, in: Oleson 2008, 393–417.

Woodworth et al. 2015 — J. Woodworth – D. Bernal-Casasola – M. Bonifay – D. De Vos – N. Garnier – S. Keay – A. Pecci – J. Poblome – M. Pollard – F. Richez – A. Wilson, The content of African Keay 25/Africana 3 amphorae: initial results of the CORONAM project, in: C. Oliveira – R. Morais – A. Morillo Cerdán (eds.), ArchaeoAnalytics. Chromatography and DNA Analysis in Archaeology (Esposende 2015) 41–57.

THE WESTERN MEDITERRANEAN

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TYPOLOGICAL FEATURES AND CAPACITY STANDARDS IN TRANSITION

THE AMPHORAE OF CÁDIZ BAY (SOUTHERN IBERIA) IN THE 1ST MILLENNIUM B.C.

Abstract

The study of the evolution of the shape and capacity standards of transport amphorae and their historical implications has a very limited historiographical background in the case of the Phoenician-Punic sphere. These shortcomings are notably accentuated in the case of the port cities of the ›Far West‹ and the Atlantic, in which this line of research has hardly been explored to date. Thus far, scholarship has focused more on the metrology of weights and their relationship with the specific practices of pre-monetary economies as well as on the connection of official weight systems (usually linked to Levantine standards) with the initial stages of the Iberian mints.

The topic that motivates this work is therefore very complex. Hence, its purpose is not to provide conclusive explanations but to try to shed light on the general from the specific, from the west to the east. We focus on the case of the production of amphorae in the city of Gadir/Gades throughout the 1st millennium B.C. In this approach to the case of the Bay of Cádiz (southwest of Iberia), we use a comprehensive dataset resulting from decades of fieldwork along with detailed analysis of local ceramic workshops (kilns, land planning, etc.) and the production of amphorae (typology, fabrics, raw material catchment areas, etc.). All this is combined with the use of digital methods and experimental archaeology to examine the average capacity of each local type or series. The exponential growth of archaeological data in the last two decades has allowed us to define the main characteristics of local amphora series, their manufacturing processes, and the standardization of both shapes and capacity patterns since at least the 6th century B.C. We propose a Levantine origin of the typologies and metric systems that were followed to create the designs of these amphorae, and we also discuss their evolution over more than five hundred years and the changes (both subtle but significant) observed in both aspects since the Roman conquest of the area in 206 B.C.

The available information on the metric standards of weight and volume in the Levant, and in other areas of Iberia itself and the western Mediterranean, connect the local traditions with others of the so-called Phoenician-Punic world. Particularly noteworthy are the changes that took place at the end of the Iron Age with the arrival of Carthage and Rome to the region. The comparison of our results with those obtained in other key related areas, such as Ibiza, Málaga, or the main river regions of Turdetania, suggests the existence of differentiated trends, locally and regionally, which correspond to the previously observed divergences in the metric (weight) systems of the Punic mints of the 4th–2nd century B.C.

INTRODUCTION

The study of the evolution of formal and capacity standards of transport amphorae and their historical implications has been the subject of numerous investigations in the Classical Greek world and in other cultural spheres of the ancient Mediterranean for decades[1] but has a more limited historiographical trajectory in the Phoenician-Punic world. This discrepancy is remarkably pronounced in the case of the port cities of the ›Far West‹, where this line of research has been barely explored to date on either amphorae[2] or other ceramic groups (finewares, kitchenware[3], etc.). For the moment, academic attention has focused more on the metrology of balance weights

1 In particular, on the Classical and Hellenistic Greek World, and Roman amphorae, see Grace 1961; Wallace – Wallace 1982; Wallace 1986; Koehler – Wallace 1987.
2 Ramon 1991; Docter 1992; Sáez – Moreno 2017; García – Sáez 2018.
3 A first approach to the case of Gadir in: Sáez – Belizón 2020.

and their relationship with metal hoards likely for pre-monetary exchange, and on the connection of weight-measurement systems (apparently linked to Levantine standards) to the initial stages of peninsular coinages.

The topic that motivates this work is therefore very complex, with extensive eastward and westward ramifications; it is also part of historical intercultural interaction developed over an equally long period that has been the subject of a large number of previous investigations. As a result, the aim of this work is not to provide definitive solutions to many of the questions still open on these issues but to try to shed light on the general from the particular, from the west to the east. To achieve this goal, we will focus on the case of the city of Gadir/Gades throughout the 1st millennium B.C., trying to decode – thanks to an exponential growth of data in the last two decades – the main characteristics of the local amphora series and the standardization of both shapes and capacity patterns. We will examine the Levantine origin of both the typologies and the metric systems followed to create their designs, their evolution over the course of more than five hundred years, and the changes observed in both aspects following the Roman conquest of the area in 206 B.C.

This approach to the case of the Bay of Cádiz will make use of an extensive data set that results from decades of fieldwork and in-depth analyses of the local ceramic workshops[4] and amphora production[5], which will be combined with the use of digital tools and experimental archaeology to examine the average capacity of each local type or series. The available information on the metric standards of weight and volume in the Levant, and in Iberia itself and the broader Mediterranean west, will also help to connect both worlds and to verify the continuities and turning points, especially regarding the changes that occurred at the end of the Iron Age. Finally, we will discuss some significant historical inferences by comparing our results with those obtained in other related areas, such as Ibiza, Málaga, and the main fluvial regions of Turdetania.

A LEVANTINE PERSPECTIVE: CAPACITY STANDARDS AND AMPHORAE

Before examining the case of Gadir/Gades, it is necessary to look back in time to review the data available for the Levant and also to pay attention to previous research on amphora typologies and capacities developed since the early 20th century in a few key sites of the Phoenician motherland and the eastern Mediterranean. This review of the eastern evidence will be important for tracing the origins of the profiles of the Phoenician-Punic amphorae from the western colonies and cities and the standards of capacity and technical criteria that guided their initial design and evolution until their integration into the Roman world.

The early stages of the process can be traced in the Levantine and Phoenician cities of the Late Bronze Age, a time when formal schemes seem to be fixed and there is an initial internationalization of the ›languages‹ of weight and capacity[6] as well as a significant growth in maritime trade in products packaged in amphorae. It was Virginia Grace[7] who first identified the ›Canaanite amphorae‹ as the earliest examples of amphora production and standardization and linked them to the ancient wine trade along maritime routes. She underlined the importance of Egyptian and Ugaritic finds for the 3rd–2nd millennium B.C., identified the presence of these amphorae in the pre-Classical Greek area, taking into account individual finds at sites such as Menidi and Mycenae, and suggested the connection between Near Eastern measurement systems and pre-Classical Greek systems. It is also worth noting the important quantities of the type found in key Levantine sites such during the French excavations in the 1920s and 1930s at the port of Ugarit[8].

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4 Muñoz – De Frutos 2006; Ramon et al. 2007; Sáez 2008; Sáez 2014a.

5 Ramon 2004; Sáez et al. 2014; Sáez 2018a; García – Sáez 2019.

6 An open debate in the western Mediterranean that has recently been the subject of several summaries; see Poigt 2018; Ialongo 2018; Pappa 2019; Poigt 2019; Ialongo – Rahmstorf 2019.

7 Grace 1956.

8 Sauvage 2006.

The presence of Canaanite amphorae in the Aegean, Crete, and Cyprus is already well known, but the discovery and excavation of the Uluburun shipwreck along the southern coast of Turkey in the 1980s and early 1990s confirmed that these amphorae were a main commercial tool linking the Levantine coast, southern Anatolia, the Aegean Islands, and the Greek mainland[9]. Some researchers have tried in the last decades to establish the capacity standards of the Canaanite amphora using both archaeological data[10] and the valuable information provided by the archives of sites such as Mari or Ugarit[11]. Most of these proposals have focused on the connection with the Biblical or Classical standard measures and have assumed that the ancient amphora capacities in the Near East and the Levant should refer to large vessels of around 25 liters or more (even 50 liters); some authors, though, have argued that the main Late Bronze Age (and Early Iron Age) capacity unit and its related standardized container had around half of this volume[12]. In any case, it is widely asserted that the first attempts to standardize the capacities of wine amphorae were developed in this area during the 2nd millennium B.C.[13].

Cross-checking textual and archaeological information seems to confirm this idea. For example, after examining both the available Ugaritic written sources and the archaeological data for size[14], it was suggested that the term *kd* (*kaddu*) was both the Ugaritic word (and then the Phoenician one) for amphora as well as a standardized unit of measure used regularly by the Ugaritic scribes. Consequently, the unit (mostly used to measure quantities of wine and olive oil) had to be born from – or in any case be related to – the extended use of some type of standardized vessels. The most common container in the city used to store and transport the kinds of goods attested in the Ugaritic administrative texts was the Canaanite amphora. This type was present in almost every Ugaritic archaeological context (such as the eighty found in the port warehouses of the city in Minet el Beida[15]) and was distributed to multiple sites in the whole eastern Mediterranean region (including the important shipwreck of Uluburun). The re-examination of these amphorae allowed the decipherment of a complex and stable system of capacity measures related to these containers, which included not only the basic unit but also multiple and fractional standards: the main types of containers (and thus probably the *kaddu* unit itself) seemed to hold about 13 liters (at least at some point in the Late Bronze Age), but, in contemporary contexts, some also held around half or double this quantity, creating a volume relationship of 1 : 2 : 4.

Thus, the coastal cities in the area would have been using a standardized group of specialized ceramic vessels, versions of the Canaanite amphora, for storage and maritime transportation of valuable commodities like wine or olive oil for many centuries before the first Phoenician seafarers arrived at the Atlantic. It is worth noting that these Canaanite amphorae would also be the earliest version of the later Phoenician amphorae produced in Tyre, Sidon, or Sarepta in the Iron Age from the very late 2nd millennium to the early 1st millennium B.C. and would of course then be the distant relatives of the amphorae produced by Phoenician colonists in the newly founded emporia on the opposite side of the Mediterranean.

Subsequent works have dealt with this same topic, addressing the study of amphorae and capacity standards both of the Phoenician amphorae of the 2nd and 1st millennium B.C. and of other related regional groups in the eastern Mediterranean, such as the containers manufactured in the southern Levantine cities and on Cyprus. Various studies have applied methodologies of both digi-

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9 Pulak 1998; Pulak 2000; Pulak 2001; Stern et al. 2008.

10 A critical retrospective of this debate, with an extensive review of the previous bibliography, is in Monroe 2016.

11 See for example Zamora 2003, with references.

12 Docter 1992, 158; the author suggested that for the oriental Phoenician transport vessels the most common capacity module would be between 11–13 liters and that at least since the 8th cent. B.C., the use of regularized standards controlled by institutions and producers would have been widespread. See also Zamora 2003.

13 Recent updates on the issue can be found in Cateloy 2016; Knapp – Demesticha 2017.

14 Zamora 2003.

15 Sauvage 2006.

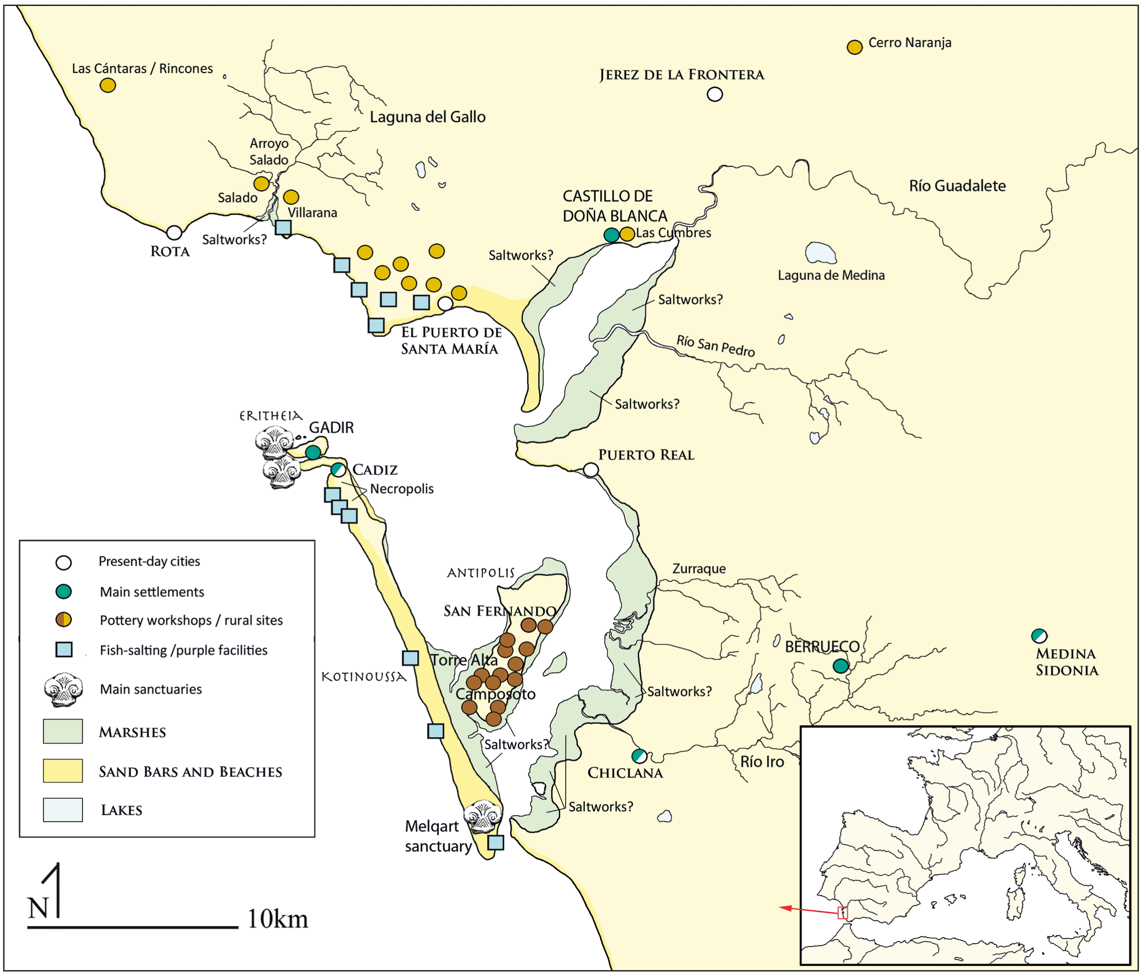
tal and physical measurement to sets of amphorae from various land sites[16] as well as underwater findspots, including the amphorae recovered from the Elyssa and Tanit wrecks off the coast of Ashkelon and dated to the 8th century B.C.[17]. Physical measurements and also those based on two-dimensional drawings made for 20 of these containers led the authors to calculate an average capacity of approximately 4 *hekats* (19.2 liters) and to propose a relationship to the volumetric system of Egypt at the time, given that this was possibly the destination of the ships and their products.

The examination of the standardization of eastern Phoenician amphorae and their capacities has also been extended to the Persian period[18], complementing regional typological and archaeometric studies which had already highlighted the remarkable homogeneity and close links between the productions of the main coastal metropolises from the 6th to the 3rd century B.C. Similar progress can be observed concerning the study of weight standards from the combination of literary, epigraphic, and archaeological sources, connecting the Levantine and Near Eastern evidence[19] with the Mediterranean world in the Iron Age, and in particular with the Aegean[20] and the Phoenician colonies that developed from the beginning of the period in the Far West[21].

Before moving on to our case study, it will be illuminating to highlight some valuable patterns and data observed in this Levantine setting. On the one hand, since at least the 2nd millennium B.C., the existence of regular maritime commercial relations between various remote regions and a certain degree of interdependence in the eastern Mediterranean could have stimulated the convergence of certain metrological systems and the design of particular forms of ceramic vessels as the primary means of transporting products such as wine, resins, and olive oil. On the other hand, in the case of Phoenician amphorae, and considering that typological standardization was always relative for these series, it has been noted that there is homogeneity in their basic typological features and in the volumes transported at least since the beginning of the Iron Age. These characteristics are applicable both to the containers that were the model for the first ones manufactured in the south of Iberia after the Phoenicians settled and for those manufactured in the Levant during the Persian and Hellenistic periods.

Finally, in relation to capacity standards, for the Late Bronze Age and the beginning of the Iron Age, the existence of various reference modules has been noted[22] (6–7, 10–15, 18–22, 30–35 and 45–50 liters) of which the smaller ones would have been the most frequent among the various eastern Mediterranean groups of containers during this phase, while larger sizes appear to be only frequent from the Iron Age II and Persian period onwards[23]. In other words, in the early days of amphora production, a smaller type of vessel (10–15 liters) was preferred, which could contain large enough quantities of valuable goods and be transported manually by one person, as represented in numerous Egyptian wall paintings of the time[24]. Amphorae which contained larger quantities (18–22+ liters) of the same goods but needed more manpower and a more developed infrastructure to be managed, gained importance in later periods. The moment of such a transition should have been at the end of the Bronze Age or the beginning of the Iron Age in the eastern Mediterranean. In fact, the main problems in the study of Phoenician amphorae can be found in the preeminence of the ›10–15 liter module‹ (according to R. Docter) or the ›18–22 liters‹ (according to T. Pedrazzi) of the Canaanite and Phoenician amphorae dating to the end of the 2nd and the first half of the 1st mil-

16 Pedrazzi 2005; Pedrazzi 2007; Karasik – Smilansky 2006; Zapassky et al. 2006; Zapassky et al. 2009; Zapassky et al. 2012; Kletter 2014.
17 Finkelstein et al. 2011.
18 Bettles 2003, 124–127. 284–291.
19 Elayi 1997; Kletter 1998; Pulak 2000; Henin 2007.
20 Heltzer 1996; Alberti – Parise 2005; Michailidou 2005; Alberti et al. 2006; Kroll 2008; Michailidou 2008.
21 Ruiz-Gálvez 2000; Parise 2006; Ialongo 2018; Pappa 2019.
22 Pedrazzi 2005; Pedrazzi 2007.
23 Knapp – Demesticha 2017, 172–184.
24 See Zamora 2000.



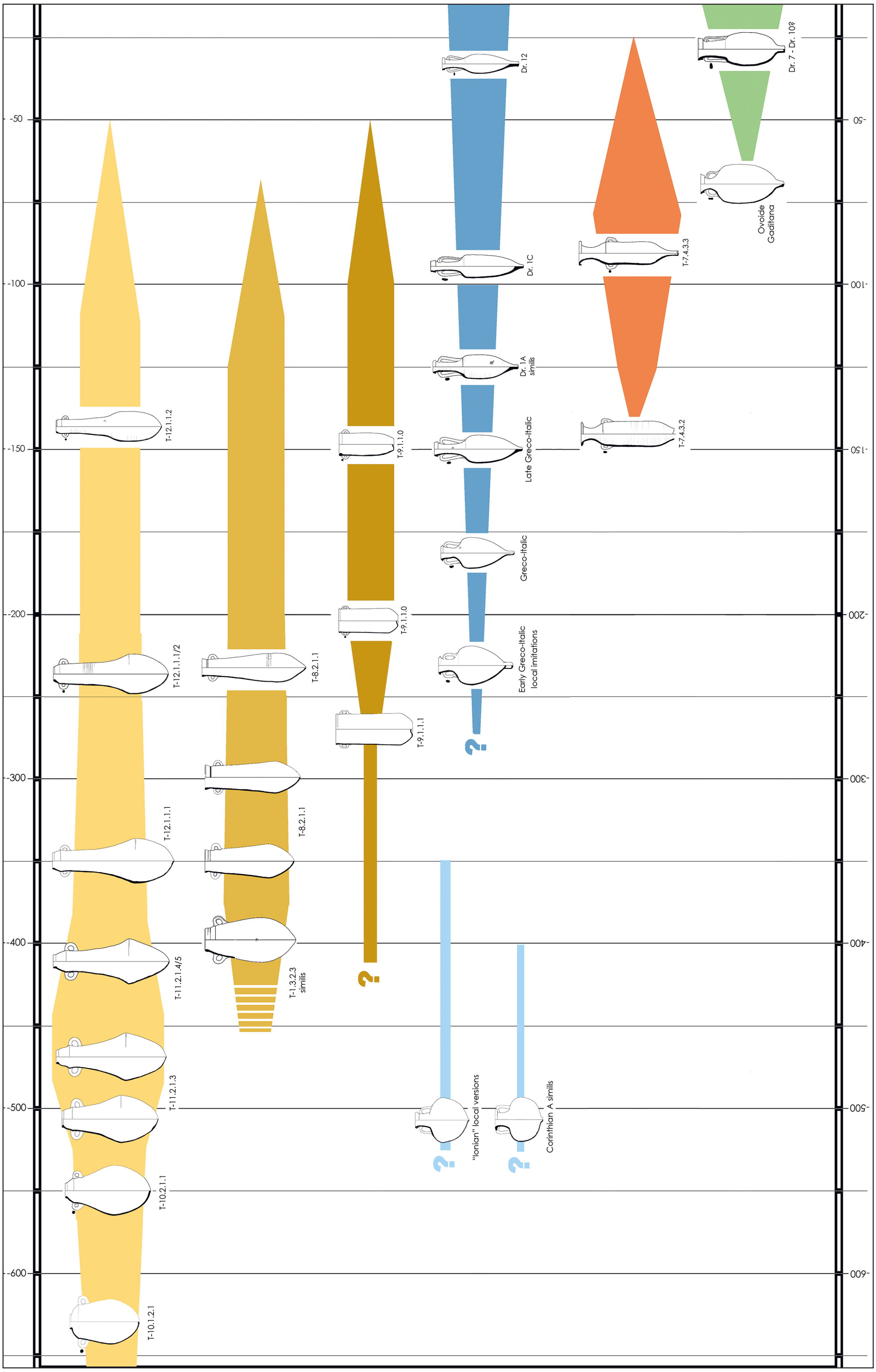
1 Main and secondary settlements in the Bay of Cádiz in pre-Roman times (© by the authors)

lennium B.C. and also in the relationship between these ›modules‹ and specific values or units of the Syrian, Tyrian, Egyptian, or Hebrew volume, weight, or linear metric systems[25].

CÁDIZ BAY THROUGHOUT THE 1ST MILLENNIUM B.C. AS TEST CASE

Gadir was a major port in the western Mediterranean since at least the 7th and 6th centuries B.C., an essential connection point between the Mediterranean world and the Atlantic with its metals (mostly tin, silver, and gold), and home to one of the most famous oracular sanctuaries in antiquity. This maritime power found in fishing one of its critical economic pillars, developing an important fish-processing business that required a large infrastructure for the production of ceramics to supply the city with both transport containers and other diverse items demanded by an expanding ›Mediterraneanized‹ market. Therefore, the Bay of Cádiz is an essential case study for the Phoenician-Punic and early Roman west and an integral reference point for the study of amphora production in a regional context as probably the area's main port and commercial hub from the 6th century B.C. to the early Roman Empire. The large number of kiln sites excavated and published (fig. 1), the substantial available information on typologies of amphorae produced in

[25] For example, C. M. Monroe (2016) has recently drawn attention to the widespread inappropriate use of the Ugaritic term *kaddu* (*kd*) as an equivalent of a unit of measurement and to the likely existence of different local typological and capacity standards in the Late Bronze Age Levant in contrast to a more homogeneous picture for the Iron Age (at least from the 8th to the 7th cent. B.C.).



2 Local amphorae production from the late 6th to the 1st century B.C., with indication of the main typological clusters. The width and form of the stripes indicate approximately the evolution of the quantitative importance of each group/type (© by the authors)

those kiln sites throughout the Iron Age and the Roman era (fig. 2), and the connection with other historical sources and processes make Cádiz Bay the best option for identifying the first steps of amphora standardization in the Far West.

GADIR/GADES: KEY ECONOMIC FEATURES OF THE ANCIENT CITY

According to the available archaeological data, in the 9th century B.C. the Phoenicians founded a colony in Cádiz Bay on the northern side of the island and settled also in fortified towns nearby in the mouth of the main rivers, establishing regular commercial links with the local communities that inhabited the surrounding coastal countryside[26] (fig. 1). Wheel-made pottery production and the intensive exploitation of marine and agricultural resources started following the arrival of the Phoenicians, but local amphora production (type T-10121[27]) does not seem to have reached a massive scale until at least the 7th century B.C. Evidence for pottery and wine production and consumption is attested, as is evidence for fishing, salting, and the manufacture of other processed foodstuffs during the Late Archaic period[28].

The settlement grew from having a secondary role to assuming a prominent regional position during the 6th century B.C., and at least since the last decades of that century, it developed a large infrastructure linked to fishing and fish salting, salt production, and probably also shipyards, perhaps then taking over for the coast of Málaga the function of main interlocutor with the Mediterranean maritime routes and the Greek world. Amphora production reached a massive scale from the early 5th century B.C. as the number of kiln sites multiplied along with the destinations where western salted fish were consumed[29]. For the 4th and 3rd century, the reliance on marine resources and maritime trade (in metals, ivory, slaves, etc.) continued, but the political-military and economic expansion of Carthage in the central and western Mediterranean forced Gadir to redirect its seaborne trade to the cities and resources of the Atlantic area, becoming again a regional power but with a limited outreach toward the Mediterranean[30].

The Romans annexed the region as part of their overseas territories after the Second Punic War, between ca. 206 and 197 B.C.; throughout much of the 2nd century B.C., a slow but steady expansion began to the north and west of the Iberian Peninsula. Gades, the ancient Phoenician city, became the major port that connected Rome with southern Iberia and its main support for the deployment of troops and supplies, participating decisively in the military maritime expeditions of the 2nd and the 1st century B.C. and in relations with the Mauritanian Kingdoms in the northwest Maghreb.

Despite the obvious benefits of the *foedus* signed with Rome and a growing Italian immigration seeking new business possibilities in trade and mining, changes in Gades' society, administrative systems, language, or economic bases were not immediate. Taking into consideration the available archaeological evidence, major changes in the economic trends, infrastructure, and land planning only took place at Gades from the mid-2nd century B.C. (ca. 170s B.C.), when the city again became the most prominent port of the region and the platform for Rome to open the gates of the ›Atlantic route‹. After that, it seems that the bay experienced rapid Romanization in both economic and social terms, but the production and commercialization of fish byproducts and amphorae remained key activities. The influence of local elites, who amassed great fortunes selling salted fish and raw materials (particularly metals), increased during the 1st century B.C. and especially after the Sertorian War. The ›fishy business‹ and the production of amphorae reached its peak in the last Republican decades and the Augustan period. Over this transitional interlude a

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26 Botto 2014.
27 For Phoenician and Punic amphora types, see Ramon 1995.
28 Sáez 2014a; Sáez – García 2019.
29 Including some key Aegean markets, such as Athens and Corinth: see Lawall 2006; Sáez et al. 2020; Fantuzzi et al. 2020.
30 Sáez 2018b.

progressive technological and metrological ›Romanization‹ of the local ceramic production took place, but major changes only became widespread after the mid-1st century B.C., involving local typologies and the technology involved in the kilns, fish-processing facilities, and other artisanal activities[31].

During the last three decades, the excavation of dozens of kiln sites and industrial areas in Cádiz Bay dating to Punic and Early Roman times has provided a robust data set allowing us to outline a comprehensive picture of the evolution of local amphora typologies throughout the 1st millennium B.C. Based on this information, up to five main phases can be distinguished:

- A first phase during the Archaic period, from the mid-7th to the early 6th century B.C., with the T-10121 as the most significant type; unfortunately, no kiln sites dating to this period have yet been excavated, and only on the basis of preliminary archaeometric research has local production of this type been suggested.
- A second phase, from the late 6th century to the *foedus* with Rome (206 B.C.) and the early 2nd century B.C. During this period the city seems to have secured a stable territory in the insular area and also around the continental margins of the bay. In both areas, facilities linked to the production of salt and salted fish as well as pottery workshops multiplied, with particular success during the 5th and the second half of the 3rd century B.C. (fig. 1). Amphora production can be divided into two sub-phases: the first, during the last years of the 6th century and throughout the 5th century B.C., is characterized by the manufacture of type T-11210 (in various sizes and capacities) and local imitations of Corinthian A and Ionian-style amphorae; complete individuals are not yet available for these, and consequently a proper assessment is impossible. A second sub-phase spans the 4th and 3rd centuries B.C., during which the T-11210 evolved into diverse variants of the T-12110 type, and most importantly the tubular series were created, such as the T-8211 (and probably later the first T-9111). It is possible that Greek forms were imitated during this period, but the production of Greek and Italic amphorae is particularly noteworthy in the 3rd and beginning of the 2nd century B.C.
- The third phase can also be divided into two parts with distinct nuances: after the signing of the *foedus*, barely a generation seems to have passed in which the production infrastructure and administrative systems remained substantially unchanged; this can be seen in the settlement patterns of the bay, which saw a general abandonment of walled sites on the continental shore and of the smaller rural settlements, although some activity remained at the mouth of the River Guadalete. Amphora production at this time was entirely a continuation of the previous phase, including tubular versions of the T-12110, T-8211, smaller forms of the T-9111, as well as local imitations of Greco-Italic jars. From the 170s/160s to the Sertorian War (c. 82–78 B.C.), it seems that both the suburban area and the territory began to be organized and exploited following Roman patterns, adding new pottery and canning facilities around the port of the city and in its suburbs (coexisting with the necropolis), and perhaps from the second half of the 2nd century B.C. in rural centers throughout the insular and continental countryside. From the perspective of the amphorae, this was a period of significant changes that gradually led to the disappearance of the traditional Punic types (T-12112, T-8211, T-9111, which were minor groups at the beginning of the 1st century B.C.), and their replacement by foreign forms like T-7430 (taken from the Late Punic Tunisian repertoire) and Dressel 1A/1C (mainly linked to the Italic wine trade).
- The fourth phase seems to consolidate the patterns of occupation and exploitation of the territory from the previous phase, with a clear strengthening of the *villae* and other rural settlements, a centuriated territory, and a large array of small production centers located in both the port and suburban areas as well as across the island and continental fluvial plains. Although during the period 80–40/30 B.C. the productions of T-7433 and Dressel 1C were

[31] García 1998; García – Sáez 2018; García – Sáez 2019.

probably still significant, both series gradually lost status in favor of new ovoid series, the formal referents for which can also be found in southern Italy and Tunisia.

- In the fifth and final phase, during the Augustan period and the 1st century A.D., major changes took place involving both amphora profiles and technological features of kilns, crystallizing the processes of technological and metrological Romanization and adaptation to the Roman Mediterranean markets that had already begun in the two preceding phases. All post-Sertorian types were replaced by the earliest variants of the Dressel 7/11 group and stylized containers of Dressel 12 type (perhaps derived from Dressel 1C); both the technical design of the containers and their capacity standards seem to bear no relationship to those from earlier phases.

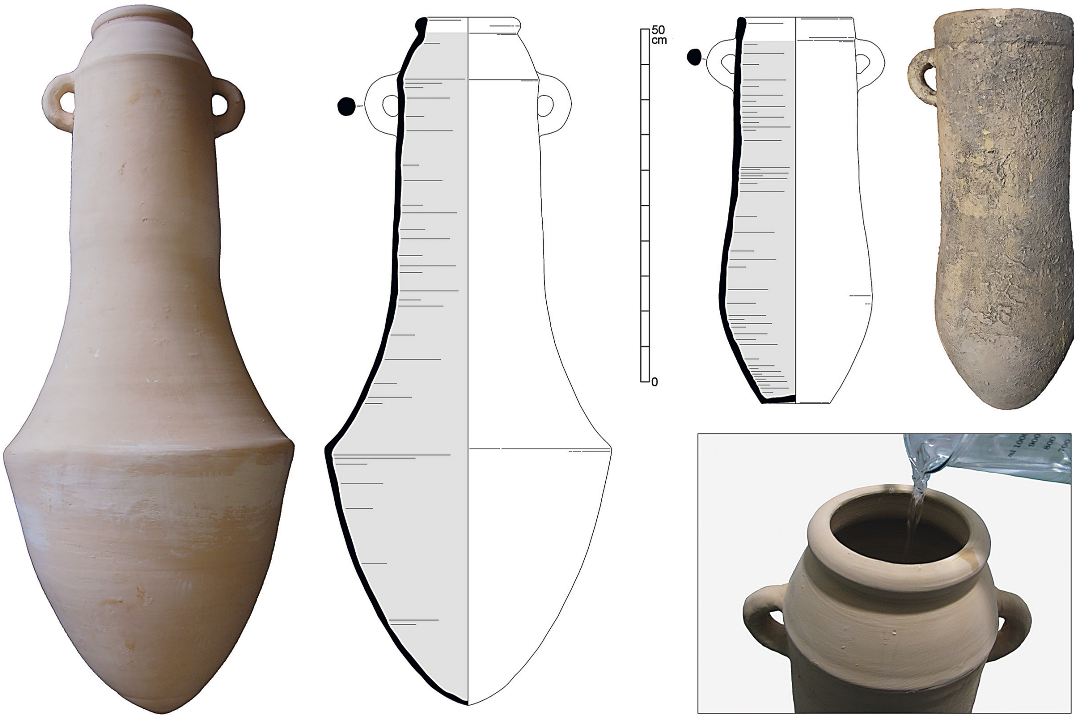
Previous research on amphora production at Gadir/Gades has focused on basic typological aspects, chronology, fabrics, sources of clay, distribution patterns, and above all the historical meaning of the containers in relation to the fish-processing business. The examination of the standardization of these diverse local series from a technological perspective – analyzing the existence of size patterns, features that define modules over long periods, etc. – has not to date been the subject of specific work for any of the aforementioned types of amphorae. This paper presents a first approach to this important issue. Similarly, in recent years, only a few papers have focused on the capacity standards of local amphorae[32], the possible eastern origins of the patterns detected, and the changes that occurred during the Roman period[33]. Likewise, the relationship to regional weight systems and the early stages of local coinage has only been preliminarily explored when a link with the ›Syrian standard‹ was proposed[34] along with a connection between weights and volumes for the design of amphorae in the 5th century B.C.[35]. Finally, this state of the scholarship should include also the first results of a project that aims to quantify the productivity of ceramic ateliers and fish-processing facilities, which have revealed significant turning points in kiln and amphora technologies in the 5th century B.C., throughout the 3rd century B.C., and in the Late Republican period: these include a progressive ›cylindricalization‹ of the containers, smaller overall dimensions and capacities, etc. These key aspects will be discussed in the following sections.

TYPOLOGICAL AND CAPACITY STANDARDS FROM PHOENICIAN TO EARLY ROMAN TIMES IN CÁDIZ BAY: AN UPDATED OVERVIEW OF THE MAIN AMPHORA SERIES AND TYPES

As we pointed out in the introduction, the study of typological and volumetric standardization of local amphorae is part of a large-scale project that intends to quantify the productivity of local kilns, fish-processing factories, salt works, and other key economic features of the Punic and Early Roman city by ›measuring‹ the entire cycle of production and transport from the potter's wheel to the hold of a ship. To examine both variables of the standardization process (morphometrics and capacities), specific software has been used to process a sizeable data set of 2D drawings of complete or almost complete amphorae[36]. Consequently, more than 200 items have been studied and digitally processed, although it should be noted that the amount of information available is uneven for the various types: the 30 T-11210s studied stand out compared to the only two complete early Greco-Italic examples available at the moment.

Blender 2.78 software was used to develop the 3D models of the containers. The models were created from the line drawing of the vessel section on a 1 : 1 scale, and then this profile was

32 Sáez – Moreno 2017.
33 García – Sáez 2018.
34 Something already suggested by other authors before: see García-Bellido 2003; Parise 2006; García-Bellido 2013.
35 Moreno – Arévalo 2017.
36 Priority has been given to analysis of objects drawn by the authors themselves or otherwise published by others but coming from highly significant contexts.



3 Two examples of the process of verifying the capacity calculations based on 2D drawings: photographs of 1 : 1 scale replicas of T-11210 (a) and T-9111 (b) amphorae and archaeological drawings of both individuals. In the box, an example of the process of measuring the capacity of one of the replicas by filling it with water (© by the authors)

vectorized and revolved to obtain a 3D object. After applying polygon subdivisions to improve and achieve a surface with fewer angles, which causes some deformation after the polygons are subdivided, the section of the amphora was refined. Once the final object was obtained, we differentiated and separated the inner profile from the outer one. Taking the inner line as the reference, the digital model results in 3D snapshots of the volumes of the vessels. The last step in the calculation of the capacity of each amphora used the algorithm of the add-on ›3D Print Toolbox‹, a tool designed to determine the volume of material required for the 3D printing of items.

To test the calculations based on the digital 3D models and to make the results more robust and reliable, supplementary information was provided by experimental archaeological research (fig. 3). The calculation was refined by producing full-scale replicas of most of the local amphora types (T-11210, T-12110, T-8211, T-9111, Greco-Italic) or, in certain cases, by measuring the capacity of the ancient vessels (some T-9111, Dressel 7). The replicas were first filled with water and then drawn following the same methodology as that used for Punic and Roman amphorae. The 2D drawings were subsequently used to develop 3D digital models from which the capacity of each item could be calculated. Again, minimal deviations were detected in the digital calculations and when compared with the figures obtained by measuring the replicas with water. Therefore, this strategy has made it possible to develop a fast and consistent digital method to calculate the capacity of the amphorae. In this way, the physical reproductions of the pots have served to compare and calibrate the results of the virtual research, ensuring the reliability of this tool so that it can be applied to a greater number of pieces than those produced in clay[37]. This refined virtual method

[37] The information provided by the production process of the replicas obviously includes other important technical features, such as the time required to produce a finished vessel, how the different parts were joined, and that most amphorae would have been coated with resin to avoid problems with porosity; these and other technical issues will be the subject of further specific work.

has established a reliable and standardized protocol, one that has been applied to the amphorae and other ceramics from the local Punic and Late Punic repertoire[38].

The investigation has been extended to other significant ceramic vessels closely connected with the main amphora series. Over many decades, dozens of miniature amphorae have been found on the seabed around La Caleta beach, located west of the ancient city and identified as a main port and worship area from Phoenician to Roman times[39]. Many of these miniature amphorae have been recently studied[40] as part of a larger project which aims to re-examine the previous underwater finds and to update the view regarding the evolution of the area throughout the 1st millennium B.C. The same methodology has been applied to these small-sized amphorae by developing replicas and 3D digital models to calculate their capacities and to establish an updated chronological framework.

The typological features of the miniatures imitated the main local amphora series (T-10/T-11/T-12) from the Late Archaic period to Early Roman times. From the 6th to the 3rd century B.C., the miniaturized amphorae were produced in at least two variants that had small typological differences but different capacity standards. Perhaps this can be explained if we take into account that these amphorae were probably used as votive offerings in the sanctuaries located in the coastal area of La Caleta, so the differences observed in size and capacity could correspond to the purchasing power of the worshipers. During the late 3rd and 2nd century B.C., variation in size and capacity seems to disappear, and all the miniature amphorae progressively reduced their volumes while their full-scale prototypes also reduced their capacities.

The underwater contexts at La Caleta have not exclusively provided support for the local manufacture of miniature vessels. More recently, some kiln sites have also yielded fresh evidence for the late 3rd and 2nd century B.C. about the production of small-sized versions of the most successful amphora types of that period. For example, at the Torre Alta workshop, half-size versions of Greco-Italic and T-12111 amphorae were produced in the late 3rd century B.C. kilns, but no complete individuals have been found, and there is no information about the real quantitative importance of these small amphorae. Also, in the same workshop in some late 3rd and early 2nd century B.C. contexts, small versions of T-9111 have been found, suggesting an important production that up to now has not been identified anywhere else in Cádiz Bay. Either way, it is an emerging line of research that will be developed in the near future, shedding new light on their role in the maritime-oriented economy and distribution.

Each of the series and amphora types produced in Cádiz Bay area from the 6th to the 1st century B.C. are examined below, sketching their typological connections, key metric and fabric data, and assessing the results obtained regarding the standardization of their profiles and volumes. Miniature vessels will also be considered, although only general data will be provided, as the focus is on the full-size versions. Almost all of the local types have been analyzed and have provided illuminating data for the study of the changes in standardization patterns, except the Late Archaic Greek amphora imitations (since no complete vessels are preserved). This is therefore a first and incomplete approach, and the results discussed here will need to be expanded and refined in the future as the number of available individuals of some of the lesser-known types increases[41].

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38 The same methodology (ceramic replicas on a 1 : 1 scale, measurement with water and digital calculations from 2D drawings) has been applied to a significant number of examples of cooking pots, pans, cups, bowls, jugs, and other series of local tablewares and cooking wares, obtaining similar results to those observed for the amphorae: generally with very low or almost no deviations of less than 1–2 %. See Sáez – Belizón 2020.

39 Higueras-Milena – Sáez 2018.

40 A preliminary report of these results was presented to »The Honor Frost Foundation Conference on ›Mediterranean Maritime Archaeology‹. Under the Mediterranean« (Nicosia, University of Cyprus, 20th–24th October 2017), but has not yet been published.

41 Specifically, not only the Greek or Greco-Italic western versions but also the early variants of T-8211, the local T-10121, complete vessels of type T-12112 and Dressel 1C, etc.

Type Ramon T-10.1.2.1

Phoenician amphorae evolved from the T-10111 type amphorae, also designed on the basis of Levantine prototypes imported to the west with the first colonizers. The T-10121 represents the most successful western Phoenician model, typical of the second half of the 7th century and the first half of the 6th century B.C., that reached a broad commercial distribution that was the result, above all, of the importance of the workshops on the coast of Málaga. Archaeological and archaeometric data[42] suggest that the type was produced in Cádiz Bay at least during the late 7th and early 6th century B.C., but as previously mentioned, the Archaic workshops have not yet been located either on the continental coast or in the insular zone. As it was the only transport container manufactured in the Late Archaic phase, it was most likely a multifunctional series, perhaps allowing direct visual identification of a capacity standard rather than specific products such as wine, olive oil, salted fish, etc.

Unfortunately, at present a very limited sample is available, and a first scrutiny of the homogeneity or variability of the profiles of this group and its capacity standards is not possible. Only at the walled settlement of Castillo de Doña Blanca (Cádiz) have some complete or almost complete individuals been published[43], which have been taken as a reference point for our research. The results indicate an average capacity of around 26.9 liters, although these data should be taken with caution and compared in the future with measurements of a greater number of individuals. Some pieces recovered in underwater contexts from the environs of the city of Cádiz also suggest that smaller-sized T-10121 containers were locally made, perhaps corresponding to divisions of the capacity unit. Specifically, two individuals with capacities of 6.63 liters and 2.37 liters have been measured[44], so if we consider that the reference unit would be 13.2 liters, these smaller versions would correspond respectively to half and one sixth. In view of these first results, it seems that during the first half of the 6th century B.C. local capacity patterns were adjusted to what was defined for the Ugaritic *kaddu* in previous research[45] and also that versions of different sizes of transport amphorae, perhaps linked to different functions, were produced around the bay, showing a similar pattern to the one described for the Canaanite amphorae of the Uluburun wreck or the warehouses excavated at Minet el Beida-Ugarit.

Type Ramon T-11.2.1.3

Unfortunately, no archaeological evidence provides information about the transitional forms developed during the middle decades of the 6th century B.C. in the Bay of Cádiz, which might have linked the last T-10121 and the earlier versions of T-11213. It is possible that their profiles were similar to the T-10221 type and other related groups produced on the coast of Málaga and dated throughout the middle decades of the 6th century B.C. The picture for this period is absolutely tentative, so it cannot be ruled out that the local development of the T-11213 was the result of an ›imitation‹ of these prototypes from the Bay of Málaga and the coast of Vélez-Málaga. In any case, the T-11210 can be considered the first variant of a family of types that represent the evolution of the same scheme from the 5th to the 2nd century B.C., a typically western Phoenician profile closely linked to the expansion of the salted fish business (fig. 4).

In any case, the archaeological data are conclusive in supporting the large-scale production of the type from the last quarter of the 6th century and during most of the 5th century B.C. in all the insular kiln sites excavated so far[46]. The contexts excavated at Camposoto[47] indicate that probably

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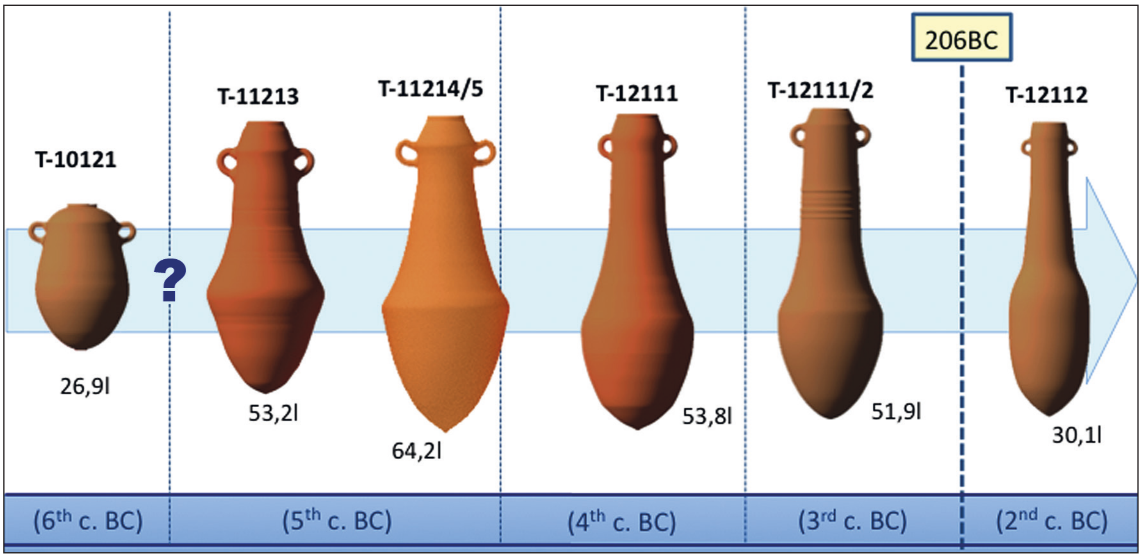
42 López et al. 2008; Behrendt – Mielke 2010.
43 Ruiz 1986; Ruiz – Pérez 1995.
44 Muñoz 1993, 312–314 fig. 9; 239 f.
45 Zamora 2003.
46 Sáez 2014a.
47 Ramon et al. 2007.



4 Synthesis of the parallel evolution of the shape and dimensions of the types that are part of the ›most long-established cluster‹ of western Phoenician and Punic amphorae, and probable relationship with changes in the baseline capacity standard (© by the authors)

the oldest versions were shorter (around 85 cm) and had a larger maximum diameter than their Archaic predecessors (40–44 cm) (fig. 5, black line). But these also suggest that during the middle decades of the century, the type became more tubular, 40–42 cm in diameter along the carinated body but at the same time grew in length to 93–96 cm (fig. 5, color lines). In the last quarter of the century, the shape (classified as type T-11214/5) developed a much more stylized and cylindrical profile, with a maximum diameter still around 42 cm but a usual length of more than 105–110 cm (fig. 5, in grey). The examination of the proportions and sizes largely suggests a high standardization of the profiles and the critical morphological features, with slightly more variability in the rims and handles, areas that would not modify the functionality of the vessels. This formal evolution could have been related to changes in the loading systems of kilns and ships – to optimize these processes – rather than to modifications of the local capacity standard.

In fact, as we have already discussed in previous research[48], the volume transported by the T-11213 amphorae seems to vary mainly between 51 and 55 liters, with an average capacity for the 30 individuals studied of almost 53 liters. Thus, if we consider that the basic unit of measure would be around 13 liters, the capacity of the T-11213 would be four times the unit or eight times if we assume a 6.7-liter unit, the most abundant pattern among the Uluburun amphora assemblage. However, the system seems to have included smaller vessels produced throughout this period, suggesting a greater complexity of the metrological system related to their design and to the control of the quantities of products traded in them.

On the one hand, a single unpublished individual with reduced dimensions but perfectly useful for commercial activity indicates production in the 5th century B.C. of versions of the T-11213 with a capacity of around 20–21 liters (fig. 6, in this case, 20.2 liters). As this is a single example, it is impossible to draw definitive conclusions, but it is significant that the capacity is not half that of the larger amphorae and does not correspond to two *sata* (c. 26.2 liters) or four *kaddu* (6.7 liters). This could be due to small variations in the design and to the fact that the standardization of pottery production at the time was more relative than absolute[49], an option to be investigated in the future when more complete specimens are available. On the other hand, there is evidence of local

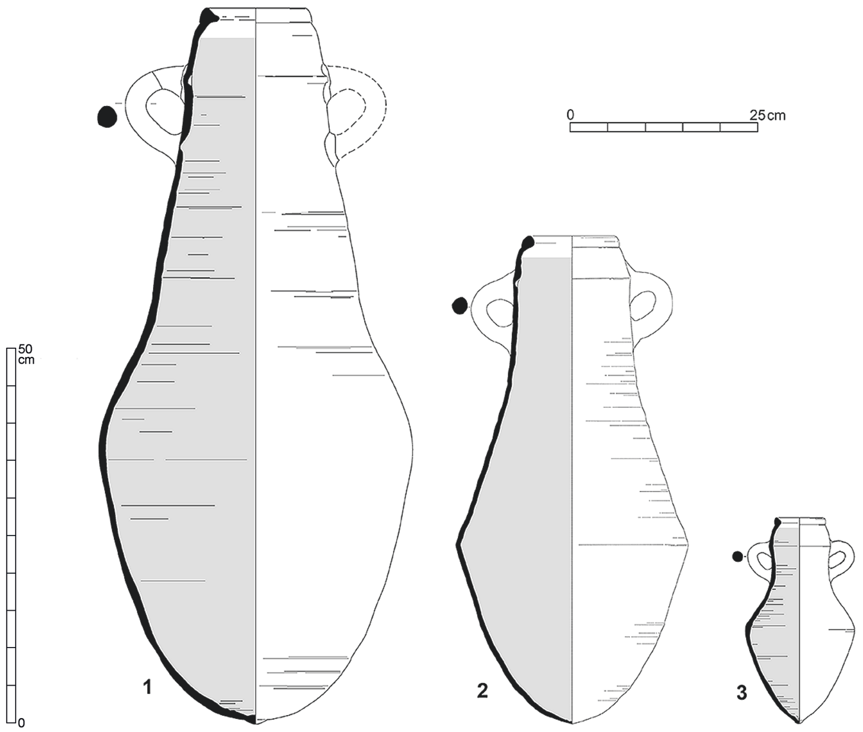
48 Sáez – Moreno 2017.
49 Kotsonas 2014, 16.

5 Uniformity and diversity: comparing the older variants of the types T-11210 (5th cent. B.C.) and T-12110 (4th–2nd cent. B.C.). For the case of T-11210, black lines indicate the oldest versions, colored lines the main profile variants and the gray background the individuals dated in the late 5th century B.C. For T-12110 amphorae, lines indicate the typical profiles of the 4th–3rd century B.C., whereas the gray silhouette corresponds to the profile of the T-12112 variant from the 2nd century B.C. (© by the authors)

production of miniature versions found in large numbers in underwater sites near the insular port area of Gadir/Gades. The dozens of vessels studied suggest that most of these small amphorae fit into three capacity standards: c. 1.5 liters, 2 liters, and 3.2 liters (fig. 6, right, shows a 1.64-liter vessel). Again, the connection with the Levantine standards of 6.7 and 13.2 liters is clear. If we consider the latter as the unit, the larger miniatures would be a quarter of a unit and the smaller ones about a sixth or an eighth of a unit. In any case, the coincidence with divisions of this theoretical unit of volume is not exact, emphasizing again that standardization in antiquity was only relative, approximate, and not absolute, as has been highlighted above and will be seen for other cases later.

Type Ramon T-11.2.1.4/5

This group includes some of the variants of the family directly evolved from the T-11213 prototypes in the late 5th century B.C., which were produced in the insular workshops of Gadir until the early years of the 4th century B.C. as a transitional form between the T-11213 and T-12111 types. As with the other family variants, it seems that their normal content was salted fish, although occasional use for other products cannot be disregarded. A comparison of their profiles with those of the T-11213 (fig. 5) suggests that the dimensions of the series remained stable in most of the key features (rim and body diameter), but it also reveals a clear tendency towards a tubular shape and a noteworthy growth of the total length (up to 115 cm). The results of the digital calculation of the



6 Main typological and volume modules detected for the T-11210 of the 5th century B.C.: regular size (left), half-size (center) and miniatures (right). The gray shaded area indicates the part that has been used to calculate the capacity of each container (© by the authors)

capacity of several vessels from land and underwater contexts suggest a change in the standard with respect to the T-11213 since in all cases their volume is around 61–64 liters. In these decades, the Carthaginian (and Ibizan) influence and commercial projection towards the west increased; thus, perhaps it is possible to find in this competition the reasons for the production in Gadir of increasingly tubular shapes and for the variations in the capacity standard. In this regard, it should be noted that the amphorae from Ibiza contemporary with the T-11214/5 (T-1323 and the first T-8111) had capacities of around 40–45 liters, which have been related by J. Ramon Torres to a Tyrian unit (*bath*) of 22.6 liters.

Type Ramon T-12.1.1.1

The trend towards the ›tubularization‹ of amphorae of this family continued and was accentuated in the types and variants created from the 4th to the 2nd century B.C. The T-12111 type can be considered a design based on the T-11214/5 prototypes of the early 4th century B.C.; it was produced in Gadir during the 4th century B.C. (T-12111) and also throughout the 3rd and early 2nd century B.C. (the latter have been identified as a different variant, the T-12111/2[50]). Again, salted fish was very likely the most common content of the series, although the sporadic transport of wine or other products cannot be overlooked. A detailed examination of the few complete profiles available reveals a relative homogeneity in the basic scheme and especially in the cylindrical shape of the upper half of the body. This uniformity only seems to disappear in relation to the maximum diameter and total length of the containers. While the T-12111 and T-12111/2 dated prior to the last years of the 3rd century B.C. have measurements close to those of the precursor types (diam-

50 Sáez 2008.

eters of 39–42 cm, lengths of approximately 100–110 cm; see fig. 5, in red), the more evolved profiles seem to reflect a reduction in both variables (fig. 5, black and green lines). This trend seems merely to anticipate the crystallization of the characteristic profile of the T-12112 vessels (see fig. 5, in gray), in a more progressive than abrupt adaptation process that can be seen in the permanence in the T-12112, for certain features common to both types: engraved lines next to the rim, small handles, rounded angles in carinations, etc. Concerning capacity standards, our results suggest that the T-12111 and T-12111/2 would have carried 51–53 liters, revealing the return of the same pattern observed for the T-11213. At the same time, miniature versions of the T-12111, which can be related to divisions within the system, carried up to 2.1 liters (about a sixth of the theoretical unit of 13.2 liters).

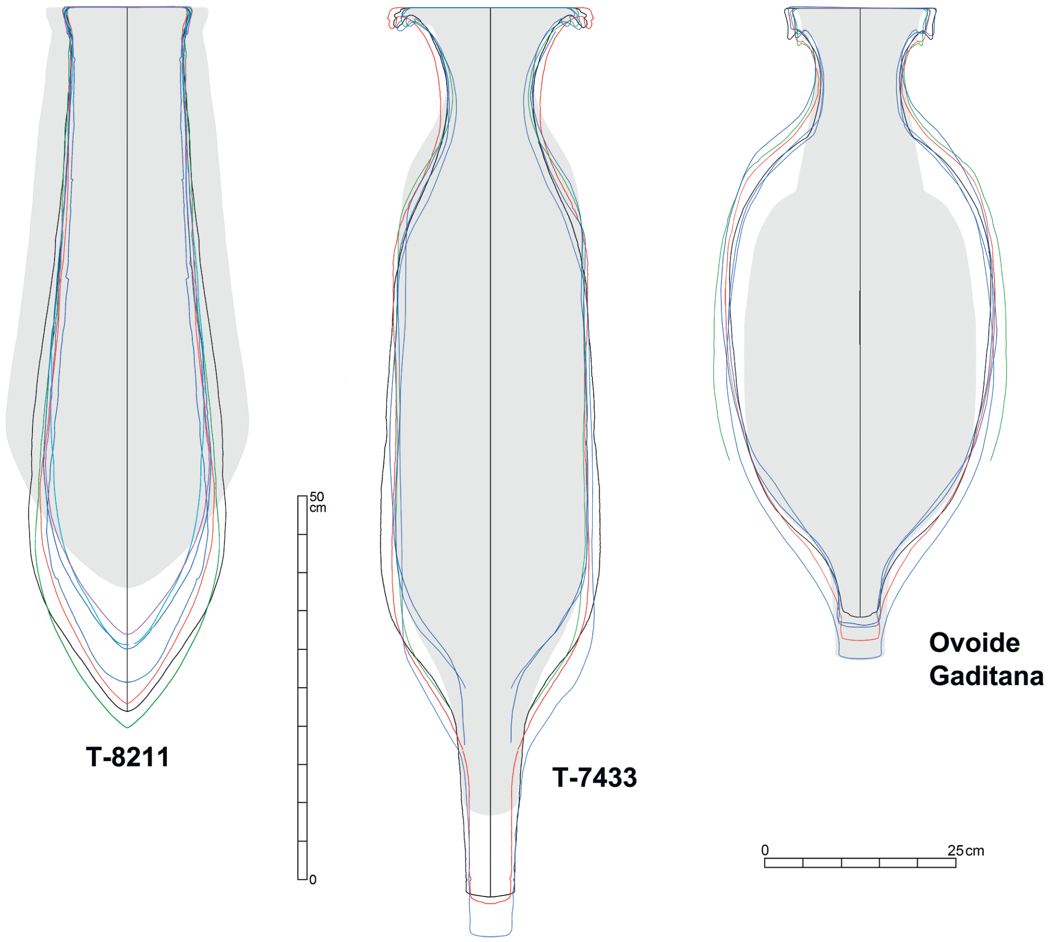
Type Ramon T-12.1.1.2

The production of tubular versions of the profiles of this family reached its peak with the T-12112 in the middle decades of the 2nd century B.C. The production of the type continued until the end of the century or perhaps the beginning of the 1st century B.C., and as with all previous types, it was primarily linked to the fish-processing business. The remarkable number of known examples uncovered both in underwater (La Caleta[51]) and terrestrial (residential and artisanal areas, necropolises[52]) contexts has made it possible to observe uniformity in the dimensions and fundamental features of the type as well as in its average capacity (estimated at around 30 liters, calculated from the only almost complete vessel available) and in the existence of numerous small differences in details, such as handles, rims, and carinated shoulders. Measuring the capacity of a single individual only allows tentative conclusions to be drawn, but the reduction in volume of the largest amphorae in the local repertoire of the 2nd century B.C. raises interesting questions and connects the Late Punic series with the ›Romanized‹ profiles locally produced in later stages, such as the ›Ovoide Gaditana‹ (see below, also with a standard around 28–33 liters). It seems quite likely that these changes in dimensions and capacity could be the result of an attempt to adapt the city standards of liquid and dry volumes to the Roman metric system, as the T-12112 would correspond to an *amphora quadrantal* (26.2 liters) or three *modii* (dry measure, up to 26.19 liters). Some miniature versions found at La Caleta reproduce the profile of the regular-sized vessels and can be related to small divisions of the volume standard (around 0.5–0.6 liters, i.e., a Roman *sextarius*).

Type Ramon T-8.2.1.1

J. Ramon Torres[53] first defined this type as a precursor of the T-9111 type, although the archaeological documentation currently available indicates that both were differentiated series from the beginning. Of possible Ebusitan inspiration, it was produced mainly in the 4th and 3rd century B.C., maintaining in general terms their key attributes throughout the period. All the diverse versions of the type have an almost cylindrical body, with a lower part often slightly wider (maximum diameter 22–30 cm) and terminating in a simple point, while the mouth is wide (14–22 cm). The handles are always placed close to the rim, which can describe different shapes, normally flat and to some extent separated from the body by an inflection or lines incised before firing. Ramon[54] proposed that the total length of these containers was between 80 and 95 cm, although there are late versions that can reach 100 cm.

51 Muñoz 1993.
52 Sáez 2008; Sáez 2018a.
53 Ramon 1995, 225 f.
54 Ramon 1995, 225.



7 Uniformity and diversity: differentiating profiles of local T-8211, T-7430 and ›ovoide gaditana‹ types. For the case of T-8211, the gray silhouette corresponds to the older variants typical of the 4th and early 3rd centuries B.C., but the lines correspond to specimens from the second half of the 3rd and the beginning of the 2nd century B.C. Six different complete or almost complete individuals of T-7433 are compared, and in the background the gray outline sketches the profile of T-7432 variant. For the case of the ›ovoide gaditana‹ lines show six different alternatives and the gray figure illustrates a local Dressel 7 of the late 1st century B.C. (© by the authors)

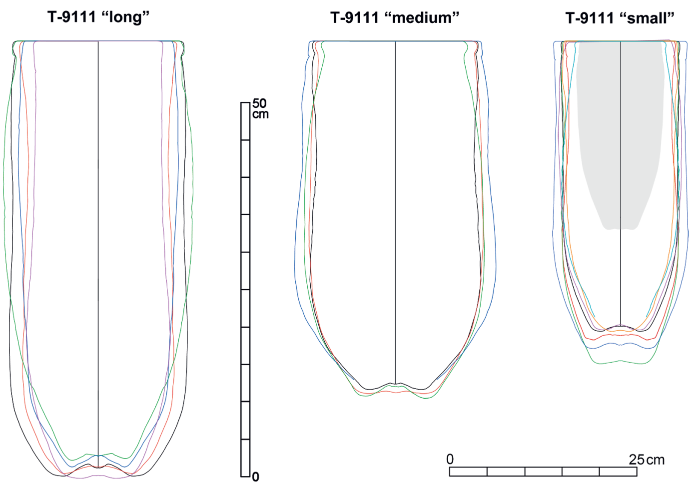
In fact, the research carried out in the Bay of Cádiz in the last two years has revealed that it is actually a family of amphorae that included at least three main variants of the tubular shape defined by J. Ramon Torres: an initial version similar to the Ebusitan T-1323, with more rounded lines, manufactured by the end of the 5th century B.C., and of which no complete individuals have been published; a second version already with straight walls, a length of around 80–85 cm, and wide diameters both in the mouth and in the body (fig. 7, in gray); and finally, a set of more stylized, long containers (usually 90–100 cm), among which the versions of the 3rd and early 2nd century have slightly wider diameters (for example, fig. 7, green line), whereas the later variants of the series were usually cylinders with a small maximum diameter (22–24 cm). As was the case for the T-11210 and T-12110 groups, this series has been linked to the transport of salted fish, although they at least sporadically might have transported other products.

The examination of the available profiles for the 3rd and 2nd century B.C. and their morphometric features clearly indicates that there was certain variability in the length of the containers (with differences of up to 15 cm) but at the same time that there was a noteworthy homogeneity in the basic profile attributes and diameter of the rim, a fact that in turn suggests that the sealing systems, wooden or cork stoppers, probably were mass-produced in a standardized way as well. With respect to the capacity standards in this series, some preliminary results can be advanced. On the one hand, the wide prototypes of the 4th and early 3rd century B.C. must have carried around 27 liters, which clearly approximates the 26.4-liter pattern already mentioned for the T-11/T-12 types. On the other hand, versions dated to the 3rd and early 2nd century B.C. suggest a capacity standard around 22–24 liters, which indicates that the same reference was maintained during this period. However, for the slimmer T-8211s found in contexts dating back to the mid-/late 2nd century B.C., data on their volume indicate a capacity of around 13–14 liters, which could be related to a Roman *urna* of 13.1 liters for liquid contents or a *modius castrensis* of 12.93 liters for solid contents.

Group Ramon T-9.1.0.0

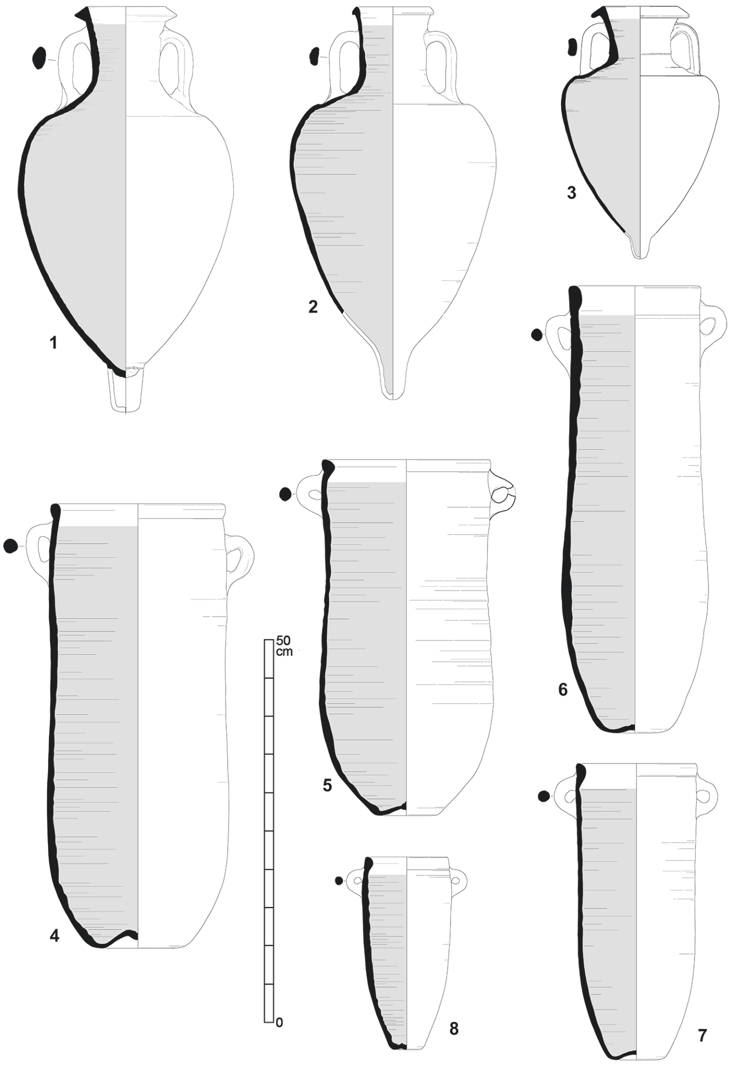
In a recent paper[55] the origin and development of the type T-9111 were discussed, and it was concluded that the type T-9111 is not a late derivative of the type T-8211, as had been assumed but is probably the result of a lengthy evolution from the 5th century B.C. of pithos-like shapes with flat bases and involved in maritime trade from the beginning. The formal parameters of the type, as described by Ramon Torres[56], seem to have been fixed throughout the 3rd century B.C. From the last years of the century, and especially throughout the 2nd century B.C., the type was manufactured in massive quantities and reached a notable commercial distribution both inland and on the Atlantic-Mediterranean routes. As in the previous cases, this form has been related to the transport of salted fish, probably containing solid by-products (chunks or fillets, as suggested by the iconography of some of the stamps associated with the series).

Fortunately, a large number of complete or nearly complete examples of T-9110 are available, from which we have selected about 30 to examine the standardization of the typological features and their capacity patterns. This extensive sample, which is mainly from underwater contexts and consumption areas (urban pits and dumps), has allowed us to observe the existence of four main modules in relation to the size or length (fig. 8). A detailed examination of the profiles makes it clear that within each module there was a high degree of standardization, with internal variation limited to minor differences in the total length of the containers or in the curvature of the upper part of the body (or other details not as important for functionality, like the size and profile



8 Uniformity and diversity within the main variants of T-9111 type. In the case of the ›small variant‹ the gray outline represents the Ramon T-9121 form, a miniature vessel. The ›long variant‹ matches with Ramon T-9111a/b type, and the ›medium‹ group correspond to type Ramon T-9112 (see Ramon Torres 1995, 455–457) (© by the authors)

55 Sáez – García 2019, 32 f. fig. 5.
56 Ramon 1995, 226–228.



9 Examples of typological and volume units in Late Punic amphorae produced in Cádiz Bay: regular size (1–2) and half-sized (3) Greco-Italic versions; ›long‹ (4), ›medium‹ (5), ›small‹ (7) and ›miniature‹ variants of T-9100, and outlier (6) of the same group (© by the authors)

of the handles). The ›long‹ variant (Ramon's types T-9111a-b and T-9112; fig. 9, 4) includes an outlier (fig. 9, 6) that has a much narrower diameter than the rest of the profiles considered. The ›medium‹ group corresponds to forms not classified in the Ramon Torres typology, shorter than the previous group but with a larger mouth and body diameter (fig. 9, 5). A third cluster includes the most frequent formal variants with great commercial importance, considered ›small‹ (fig. 9, 7) since they have a reduced length and diameter compared to the previous groups. Finally, the fourth group (represented only by one complete container; fig. 9, 8, also fig. 8, in grey) comprises the miniatures (Ramon's type T-9121), which must have been frequent in this type if we consider the many fragmentary examples documented at the Torre Alta workshop[57].

Finally, we offer brief consideration of the capacities of these groups of flat-bottomed vessels. In the case of the long group, the individuals with greater length and diameter reach capacities of

57 Unpublished.

about 18.5–24 liters, while the outlier has a capacity of 9.56 liters. The amphorae of the medium group have an average capacity of about 12.5 liters, whereas the variants of the small group have volumes ranging from 4.8 to 7.4 liters. The miniature container, on the other hand, has a capacity of approximately 1.26 liters, which could perhaps be interpreted as two Roman *sextarii*. For most of these values, it is not easy to find a clear equivalence with the Roman metrological system for liquid or dry volumes, although in the case of larger containers an attempt to match the *amphora* (26.2 liters) can be intuited, and for the small series, they all range among the *semimodius* to the *modius* (corresponding to 8.73 liters).

Type Ramon T-7.4.3.3

This form was probably created on the basis of the shape of the T-7432 type, which can be identified as the first wave of imitations in Gades during the middle of the 2nd century B.C. of some successful Tunisian prototypes (such as the T-7431 and T-7421). This antecedent would have been produced in a number of insular workshops throughout the third quarter of the 2nd century B.C. After that, the shape grew in length, and certain key features changed, giving rise to the T-7433 in the last quarter of the century. The production of the T-7433 type in the Bay of Cádiz and its surroundings seems to have lasted through most of the 1st century B.C., perhaps until the early Augustan period. Although both have tubular bodies (diameters of 22–26 cm), the differences between the two types are notable in dimensions as well as basic aspects of their structure and significant morphological details: the T-7432 (fig. 7, in gray) have shorter necks, handles on the upper part of the body, and shorter toes, giving rise to a total length of the container that is also shorter (around 105–110 cm). For both types, it has been assumed so far that their usual content was salted fish, as evidenced by finds in the southern district of Baelo Claudia, although other evidence suggests that at least in the continental countryside it may also have been used for the transport of grape by-products.

The specific morphometric analysis of a sizeable number of T-7433 amphorae with complete or almost complete profiles reveals that the series developed a high degree of formal standardization. The diameters of rims and necks, as well as the profile of the body, notably tubular in most of the examples studied, seem to be particularly stable. Only small variations have been detected concerning the length of the toe and the full length of the vessel, as some of them are larger than the average (up to 120 cm). Some of the individuals could also be classified as having a baggy profile because the lower part of the body is slightly wider than the upper part (fig. 7, color lines). Despite these differences in size, both the T-7432 and T-7433 show a shared capacity standard, as all the individuals measured are between 24 and 26 liters. As these are forms from the Punic tradition, a relationship with the capacity standard of c. 13.2 liters (twice the unit) cannot be disregarded, but given that the group was actually developed from the late 2nd century B.C., it seems more likely that the T-7433 tried to approximate the Roman *amphora quadrantal* of 26.2 liters.

Greco-Italics

As early as the second half of the 3rd century and the first half of the 2nd century B.C., local workshops produced imitations of Greco-Italic prototypes, probably to compete in regional markets with Roman imports. The lack of direct evidence, like faunal or botanical remains, epigraphy (*dipinti*) or archaeometric analyses, prevents us from determining whether these containers were intended for the transport of local wines or used for other products, such as preserved fish.

Even though a significant number of vessels (mostly fragments) have been unearthed in residential, artisan, and funerary contexts around the bay, there are only two complete or almost complete examples available to develop a tentative examination of the formal and volumetric standardization of these imitations. The regular-sized vessels of the series have total lengths around 55–60 cm and maximum diameters around 28–30 cm, in all cases with shared characteristics like top-shaped bodies and short necks differentiated by a marked carination. Also, an almost complete individual of reduced size was recorded in a context dating to the second half of the 3rd century B.C. within kiln 4 at the insular ceramic workshop of Torre Alta[58], where it had an estimated length of about 40 cm and a diameter of 19 cm. The examination of the capacities of these vessels suggests some degree of variability, at least for the larger ones, whose volumes are around 16.2 (fig. 9, 1) and 10.9 liters (fig. 9, 2), not far from the Punic (13.2 liters) and Roman patterns (13.1 liters, one *urna*). In turn, the small-sized example (fig. 9, 3) has a capacity of 5.57 liters, which brings it closer to the traditional Punic standard of 6.7 liters, but also to a capacity of 2 Roman *congii* (that is, 6.34 liters).

Late Greco-Italic or Dressel 1A

This form was probably developed from the Greco-Italic amphorae produced in local workshops in the previous decades but was also influenced by the continuous arrival of Italic materials to the Atlantic throughout the 2nd and 1st century B.C. Remarkable quantities of these vessels imitating the design of the Italic Dressel 1A and 1C were produced in the kiln sites of Gades from the end of the 2nd century B.C. until the late Republican period. The local Dressel 1C amphorae probably were produced over the period 90/80–40/30 B.C., strengthening the Romanization of the local repertoire together with the Ovoide Gaditana form (see below). Unfortunately, for the moment, there are no complete examples of Dressel 1C available, so it has not been possible to develop an in-depth evaluation of their formal and volumetric standardization patterns. In general, it has been assumed that these local imitations of Italic forms were related to the commercialization of local wine, though (as for their prototypes) it is possible that some of these amphorae were filled with liquid or semi-liquid fish products. Research conducted on some complete examples of ›pseudo-Dressel 1A‹ unearthed at Baelo Claudia[59] and Lisbon[60], and also some almost complete vessels from several shipwrecks and underwater sites, reveal the average capacity of this group as 21–22 liters, not far from the Roman *amphora quadrantal* of 26.2 liters.

Ovoide Gaditana Series

This series is the first fully Romanized provincial type dating to the middle decades of the 1st century B.C. (c. 80–40/30 B.C.), perhaps inspired by other successful series of Adriatic and African ovoid Republican amphorae with no local precursors. The usual contents of this type must have been fish sauces and salted fish, although their participation, at least sporadically, in the transport of local wines should not be ruled out[61]. It can be considered the direct precursor of the Dressel 7 and other related types mass-produced in the late Republican era that shared basic typological features (shape of the rims and toes, handles, body profile) but differed in maximum diameter (larger in this ovoid group) and in the neck-body transition (rounded and barely carinated in this series). The comparison established between both typological forms (ovoid and Dressel 7), as well as among a dozen profiles of Ovoide Gaditana (see fig. 7, with Dressel 7 in grey), clearly shows that the latter were manufactured following closely certain specific metrological parameters, introducing only small changes in length (differences of no more than 5–7 cm) and in the shoulders (rounded or slightly carinated).

The results of the calculations developed on 10 complete examples reveal significant data related to the capacity standard of this series: most of them are grouped around 28–33 liters, while only one exceeds this figure (36.1 liters), and two others have a volume of 24–24.5 liters. The average standard obtained is 29.96 liters. Given the small sample analyzed, it is difficult to

[58] Sáez 2008.
[59] Bernal-Casasola et al. 2007.
[60] Pimenta 2004.
[61] García – Sáez 2019.

explain the capacity variability within the series, although factors such as production of the type carried out at a large number of workshops and also chronological change (evolution of the profile and capacity until gradually giving rise to the first Dressel 7) can be suggested[62]. There is no convincing reasoning at present to define a large and small variant for the series, and it will be necessary to broaden the sample to verify the specific causes for this relative lack of uniformity in the capacity of the series. As for the Dressel 7, it is not clear whether the pattern applied to the design of their profiles and the measurement of their capacity corresponds to the standards for liquid (*amphora quadrantal*, 26.2 liters) or dry products (4 *modii*, 34.92 liters) since both options match their potential contents of salted fish and wine.

Dressel 7

This type is part of the well-known Dressel 7/11 family and can be considered the earliest and most expressive series of the newly developed ›provincial repertoire‹, which also included Dressel 9–10 and 12, as well as local Dressel 1C versions. These types were produced in Gades from ca. 40/30 B.C. until the mid-1st century A.D. Other versions of the same profile, such as Dressel 8, manufactured since the end of the 1st century B.C., represented more particular adaptations of the family that some authors have attributed to the activity of specific workshops in the Puerto Real area[63]. Archaeological evidence (faunal remains) and *tituli picti* suggest that fish products were the regular content of the series. The data available for Gallineras-Cerro de los Mártires and other workshops on the island of Cádiz or in the countryside of El Puerto de Santa María suggest a high level of standardization in terms of dimensions, main formal attributes (rims, toes, handles), and general design of profiles, indicating that the production of the entire bay in the late 1st century B.C. was probably governed by shared patterns, perhaps adapted to the morphology of the new and larger kilns and merchant ships[64].

Calculations developed so far for Dressel 7 examples from the initial stages of its manufacture suggest an average capacity of around 24–25 liters[65]. However, despite being close to the standard of the Roman *amphora* (26.2 liters), it is not clear whether the regulations for these amphorae could have been based on the measurement of dry volumes (perhaps two *modii castrenses*, equivalent to 25.83 liters) given that the contents could have been either liquids (*garum* or related fish products) or solids (whole small fish or chunks of salted fish). Further specific research will be needed to resolve these uncertainties, although there is no doubt about the connection with the Ovoide Gaditana in terms of profile design, which is less voluminous and more robust in Dressel 7 and 9–10, and the establishment of a local capacity standard from the beginning of the 1st century B.C. until imperial times.

A DIACHRONIC PERSPECTIVE ON FORMAL AND CAPACITY STANDARDIZATION IN GADIR/GADES IN THE FIRST MILLENNIUM B.C.

The data sets discussed in the previous sections, both the Levantine precursors and the local amphora types from much of the 1st millennium B.C., provide a solid basis to develop a first overview of the standardization of amphora shapes and the associated manufacturing and transport processes over an extensive duration between the Punic and Roman periods. This information also allows us to examine capacity standards and their evolution throughout different historical

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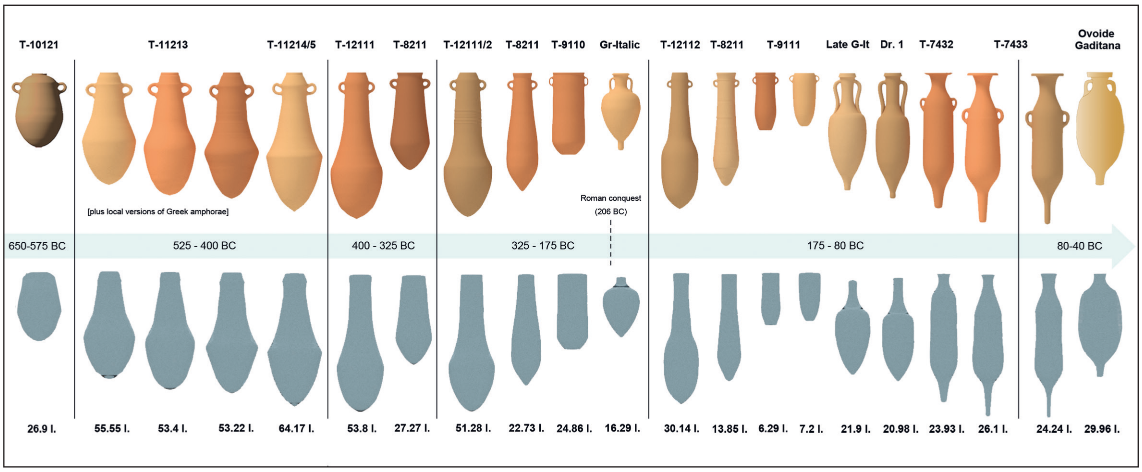
[62] However, assemblages such as the one provided by the Grand Conglué 3 wreck, dated to the mid-1st cent. B.C., demonstrate the existence of variable volumes within the amphorae included in the cargo: see Quillon – Luaces 2019, 301–303.

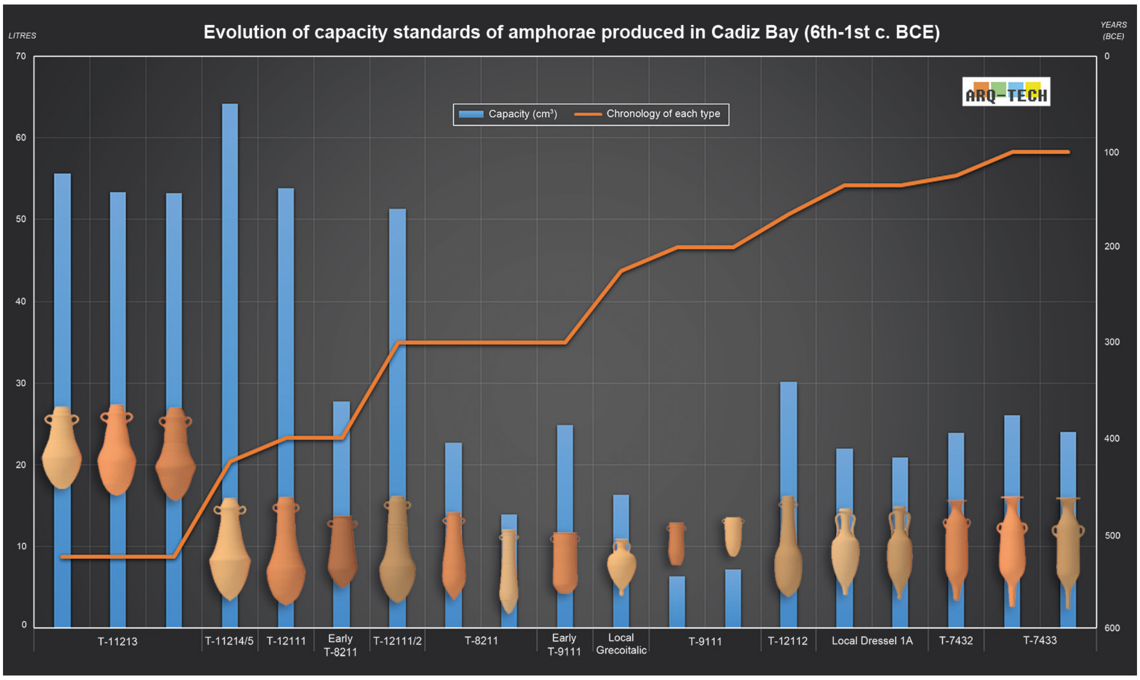
[63] García 2010, 588–593.

[64] See infra; preliminary data can also be found in García – Sáez 2018.

[65] García – Sáez 2018, 191 f.



10 Amphora types produced in Cádiz Bay from Phoenician to late Roman Republican times (from the late 7th to mid 1st century B.C.), with indication of the results of digital calculation of capacity standards of the main variants of successive historical stages (© by the authors)



11 Chronology, typology and capacity standards of local amphorae from early Punic to early Roman times. The graph aims to compare the three variables, reflecting changes in vessel typology that impact on adoption since the Roman conquest of different capacity standards to those of the Punic era (© by the authors)

phases and to identify distinctive metrological patterns that were the result of changes in amphora morphologies as well of the political and economic situation of the city (figs. 10. 11).

First, it is worth noting that there was a high degree of standardization in the shapes, dimensions, and attributes of all the series of local amphorae studied, dated between the end of the Archaic era and the late Roman Republican period. This indicates that throughout this long period of the city's life the production processes and models manufactured were subject to shared approaches that were probably set by local institutions to optimize the *chaîne opératoire* from production through transport. These data also suggest that in all these phases, groups of specialized, highly qualified craftsmen as well as stable infrastructures and operational sequences were involved in local amphora production and allowed for these formal standards to be reproduced, resulting in the manufacture during each annual production season of thousands of almost identical containers with the same characteristics in terms of fabrics, wall thicknesses, systems used to join the parts on the potter's wheel, etc.

Regarding the archaeometric study of the clays, the recent work carried out on the so-called Punic Amphora Building excavated at Corinth[66] has verified that the fabrics of the local amphorae were homogeneous in relation to the ›recipes‹ used throughout the entire period studied in this paper, and even after the Roman conquest. This archaeometric evidence further suggests that the *chaîne opératoire* relating to the supply of clays, tempers, and even the production of tools for turning, molding, sealing, and decorating, as components of consolidated artisan practices and habits, was also highly standardized. According to the available archaeological evidence, the same can be assumed for other key facets of the production processes and the essence of that craft tradition, such as the architecture of the kilns – building materials, sizes, number, and association in pairs/trios, etc. – and their maintenance and repair.

Additional evidence also suggests that standardization was developed not only for shapes but also for manufacturing processes and production organization, at least from the Hellenistic period. For example, archaeological support for this can be found in the systematic use of stamps with regular shapes and sizes (signet ring impressions), recorded in limited numbers but always placed in the same position for each type of amphora. In addition to the information provided by studies focusing on amphorae, research conducted on other local ceramics, such as finewares, cooking vessels, household plain wares, and even net weights, illustrates similar parameters of typological and volumetric standardization[67].

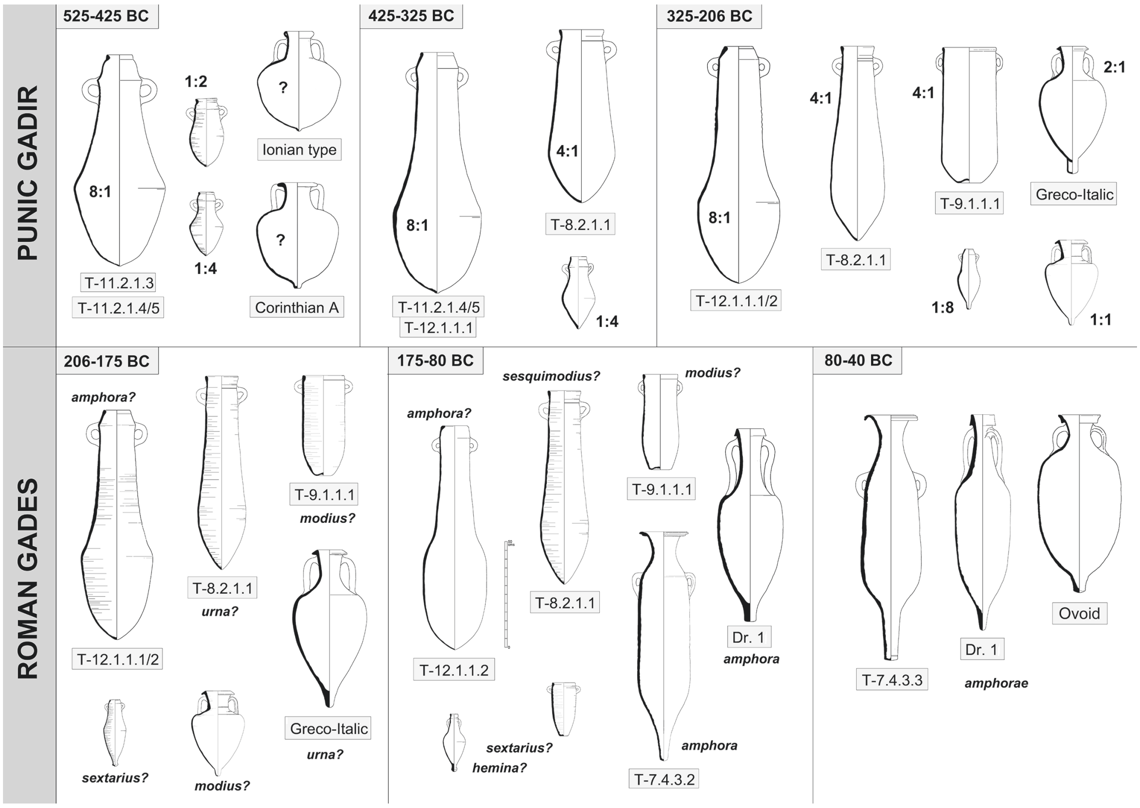
In short, there is no doubt that the amphorae of Gadir/Gades were formally and technologically standardized goods created by a large and sophisticated infrastructure and by the skills of specialized craftsmen that were equally standardized in terms of procedures and regulations, surely set by civil or religious authorities in charge of the city's government. A model with Levantine roots probably served as an inspiration for other coastal and inland cities in the south of the Iberian Peninsula and the Atlantic area.

The data set presented in the preceding sections is also revealing with regard to the origin and evolution of the metrological system that may have guided the design of the transport amphorae and other containers that reproduced the same profiles on a smaller scale. The evolution of the main local amphora series from the 6th to the 1st century B.C. shows that almost all types and variants fit within the Levantine standards until the end of the Second Punic War: the unit for volume, dry or liquid, can be identified with the *kaddu* defined for Ugarit and the Canaanite amphorae found at Uluburun. Not long after the Roman conquest, the T-12111/2 variant evolved, and the T-12112 type reduced by half its size and capacity, probably to follow the Roman *amphora* standard, illustrating the far-reaching changes in the capacity standard of local amphorae developed during the 2nd and 1st century B.C. (fig. 12). The amphora series created in the Far West in the 8th–7th century B.C. developed following the typological features and capacity standards of the Canaanite jar, so for the 6th century B.C., the local T-10121 amphora and its smaller versions fit perfectly in the Levantine system based on a theoretical unit of 6.7 liters.

During the late 6th and 5th century B.C., in a pre-monetary economic system, local T-11213 amphorae were produced in massive quantities as well as in half-sized variants and two series of miniature versions. The latter jars had reduced capacities that correspond to a ⅔ and ¼ of the Levantine unit (6.7 liters), and the full-scale transport amphorae had a capacity of eight units. Minor changes can be detected for the following phase, from the late 5th to the late 4th centu-

[66] More than 200 samples from the PAB and a large number of insular workshops of Cádiz Bay were analyzed: see Fantuzzi et al. 2020. For the Archaic period, see also Johnston 2015. For Hellenistic and Early Roman times, see Bernal-Casasola et al. 2016.

[67] Ramon et al. 2007; Sáez 2020; Sáez – Belizón 2020.



12 Diachronic synthesis of the evolution of local amphorae and their capacity standards between the 6th and 1st centuries B.C. (Punic proportions refer to a 6.7 liters unit) (© by the authors)

ry B.C. The T-12111 continued with the same pattern (eight units), and the miniaturized vessels were produced in two series of ¼ and ⅙ of the unit. The system also included new amphora types such as the T-8211 of 26–27 liters, which means that they had a capacity of four units. The Late Punic repertoire of the 3rd century B.C. repeats, in general terms, the same pattern. The miniature versions of T-12111 vessels reduced their capacity even more, now to an ⅛ of the unit, and the nascent local versions of Greco-Italic amphorae had an approximate capacity of two units (c. 14–16 liters). The creation of Gadir's coinage and the monetization of the local economy in the Late Punic period[68] apparently did not result in drastic changes in the production of amphorae and their capacity/weight standards.

Major changes only occurred after the Roman conquest of the area in 206 B.C. The available information for the Early Roman period is not explicit enough to define such changes, but it seems that the amphora capacities were reduced and that they all progressively tended toward the Roman *amphora* (liquid measure) or multiples of the *modius* (dry measure). At least two main stages have been observed for this Romanization of the local measurement system: a first one developed from the mid-2nd century B.C. to the Sertorian War in the early 1st century B.C.; and a second and more important stage, developed in the middle third of the 1st century B.C., which would end in the creation of the Augustan provincial (Baetican) amphora repertoire. During the process, throughout the last decades of the Roman Republic, the Punic typologies were dropped, and innovative Romanized profiles took over as the main forms within regional maritime trade; the new containers followed from the beginning the Roman standards.

In light of this new evidence, it seems quite clear that there was a quick adaptation to the Roman measurement systems even during the first Romanization stage. It is not so clear whether this

68 Alfaro 1988; García-Bellido 2013.

shift might have been the result of a commercial strategy or of Roman pressure on local elites, but the archaeological record describes how the local amphora repertoire became even more diversified and most of the emerging types fit within the Roman capacity system. Some of the types (T-9111, Greco-Italic, and miniatures) seem to follow the Roman *modius* from the beginning. For the latter half of the 2nd century and the first two decades of the 1st century B.C., changes are noticeable: all the local Late Punic types adapted their size to fit Roman capacity standards, with approximately one Roman *amphora* for the T-12112 type, a *sesquimodius* (1.5 : 1) for the T-8211 and around one *modius* for the T-9111 type. The series that were more successful in the late 2nd and early 1st century, local pseudo-Dressel 1A and T-7433, were produced from the start according to Roman standards, namely one Roman *amphora* of 24–26 liters, or three *modii*).

A second and more intense momentum of Romanization occurred after the Sertorian conflict in Hispania. Local coinage evolved and introduced Latin inscriptions after the mid-1st century B.C.; the same happened with stamps on local amphorae, which show both neo-Punic and Latin inscriptions with short versions of the names of the elites involved in the businesses. The amphora repertoire for the middle of the 1st century B.C. included both amphorae continuing from the previous period and a newly created series, probably inspired by central Mediterranean profiles, that became the most important transport vessel of the period. In any case, all of them – Ovoide Gaditana, Dressel 1A/C and T-7433 – were produced following Roman capacity standards based on the *amphora* of 26.2 liters.

To conclude these final remarks, a quick reflection on the case of the Ovoide Gaditana will illustrate the difficulties and limitations of the conclusions that can be drawn for the moment regarding the process of metrological and typological Romanization of the local repertoire during the 1st century B.C. and why the production of ovoid forms was introduced in Gades. The whole repertoire and all production infrastructures and transport systems were already adapted to the Punic-style tubular profiles, stacking systems, and volume standards. Introducing the production of ovoid types could be understood as an ›uneconomical‹ practice, perhaps developed for other reasons that have nothing to do with the implementation of technological improvements or measuring regulations aimed at increasing productivity. The presence of Italic agents, or the need to adapt to their markets or military consumption-transport systems, could be behind their introduction in Gades, a well-known phenomenon in a largely ›containerized‹ Roman Mediterranean[69].

In this regard, some data are revealing about the process of introduction for these shapes inspired by the African and south Italic repertoire of the time and their incorporation into the local commercial structure, until then dominated only by the export of food products carried in T-7433 and local versions of Dressel 1. Despite the available archaeological evidence clearly showing that the three series were manufactured between c. 80/70 and 40 B.C. in the same workshops (Gallineras, Cerro de la Batería, Jardín de Cano, Verinsur, La Caleta area, etc.[70]), certain wrecks reveal a different organization: while some examples, like La Chrétienne M2 or Les Moines 2[71] from the first half of the 1st century B.C., carried shipments composed exclusively of T-7433 and Dressel 1 from Gades and other coastal cities of the Strait of Gibraltar region, other shipwrecks of the same period, such as Grand Conglué 3[72], mostly transported ovoid vessels and minor quantities of other containers (early Dressel 12 [?]). This could be a reflection of the process of change that took place in the kiln sites of southern Hispania during the early decades of the 1st century B.C. and the gradual transition from a metrological practice and infrastructures (kilns, warehouses, ships, etc.) adapted to Punic local shapes and volumes to other standards closer to the Roman regulations and to the new technological innovations that were applied from that time onwards in the facilities related to the fish-processing industry and maritime trade.

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69 Bevan 2014.

70 For a significant example associated with several kilns, vats, and pits at Jardín de Cano in El Puerto de Santa María, see López 2010.

71 Luaces 2016; Luaces – Sáez 2019.

72 Quillon – Luaces 2019.

The comparison with the first series of Dressel 7/11 amphorae from the Augustan or early imperial period, manufactured in many cases in the same workshops as the containers of the first half or mid-1st century B.C., shows that in the final phase of the Republican period, the two formal trends (ovoid and cylindrical) must have converged. The containers in the Punic tradition and the Dressel 1 versions were not produced thereafter, giving rise to a series with an ovoid profile but much more stylized, with a smaller maximum diameter (especially in the Dressel 7 and 8), longer spikes, necks, and handles, and slightly narrower mouths. It is likely that by this time both the workshops, which now show a general replacement of their kilns, and the merchant ships would have evolved in a synchronized manner to coordinate stacking/loading criteria and to optimize the entire *chaîne opératoire* and selling of the salted fish and other foodstuffs carried in the local amphorae.

These critical changes were developed at the same time as other significant shifts in the local maritime-oriented economy, such as a technological Romanization of the infrastructures (fish-processing facilities, kiln sites, etc.)[73] and merchant ships, the consolidation of the landscape dominated by *villae* in the territory of Gades[74], and the development of metrological and iconographic changes in local coinage[75].

JUST A FIRST REGIONAL STEP: ONGOING AND FUTURE RESEARCH

Even if we focus on this case study in the regional setting, many complementary aspects and related issues should be addressed in the future to achieve a refined understanding of the typological and volumetric evolution of the local amphora repertoire and to connect it with historical milestones, changes in other metrological systems (dry volume standards, weights, etc.), and other case studies across the Mediterranean world (and, in particular, within the Levantine and Carthaginian spheres).

A first obvious matter is to increase the number of contextualized examples of complete profiles to strengthen our methodological foundations and to expand the analysis to the miniature vessels that have been found in significant quantities on the coast northwest to present-day Cádiz[76]. The increased availability of complete amphorae will not only make it possible to examine a greater number of profile variants and typological features and to obtain new results from the calculation of their transport capacities but will also extend the data relating to the average weights of the containers themselves. At the moment, the results on this aspect are very limited apart from the 14 kg weight on average for the T-11213 type, so it is not possible yet to establish connections with other variables, such as the width of the walls, the total dimensions of the parts, or the total theoretical weight calculated from their load capacity.

Closely related to this topic, through using our replicas and more advanced software, the weight of filled amphorae should be explored to clarify possible connections with the monetization process (which did not start in Gadir before the late 4th or early 3rd century B.C.[77]) and local weight standards[78]. Given that a preliminary overview of the theoretical capacities and weights of all local amphora types is now available, including their divisions and miniature forms, some ideas can be advanced on key aspects of this complex relationship of volume-weight standards for amphorae and coins. At least since the late 6th and throughout the 5th century B.C., the average capacity of the T-11213 group matches the Syrian *kaddu* pattern, suggesting that the capacity of these amphorae was a unit of volume around 26 liters (equal to c. 27 kg, i.e., an Ugaritic talent of 28.2 kg). As shown in figure 9, regular-sized T-11213 amphorae would have carried 52–55 liters,

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73 Sáez – García 2019.
74 García 1998; Sáez 2008.
75 Alfaro 1994.
76 Higueras-Milena – Sáez 2018.
77 Alfaro 1988.
78 Some results were first published in Sáez – Moreno 2017 and later developed, focusing on the case study of T-11213 amphorae and the first series of local coinage, in Moreno – Arévalo 2017.

with half-sized versions approaching that unit (or at least 20–21 liters) and some of the miniature vessels suggesting a standard of around 1.6 liters (i.e., 1⁄16 of the unit). In summary, the available information for the Late Archaic period indicates that a rich and complex (duodecimal or hexadecimal) system of weights and volumes from the Levantine-Syrian-tradition was already in use in the city, involving not only the larger containers but also a wide range of reduced versions probably also involved in commercial and fish-processing businesses.

The capacity of the long T-11214/5 type of the late 5th and early 4th century B.C. represents an exception within the evolution of this system that is still difficult to explain satisfactorily: most examples examined show an average capacity of 60–64 liters. A similar atypical result has been linked to type PE-11 for the case of 5th-century B.C. amphora production of Punic Ibiza, a volume that might fit with three times the unit defined by Ramon as the Tyrian *bath* of the Iron Age (c. 22.6 liters)[79]. In any case, after this short interval, which seems to coincide with a notable crisis in the salted-fish business after the loss of the Aegean markets[80], the local amphora repertoire of the 4th and 3rd centuries B.C. seems to fit without trouble into the Syrian pattern defined for the 5th century B.C. As shown in figures 8–9 and 12, the T-12110 and T-8211 types suggest that the regular-sized vessels of both groups were designed to carry, respectively, 51–54 liters and 23–27 liters, which would be equal to c. 55 and 28 kg, again reproducing the relation with the Ugaritic talent of 28.2 kg. Other less known types characteristic of the last moments of the Punic phase of the city, such as the T-9111 type, can be integrated into this same capacity standard. Therefore, the amphora repertoire of the 4th and 3rd century B.C. provides robust archaeological support for examining the process of transmission of the ›Syrian standard‹ – already in use in the southwest of the Iberian Peninsula from at least the Archaic period[81] – to the first local coinage of the late 4th or early 3rd century B.C., as already proposed based on the study of 5th-century B.C. balance weights found in Cancho Roano (Badajoz)[82].

As we have seen in the previous sections, changes in typology and capacity standards followed quickly after the Roman conquest in 206 B.C. Most of the containers manufactured locally, both those of Punic tradition and versions of Roman amphorae of the 2nd century B.C., seem to take the Roman *amphora* (26.2 liters) as the reference for capacity[83]. The adaptation of the forms and volumetric capacities in the local repertoire seems to accelerate and reach completion throughout the middle decades of the 1st century B.C., finally crystallizing with the late Republican or early Augustan creation of the Dressel 7/11 series and the local variants of the Dressel 12. The parallel changes in the Gadir/Gades coinage and volume standards suggest that there may have been a connection between both aspects, as parts of the same administrative and economic system. Although they kept their legends in Punic until the 1st century B.C., the local bronzes of the 2nd and early 1st century B.C. (series VI, defined by Alfaro Asins[84]) present notable stylistic differences, and above all a change in the metrological pattern to a standard of 10/11 g. It is likely that both changes are a consequence of the adaptation of the city to the standards of the Roman Republican world and that they are in turn related to the evolution of the supply needs of markets, production infrastructures, and means of transport. Progress on this discussion and amphorae and coins will

79 Ramon 1991, 129.

80 Sáez 2018b.

81 As has been suggested based on the study of balance weights and metal hoards: see Vilaça 2011; Mora 2006. Recently it has been proposed that the introduction of the system took place during the early stages of the Iberian Iron Age, and that regional late Punic mints could have followed a Carthaginian standard rather than the ›Syrian standard‹ (see Pappa 2019). For a wider perspective on the Iberian case, see Ialongo – Rahmstorf 2019.

82 García-Bellido 2003, 145–147 (a 9.4 g *shekel*); García-Bellido (2013, 38–42) proposed that this ›Syrian standard‹ could have been a ›vehicular language‹ for the multicultural communities settled in southwest Iberia, but that it would not exclude the parallel use of other systems on a local/regional scale. Our developments seem to support her assumption that Gadir must have played a major role in the dissemination and normalization of the use of this standard in the south of Iberia and the Atlantic sphere.

83 Jedrzejewski 1999.

84 Alfaro 1988, 81–85. 127 f.; Alfaro 1994, 62.

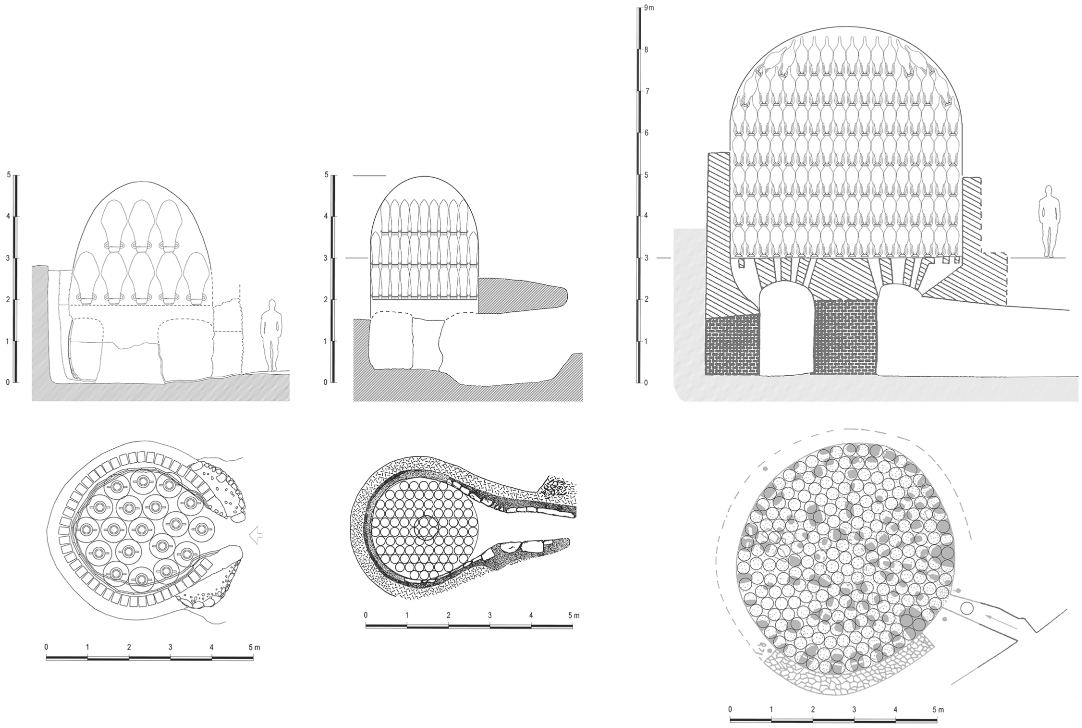
be useful for studying in more detail other aspects, such as the theoretical number of amphorae that were loaded in a regular-sized merchant ship, in combination with new finds and excavations in Punic or Late Punic wrecks.

Another element that has traditionally been considered a possible source of information on administrative control systems for local amphora production is the corpus of stamps documented on a small number of individuals. However, the most recent research[85] rules out that at least the oldest series of these labels do not provide any information on aspects such as the shape or capacity of the containers; nor does it seem that the function of these labels was to guarantee both aspects within the official standards of the city. On the contrary, it seems that they are personal seal impressions made with signet rings and linked to relevant public figures, wholesalers, or groups involved in the fish-processing business or in ceramic production itself. Nevertheless, it would be worthwhile to study other types of marks in greater depth, such as painted inscriptions or graffiti engraved on some local amphorae both before and after firing, which could indicate, through letters as numbers or more complete and explicit descriptions, the capacity in weight or volume attributed to these containers. In any case, this is a complex detective task since a very limited number of graffiti have so far been published[86] that could potentially provide such information.

In addition to examining the evidence related to capacity standards, aspects related to amphora production technology, the standardization of firing and transportation processes, and their relationship to the choice of certain types and volumes at various historical times will also merit attention in the coming years. A specific project will delve into these key aspects of the manufacture and commercialization of Punic and Turdetanian amphorae throughout the late Iron Age. The »Ergasteria Project« (2020–2022)[87] will focus on the vessels and pottery kilns as well as on the theoretical productivity rate of the workshops and maritime shipments. Some preliminary work has already dealt with these issues by addressing the formal and size evolution of both amphorae and kilns between the 6th century B.C. and the 1st century A.D. in the Bay of Cádiz. The results of these first experiments to recreate in 2D and 3D the kilns and their loading systems indicate that during this period the shape of the containers became gradually smaller and more compact – more stackable – and that the kilns decreased during the late Punic phase and then multiplied in their capacity exponentially from the time of Augustus[88], as can be seen in figure 13, based on examples from Camposoto[89], Torre Alta[90], and Puente Melchor[91]. The next steps in the project are to go beyond the theoretical outcomes and to build a fully operational kiln that will allow the production of amphorae, and thus providing the opportunity to test the results obtained so far from drawings and the use of digital tools.

Closely related to this, the project aims to expand the analysis to the *modus operandi* for loading the amphorae within merchant ships and how the amphora typologies could have influenced changes in the design of ships' hulls and vice versa. Clearly, considering the limited information available on pre-Roman shipwrecks in the region[92], an important step ahead will be to calculate how many amphorae could have been shipped in each vessel and how many firing processes were necessary to produce a complete load. Finally, we are exploring literary and epigraphic evidence – for example, fish lists – to calculate the value of a full Punic amphora, a first step towards the estimation of the price for a full shipment. We hope that these many lines of research will

85 Sáez 2014a; Sáez et al. 2021.
86 See an unusual example of a western Phoenician inscription painted on an amphora possibly referring to a capacity measurement in Zamora 2014; Zamora 2014.
87 Funded by the University of Seville, Junta de Andalucía, and the EU-FEDER Program (Ref. US-1266376), the project will be based at the Cerro Macareno site (Seville), see <http://ergasteria.us.es/> (01. 04. 2023).
88 Sáez – Moreno 2017; García – Sáez 2018.
89 Ramon et al. 2007.
90 Muñoz – De Frutos 2006.
91 Lavado 2004.
92 Sáez 2014b.



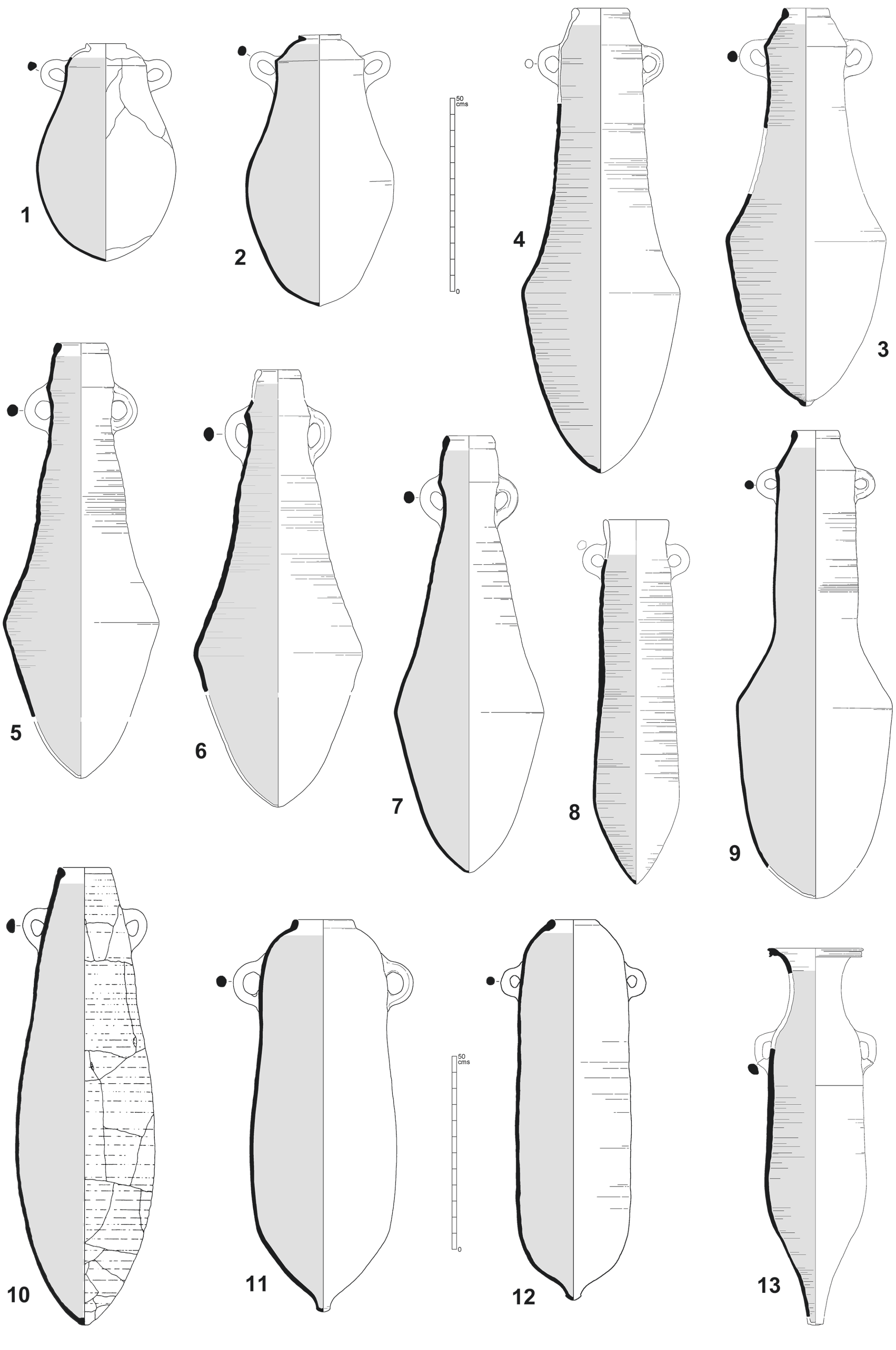
13 Comparison of the theoretical firing capacity and the stacking system of amphorae in Punic (left), Late Punic (centre) and 1st century A.D. kilns (right) excavated in the Bay of Cádiz (© by the authors)

produce substantial results in the coming years and converge on a deeper technical knowledge of amphora production in the Bay of Cádiz throughout the 1st millennium B.C.

In addition to continuing the investigations of this case study in the Bay of Cádiz in the near future, our intention is to expand the analysis to other major amphora production areas of the region and to set up alternative models for comparison with our results. Unfortunately, at the moment, the quantity and quality of the information available for the case of Gadir/Gades cannot be found in any other coastal area of the region for the entire 1st millennium B.C., but we are sure that Málaga and nearby coastal cities could provide enough contextual, typological, and archaeometric data for Phoenician, Punic, and Early Roman times. A significant number of kiln sites have been excavated there since the 1980s[93], but the typological and chronological study of the local amphorae has not yet been as refined as for the case of Cádiz Bay[94]. Even so, we are currently developing the study of some kiln contexts in the area and a first attempt at applying the same methods to calculate the local capacity standards of the amphorae to verify if their source and evolution were similar to those described by Gadir's archaeological record.

A few sites, such as Cerro del Villar[95] and Avenida Juan XXIII[96] (near Málaga), consumption contexts overseas, such as La Fonteta[97] (Guardamar del Segura, Alicante) or the Punic Amphora Building at Corinth[98], and some underwater sites and wrecks, which include finds from the Estepona and Benalmádena coast[99] (near Málaga), have provided a first sample to test our calculation methodology with reliable drawings (fig. 14). The first results obtained provide significant data

93 Aubet et al. 1999; Arancibia et al. 2012.
94 See recent approaches in Mateo 2015; Chacón et al. (in print).
95 Aubet et al. 1999.
96 Arancibia et al. 2012; Chacón et al. (in print).
97 González 2011.
98 Sáez et al. 2020.
99 Sáez 2014b; Sáez 2016.



14 Phoenician, Punic and Turdetanian amphorae produced in other areas of the south of the Iberian Peninsula: T-10121 (1), T-10221 (2), T-11214 (4), T-11216 (5-7), T-12111 (3 and 9), T-8211 (8) and T-7433 (13) probably produced in kiln sites on the coast of Málaga; T-8112/Tiñosa (10) and Pellicer D (11–12) vessels possibly fired in kilns located along the Guadalete Valley or the northern area of Cádiz province (© by the authors)

for both the Phoenician period and later phases, covering a varied group of types whose fabrics – some of which are the subject of archaeometric analysis[100] – suggest their production in Málaga or other port cities on the Velez-Málaga coast. For example, the T-10121 produced in Cerro del Villar in the first half of the 6th century B.C. suggests a capacity of around 21.2 liters, though the T-10221 vessels fired in the same area and in Vélez-Málaga indicate that by the mid-6th century B.C., the average capacity of Málaga's amphorae had already reached around 28.5 liters.

For the Punic and Late Punic periods, the novelties raised by this first approach are also quite significant. A fragmentary example of type T-11214 found at Corinth and dated to the middle decades of the 5th century suggests that for that period the average capacity of the series would have been less than 50 liters (39.2 liters for the example in fig. 14, 4). Some T-11216 vessels from diverse unpublished underwater contexts dating to the second half of the 5th century B.C. (fig. 14, 5–7) also indicate that the regular capacity of that type was 48.5 liters. It is worth noting that at the early and mid-5th century B.C. kiln sites in Gadir, T-11213 amphorae were being fired with an average capacity of 52–53 liters, and this figure increased to 58–60 liters with the development of T-11214/5 throughout the late 5th and early 4th century B.C. Some other examples belonging to type T-12111 found also in underwater sites located near Estepona and Benalmádena show a similar pattern since the approximate calculation of their capacities indicates that during the 4th and 3rd centuries B.C., these series of Málaga must have carried around 43 (fig. 14, 4) to 47.5 liters (fig. 14, 9).

Another underwater discovery, without context but with typological features that suggest a date in the 3rd or 2nd century B.C., indicates that not all the series in the Málaga area were separate from the Gadir/Gades patterns: an almost complete T-8211 with a capacity of around 12.9 liters (fig. 14, 8). The fragmentary examples examined for the case of type T-7433, produced in the suburban ateliers that surrounded Málaga in the late 2nd and early 1st century B.C., suggest a capacity for the series of around 15–16 liters (15.9 liters for the vessel in fig. 14, 13), significantly lower than the 24–26 liters of those produced in Cádiz Bay in the same period.

The information about the Málaga area indicates that its standards of capacity and some formal and technical details of the local transport amphorae do not match with the evolution known for the Bay of Cádiz. In this sense, the significant differences detected between the local series of T-11210 and T-12111 in both areas are remarkable, as both groups seem to maintain similar but significantly different capacity patterns throughout the 5th, 4th, and 3rd centuries B.C. It is difficult at this initial stage of the research to find historical explanations for this phenomenon, apart from the fact that the Málaga area had developed its own craft and economic practices since Phoenician times and probably played a predominant role in regional trade in the Alboran Sea. It does not seem that during the 2nd and 1st century B.C. a pan-regional series such as T-7433, already produced according to Roman commercial patterns, contributed to unifying the capacity standards and typological features of the amphorae of the main port cities on the Strait of Gibraltar.

It seems likely that in the future when it is possible to reproduce and extend these calculation experiments to other cities of the Strait of Gibraltar region (Carteia, Lixus, Seks, or Baria, etc.), the results will show an even more varied and complex setting for the local particularities of volumes and technical characteristics of transport containers of the Phoenician tradition. In this sense, it is worth considering the results of the pioneering studies carried out in Ibiza by J. Ramon Torres, who calculated the capacities of several of the main Ibizan types from drawings or by means of direct physical measurements[101]. Ramon considered that the basic unit of reference should be the Tyrian *bath* of about 22.6 liters and that multiples or divisions of this standard fit well with the series manufactured on the island between the end of the 5th and the 3rd century B.C. Ebusitan trade expanded significantly and reached the Straits of Gibraltar from the end of the 5th and during the 4th century B.C. It is therefore important to bear in mind that T-1323 (PE-13), T-8111 (PE-14), and

[100] Fantuzzi et al. 2020.
[101] Ramon 1991, 127–130.

T-8121 (PE-15) amphorae seem to have had maximum capacities of around 40–45 liters, although there were also versions of less than 17–23 and 7–9 liters.

Consequently, it is worth taking into account that the Málaga T-10121, T-11210, and T-12111 vessels also seem to fit the *bath* defined by Ramon for Ibiza, involving regular-sized units with a capacity of around 40–47 liters, and then reflecting on whether that was the result of local Phoenician tradition or Ibizan/Carthaginian influence, a voluntary adaptation to a Classical/Hellenistic Mediterranean scenario dominated by Carthage or some other possible motivation. In any case, given the clear differences between the capacity standards of Gadir/Gades and Málaga/Ibiza, it is evident that the procedures and metrological traditions of the Atlantic city were probably different from those of the Phoenician-Punic cities on the Mediterranean side of the Strait of Gibraltar region and the central Mediterranean, at least since the diversification of the post-colonial amphora typologies developed in the second half of the 6th century B.C.

Undoubtedly, the questions raised by these first results go far beyond the study of amphorae. It is worth asking if the production of smaller and more easily manufactured amphorae was the result of the lack of ability of local craftsmen to create larger vessels to meet Cádiz Bay standards, a clear indication of the desire to distinguish themselves from Gadir, an intention to fit in with foreign volume standards (Carthaginian, Greek, etc.), or factors unrelated to the amphorae themselves, such as stacking systems in kilns or holds of ships that were different from those used at Gadir. These are undoubtedly key aspects that will have to be addressed in the future within the framework of the »Ergasteria Project« and others that focus on the examination of the Málaga coast in the Phoenician, Punic, and Late Punic periods.

Similar uncertainties and intriguing questions can be raised concerning the comparison of data from Gadir/Gades with the typological and capacity standards of the amphora repertoires of the main fluvial centers of Turdetania. From at least the mid-5th century B.C., not only the products packaged in local amphorae were important for the maritime trade from Cádiz Bay; large numbers of amphorae coming from the inland areas of the Lower Guadalquivir region, the Jerez countryside, and the Guadalete Valley were also distributed along regional and Mediterranean routes by Gadir's merchant fleet, together with their own vessels and products. This economic interdependence, particularly relevant during the 4th and 3rd centuries B.C.[102], pushed us to expand our analysis to the Turdetanian amphora types produced in Punic and Late Punic times[103]. Only a few complete examples have been published, and consequently just a few can be discussed as a sample for future research that should focus on the topic. The preliminary results suggest that both typological features and capacity standards in these fluvial valleys were not homogeneous, pointing to a similar pattern of uniformity/diversity to that observed for Gadir and other coastal Punic cities that shared a joint Phoenician tradition but interpreted it with particular local features and measures. In general terms, the Turdetanians, or the communities that inhabited the countryside around Cádiz Bay, employed a different capacity standard system than the one used in Gadir.

A significant case is that of the Tiñosa/T-8112 containers, produced in unidentified potteries in the countryside, perhaps in the territories of Asta, Asido, and other cities in the center and north of the current province of Cádiz, and used mainly for the marketing of olive oil[104]. The standard form of the series reproduces in profile and measures the shape of the Ibizan T-8111 type, and according to our calculations, its capacity is also close to the same (around 42 liters; fig. 14, 10). On the other hand, the productions of the Guadalete and perhaps the surroundings of the bay itself offer limited but very significant data. The Pellicer D amphorae were probably fired in many workshops from the late 4th to the 2nd/1st century B.C.[105] and show diverse capacities for the 3rd century B.C.: the older versions reach a maximum capacity of around 70 liters (fig. 14, 11), although those dating

102 Sáez 2018a.

103 A complete update on these amphora groups and the micro-regional circuits and typologies can be found in several works included in García – Sáez 2020.

104 Carretero 2007.

105 Niveau de Villedary 2002; Sáez – Niveau de Villedary 2016.

to the Second Punic War found at Castillo de Doña Blanca have capacities calculated at around 52 liters (fig. 14, 12). Since contemporary T-12110 amphorae are also around 51–52 liters, was the Pellicer D group adapted during the Carthaginian episode to the standards of Gadir? Was it a local choice seeking more profit on that commercial relationship or a change resulting from military occupation?

Certainly, there is still a world to be measured and compared on a regional and Mediterranean scale, and much more research is still necessary to clarify the capacity patterns in each port city or main *oppidum* of the Far West. With this work, we have sought not only to provide data on one of the main case studies of the region, probably its main economic pillar between the ›6th-century B.C. crisis‹ and the Roman Imperial period, but also to draw attention to a line of research that has been completely forgotten in recent decades. We hope to be able to continue providing new information in the near future and to answer as far as possible some of the questions raised in these pages.

BIBLIOGRAPHY

Alberti et al. 2006 — M. E. Alberti – E. Ascalone – L. Peyronel, Weights in Context. Bronze Age Weighing Systems of the Eastern Mediterranean: Chronology, Typology, Material and Archaeological Contexts (Rome 2006).

Alberti – Parise 2005 — M. E. Alberti – N. Parise, Towards a Unification of Mass-Units between the Aegean and the Levant, in: R. Laffineur – E. Greco (eds.), EMPORIA. Aegeans in the Central and Eastern Mediterranean, Aegaeum 25 (Liège 2005) 381–391.

Alfaro 1988 — C. Alfaro Asins, Las monedas de Gadir/Gades (Madrid 1988).

Alfaro 1994 — C. Alfaro Asins, SNG. España. Museo Arqueológico Nacional. I. Hispania. Ciudades Feno-púnicas. Parte 1: Gadir y Ebusus (Madrid 1994).

Arancibia et al. 2012 — A. Arancibia Román – C. Chacón Mohedano – B. Mora Serrano, Nuevos datos sobre la producción anfórica tardopúnica en *Malaca*: el sector alfarero de la margen derecha del río Guadalmedina (Avda. Juan XXIII), in: B. Mora – G. Cruz (coords.) La etapa neopúnica en Hispania y el Mediterráneo centro occidental: identidades compartidas (Sevilla 2012) 391–412.

Aubet et al. 1999 — M. E. Aubet Semmler – P. Carmona – E. Curia – A. Delgado – A. Fernández – M. Párraga, Cerro del Villar I. El asentamiento fenicio en la desembocadura del Guadalhorce y su interacción con el hinterland, Monografías de la Junta de Andalucía (Sevilla 1999).

Behrendt – Mielke 2010 — S. Behrendt – D. P. Mielke, Provenienzuntersuchungen mittels Neutronenaktivierungsanalyse an phönizischer Keramik von der iberischen Halbinsel und aus Marokko, MM 52, 2010, 139–237.

Bernal-Casasola et al. 2007 — D. Bernal-Casasola – A. Arévalo González – A. M. Sáez Romero, Nuevas evidencias de la ocupación en época republicana (ss. I–II a.C.), in: A. Arévalo – D. Bernal (eds.), Las cetariae de Baelo Claudia. Avance de las investigaciones arqueológicas en el barrio industrial (2000–2004), Monografías de Arqueología, Junta de Andalucía (Sevilla 2007) 239–355.

Bernal-Casasola et al. 2016 — D. Bernal-Casasola – M. Kbiri Alaoui – A. M. Sáez Romero – J. J. Díaz Rodríguez – R. García – M. Luaces, Atlas de pastas cerámicas del Círculo del Estrecho (APAC). En busca de nuevas herramientas arqueológicas para la identificación visual de talleres alfareros, in: R. Járrega – P. Berni (eds.), Amphorae ex Hispania: paisajes de producción y consumo. III Congreso Internacional de la Sociedad de Estudios de la Cerámica Antigua (SECAH), Ex Officina Hispana (Madrid 2016) 362–375.

Bettles 2003 — E. Bettles, Phoenician Amphora Production and Distribution in the Southern Levant: A Multi-Disciplinary Investigation into Carinated-Shoulder Amphorae of the Persian Period (539–332 BC), BARIntSer 1183 (Oxford 2003).

Bevan 2014 — A. Bevan, Mediterranean Containerization, Current Anthropology 55, 4, 2014, 387–418.

Botto 2014 — M. Botto, Los fenicios en la Bahía de Cádiz: estrategias de poblamiento y de aprovechamiento del territorio, relaciones con el mundo indígena, comercio (siglo IX – finales del siglo VII/inicios del VI a.C.), in: M. Botto (ed.), Los Fenicios en La Bahía de Cádiz. Nuevas investigaciones. Collezione di Studi Fenici 46 (Pisa) 265–281.

Carretero 2007 — P. Carretero Poblete, Agricultura y Comercio Púnico-Turdetano en el Bajo Guadalquivir. El inicio de las explotaciones oleícolas peninsulares (siglos IV–II a.C.), BARIntSer 1703 (Oxford 2007).

Cateloy 2016 — C. Cateloy, Trade and capacity studies in the eastern Mediterranean: the first Levantine trade amphorae, in: S. Demesticha – A. B. Knapp (eds.), Maritime Transport Containers in the Bronze–Iron Age Aegean and Eastern Mediterranean, SIMA 183 (Uppsala 2016) 39–55.

Chacón et al. (in print) — C. Chacón Mohedano – A. Arancibia Román – A. M. Sáez Romero – B. Mora Serrano, Amphorae Production in Punic and Late Punic Malaka (Málaga, Spain). New Evidence from the Carranque – Juan XXIII Area, 1st Amphoras in the Phoenician-Punic World – The State of the Art, AncNearEastSt Suppl. (in print).

Docter 1992 — R. F. Docter, Amphora Capacities and Archaic Levantine Trade, HambBeitrA 15–17, 1992, 143–188.

Elayi 1997 — A. G. Elayi, Studies in Phoenician Weights (Paris 1997).

Fantuzzi et al. 2020 — L. Fanzuzzi – E. Kiriatzi – A. M. Sáez Romero – N. Müller – C. K. Williams, Punic amphorae found at Corinth: Provenance analysis and implications for the study of long-distance salt-fish trade in the Classical period, Archaeological and Anthropological Sciences 12, 2020; DOI: 10.007/s12520-020.01093-3

Finkelstein et al. 2011 — I. Finkelstein – E. Zapassky – Y. Gadot – D. M. Master – L. E. Stager – I. Benenson, Phoenician ›Torpedo‹ Amphoras and Egypt: Standardization of Volume Based on Linear Dimensions, AegLev 21, 2011, 249–259.

García – Sáez 2020 — F. J. García Fernández – A. M. Sáez Romero (eds.), Las ánforas turdetanas »tipo Macareno« cuarenta años después: actualización tipológica y nuevas perspectivas (Sevilla 2020).

García 1998 — E. García Vargas, La producción de ánforas en la Bahía de Cádiz en época romana (ss. II a.C.–IV d.C.) (Écija 1998).

García 2010 — E. García Vargas, Ánforas béticas de época augusteo-tiberiana. Una retrospectiva, in: A. M. Niveau – V. Gómez (Coords.), Las necrópolis de Cádiz. Apuntes de arqueología gaditana en homenaje a J. F. Sibón Olano (Cádiz 2010) 581–624.

García – Sáez 2018 — E. García Vargas – A. M. Sáez Romero, Todo el pescado vendido. Una lectura cuantitativa de la producción púnica y romana de sal y salazones en la Bahía de Cádiz, in: J. Remesal Rodríguez – V. Revilla Calvo – J. M. Bermúdez Lorenzo (coords.), Cuantificar las economías antiguas. Problemas y métodos, Instrumenta 58 (Barcelona 2018) 153–204.

García – Sáez 2019 — E. García Vargas – A. M. Sáez Romero, Ovoid amphorae production in the Bay of Cádiz and the southern coast of the Ulterior/Baetica (Late Republican and Early Imperial periods), in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. M. Sáez Romero (eds.), The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 112–147.

García-Bellido 2003 — M. P. García-Bellido, Los ponderales y sus funciones económica y religiosa, in: S. Celestino (ed.), Cancho Roano IX. Los materiales arqueológicos, II (Mérida 2003) 127–155.

García-Bellido 2013 — M. P. García-Bellido, Los sistemas ponderales en el mundo púnico de Iberia e Ibiza, in: B. Costa – J. H. Fernández (eds.), La moneda y su papel en las sociedades fenicio-púnicas, XXII Jornadas de Arqueología fenicio-púnica (Ibiza 2013) 35–60.

González 2011 — A. González Prats, Las ánforas (tipos 1 a 6), in: A. González Prats (ed.), La Fonteta. Excavaciones de 1996/2002 en la colonia fenicia de la actual desembocadura del río Segura. Guardamar del Segura (Alicante) (Alicante 2011) 291–374.

Grace 1956 V. Grace, The Canaanite Jar, in: S. Weinberg (ed.), The Aegean and the Near East. Studies presented to Hetty Goldman (New York 1956) 80–109.

Grace 1961 V. Grace, Amphoras and the Ancient Wine Trade. Excavations of the Athenian Agora. Picture Book 6 (Princeton, NJ 1961).

Heltzer 1996 M. Heltzer, The ›unification‹ of weight and measure system in foreign trade in the Eastern Mediterranean (1500–700 BCE), Michmanim 9, 1996, 31–38.

Henin 2007 D. Henin, Ancient Scale Weights and Pre-Coinage Currency of the Near East (New York 2007).

Higueras-Milena – Sáez 2018 A. Higueras-Milena Castellano – A. M. Sáez Romero, The Phoenicians and the Ocean: trade and worship at La Caleta, Cádiz, Spain, IntJNautA 47, 1, 2018, 81–102.

Ialongo 2018 N. Ialongo, The earliest balance weights in the West: Towards an independent metrology for Bronze Age Europe, CambrAJ 29 (1), 2018, 103–124.

Ialongo – Rahmstorf 2019 N. Ialongo – L. Rahmstorf, The identification of balance weights in pre-literate Bronze Age Europe: Typology, chronology, distribution and metrology, in: L. Rahmstorf – E. Stratford (eds.), Weights and Marketplaces from the Bronze Age to the Early Modern Period 1 (Göttingen 2019) 105–126.

Jedrzejewski 1999 F. Jedrzejewski, Le nombre et la mesure: Logique des classifications métriques et prémétriques (Paris 1999).

Johnston 2015 P. A. Johnston, Pottery production at the Phoenician colony of El Castillo De Doña Blanca (El Puerto De Santa María, Spain) C. 750–550 BCE (PhD thesis Harvard University 2015).

Karasik – Smilansky 2006 A. Karasik – U. Smilansky, Computation of the capacity of pottery vessels based on drawn profiles – Appendix 1 A to Chapter 12, in: A. Mazar (ed.), Excavations at Tel Beth Shean 1989–1996, I (Jerusalem 2006) 1–4.

Kletter 1998 R. Kletter, Economic Keystones. The Weight System of the Kingdom of Judah, Journal for the Study of the Old Testament Supplement Series 276 (Sheffield 1998).

Kletter 2014 R. Kletter, Vessels and Measures: The Biblical Liquid Capacity System, IEJ 64, 1, 2014, 22–37.

Knapp – Demesticha 2017 A. Knapp – S. Demesticha, Mediterranean Connections. Maritime Transport Containers and Seaborne Trade in the Bronze and Early Iron Ages (New York 2017).

Koehler – Wallace 1987 C. G. Koehler – M. B. Wallace, The transport amphoras: description and capacities, in: C. Pulak – R. F. Townsend, The hellenistic shipwreck at Serçe Limani, Turkey: preliminary report, AJA 91, 1987, 49–57.

Kotsonas 2014 A. Kotsonas, Standardization, variation, and the study of ceramics in the Mediterranean and beyond, in: A. Kotsonas (ed.), Understanding Standardization and Variation in Mediterranean Ceramics: mid 2nd to late 1st millennium BC (Louvain 2014) 7–24.

Kroll 2008 J. Kroll, Early Iron Age balance weights at Lefkandi, Euboea, OxfJA 27, 1, 2008, 37–48.

Lavado 2004 M. L. Lavado Florido, El complejo industrial de Puente Melchor: el centro productor, la organización del espacio y su área de influencia, in: D. Bernal-Casasola – L. Lagóstena Barrios (eds.), Congreso Internacional Figlinae Baeticae. Talleres Alfareros y producciones cerámicas en la Bética romana (ss. II a.C.–VII d.C.), BARIntSer 1266, I (Oxford 2004) 473–488.

Lawall 2006 M. L. Lawall, Consuming the West in the East: Amphoras of the western Mediterranean in the Aegean befote 86 BC, in: D. Malfitana – J. Poblome – J. Lund (eds.), Old pottery in a new century. Innovating perspectives on Roman Pottery Studies. Actas del Congreso Internacional (Catania, 22–24 abril 2004), Monografie IBAM 1 (Catania 2006) 265–286.

López et al. 2008 J. J. López Amador – D. Ruiz Mata – J. A. Ruiz Gil, El entorno de la Bahía de Cádiz a fines de la Edad del Bronce e inicios de la Edad del Hierro, in: O. Arteaga – H. D. Schulz (eds.), Geoarqueología y proceso histórico en la Bahía de Cádiz, RAtlMed 10 (Cádiz 2008) 215–236.

López 2010 E. López Rosendo, Los talleres alfareros del Jardín de Cano (El Puerto de Santa María). La producción cerámica de Gades en torno al cambio de era, ReiCretActa 41, 2010, 411–419.

Luaces 2016 M. Luaces, Nuevos datos sobre la difusión de las ánforas tardopúnicas hispanas: algunos casos de estudio franceses, in: R. Járrega Domínguez – P. Berni Millet (eds.), Actas del III Congreso Internacional de la Sociedad de Estudios de la Ceramica Antigua (SECAH), Ex Officina Hispana. Amphorae ex Hispania: paisajes de produccion y consumo (Madrid 2016) 699–712.

Luaces – Sáez 2019 M. Luaces – A. M. Sáez Romero, Late Punic amphorae in »Roman« shipwrecks of southern Gaul: the evidence of a trading route from the Atlantic and the Strait of Gibraltar region to the Tyrrhenian Sea, in: A. Peignard-Giros (ed.), Daily Life in a Cosmopolitan World. Pottery and Culture during the Hellenistic Period. Proceedings of the 2nd Conference of the International Association for Research on Pottery of the Hellenistic Period (University of Lyon 2, 5th –8th November 2015) (Vienna 2019) 143–157.

Mateo 2015 D. Mateo Corredor, Producción anfórica en la costa malacitana desde la época púnica hasta el periodo julioclaudio, Lvcentvm 34, 2015, 183–206.

Michailidou 2005 A. Michailidou, Weight and Value in Pre-Coinage Societies: An Introduction (Athens 2005).

Michailidou 2008 A. Michailidou, Weight and Value in Pre-Coinage Societies II. Sidelights on Measurement from the Aegean and the Orient (Athens 2008).

Monroe 2016 C. M. Monroe, Measure for ›measure‹: connecting text to material through Late Bronze Age shipping jars, in S. Demesticha – A. Knapp (eds.) Maritime Transport Containers in the Bronze–Iron Age Aegean and Eastern Mediterranean, SIMA 183 (Uppsala 2016) 79–96.

Mora 2006 B. Mora Serrano, Metrología y sistemas monetarios en la Península Ibérica (siglos V–I a.C.), Actas del XII Congreso Nacional de Numismática (Madrid – Segovia, 25–27 octubre 2004) (Madrid 2006) 23–61.

Moreno – Arévalo 2017 E. Moreno Pulido – A. Arévalo González, ¿Cómo medían en Gadir? Pesos y volúmenes entre los siglos V y III a.C., Byrsa. Scritti sull'Antico Oriente Mediterraneo 29–32, 2017, 171–210.

Muñoz 1993 A. Muñoz Vincente, Las cerámicas fenicio-púnicas de origen submarino del área de la Caleta (Cádiz), Cuadernos de Prehistoria y Arqueología Castellonenses 15, 1993, 287–333.

Muñoz – De Frutos 2006 A. Muñoz Vicente – G. De Frutos, El complejo alfarero de Torre Alta en San Fernando (Cádiz). Campaña de excavaciones de 1988. Una aportación al estudio de la industria pesquera en la Bahía de Cádiz en época tardopúnica, I Conferencia Internacional Historia de la Pesca en el ámbito del Estrecho (1–5 junio de 2004, El Puerto de Santa María) II (Sevilla 2006) 705–803.

Niveau de Villedary 2002 A. M. Niveau de Villedary, Las ánforas turdetanas del tipo Pellicer-D. Ensayo de clasificación, Spal 11, 2002, 233–252.

Pappa 2019 E. Pappa, The metrological system of the Final Bronze Age balance weights and the pre-Roman coinage of Atlantic Iberia: a shared Syrian standard?, Journal of Ancient History and Archaeology 6, 1, 2019, 60–80.

Parise 2006 N. Parise, Equivalencias entre las antiguas unidades ponderales en Oriente y las primeras especies monetarias de Occidente, Actas del XII Congreso Nacional de Numismática (Madrid – Segovia, 25–27 ottobre 2004) (Madrid 2006) 15–22.

Pedrazzi 2005 T. Pedrazzi, Misure di capacità fra Egeo e Levante durante la tarda Età del Bronzo: il contributo delle anfore, Agoge 2, 2005, 55–66.

Pedrazzi 2007 T. Pedrazzi, Le giare da conservazione e trasporto del Levante: Uno studio archeologico dell'economia fra Bronzo Tardo II e Ferro I (ca.1400–900 A.C.) (Pisa 2007).

Pimenta 2004 J. Pimenta, As ânforas romanas do Castelo de São Jorge (Lisboa), Trabalhos de Arqueologia 41 (Lisbon 2004).

Poigt 2018 — T. Poigt, Weighing premonetary currency in the Iberian Iron Age, in: D. Brandherm – E. Heymans – D. Hofmann (eds.), Gifts, Goods and Money. Comparing currency and circulation systems in past societies (Oxford 2018) 105–130.

Poigt 2019 — T. Poigt, De poids et de mesure. Les instruments de pesée en Europe occidentale aux âges des Métaux (XIV[e]–III[e] s. av. n.è.): conception, usages et utilisateurs (PhD thesis Université Toulouse Jean Jaurès 2019).

Pulak 1998 — C. Pulak, The Uluburun shipwreck: an overview, IntJNautA 27, 1998, 188–224.

Pulak 2000 — C. Pulak, The Balance Weights from the Late Bronze Age Shipwreck at Uluburun, in: C. F. E. Pare (ed.), Metals Make the World Go Round. The Supply and Circulation of Metals in Bronze Age Europe (Oxford 2000) 247–266.

Pulak 2001 — C. Pulak, The cargo of the Uluburun ship and evidence for trade with the Aegean and beyond, in: L. Bonfante – V. Karageorghis (eds.), Italy and Cyprus in Antiquity 1500–450 BC. The Costakis and Leto Severis Foundation (Nicosia 2001) 13–60.

Quillon – Luaces 2019 — K. Quillon – M. Luaces, The diffusion of south-Hispanic ovoid amphorae in Gaul, between the Late Republican and Early Empire time, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. M. Sáez Romero (eds.), The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 298–313.

Ramon 1991 — J. Ramon Torres, Las ánforas púnicas de Ibiza, Trabajos del Museo Arqueológico de Ibiza y Formentera 23 (Ibiza 1991).

Ramon 1995 — J. Ramon Torres, Las ánforas fenicio-púnicas del Mediterráneo Central y Occidental, Instrumenta 2 (Barcelona 1995).

Ramon 2004 — J. Ramon Torres, La producción anfórica gaditana en época fenicio-púnica, Actas de los XVI Encuentros de Historia y Arqueología de San Fernando. Las industrias alfareras y conserveras fenicio-púnicas de la bahía de Cádiz (Córdoba 2004) 63–100.

Ramon et al. 2007 — J. Ramon Torres – A. Sáez – A. M. Sáez – A. Muñoz, El taller alfarero tardoarcaico de Camposoto, Monografías de Arqueología 26 (Sevilla 2007).

Ruiz 1986 — D. Ruiz Mata, Castillo de Doña Blanca (Puerto de Santa María, prov. Cádiz): Stratigraphische Untersuchung einer orientalisierenden Ansiedlung, MM 27, 1986, 87–115.

Ruiz – Pérez 1995 — D. Ruiz Mata – C. J. Pérez Pérez, El poblado fenicio del Castillo de Doña Blanca (El Puerto de Santa María, Cádiz) (El Puerto de Santa María 1995).

Ruiz-Gálvez 2000 — M. L. Ruiz-Gálvez, Weight Systems and Exchange Networks in Bronze Age Europe, in: C. F. E. Pare (ed.), Metals Make the World Go Round. The Supply and Circulation of Metals in Bronze Age Europe (Oxford 2000) 267–279.

Sáez 2008 — A. M. Sáez Romero, La producción cerámica en Gadir en época tardopúnica (siglos -III/-I), BARIntSer 1812 (Oxford 2008).

Sáez 2014a — A. M. Sáez Romero, Fish Processing and Salted-Fish Trade in the Punic West: New Archaeological Data and Historical Evolution, in: E. Botte – V. Leitch (eds.), Fish & Ships: Production et commerce des salsamenta durant l'Antiquité, Bibliothèque d'Archéologie Méditerranéenne et Africaine 17 (Aix-en-Provence 2014) 159–174.

Sáez 2014b — A. M. Sáez Romero, Estudio de las ánforas de un pecio púnico inédito de la costa de Málaga, in: X. Nieto – A. Ramírez – P. Recio (eds.), I Congreso de Arqueología Náutica y Subacuática Española (ARQVA, Cartagena, 14–16 marzo 2013) (Madrid 2014) 36–50.

Sáez 2016 — A. M. Sáez Romero, Ánforas del tipo T-12111 inéditas del litoral de Málaga, Boletín de la SECAH 7, 2016, 11–14.

Sáez 2018a — A. M. Sáez Romero, ¿Tipologías mediterráneas vs. tipologías locales? Valoraciones metodológicas a partir de una nueva propuesta de sistematización de la producción anfórica gaditana, in: R. Járrega Domínguez (ed.), Estudios sobre ánforas hispanas, Ex Officina Hispana. Cuadernos de la SECAH 3 (Madrid 2018) 39–80.

Sáez 2018b — A. M. Sáez Romero, Apuntes sobre las dinámicas comerciales de Gadir entre los siglos VI y III a.C., Gerión 36, 1, 2018, 11–40.

Sáez 2020	A. M. Sáez Romero, Pesca e instrumental pesquero en el mundo fenicio-púnico, in: J. M. Vargas (ed.), El instrumental de pesca en el Fretum Gaditanum: Catalogación, análisis tipo-cronológico y comparativa regional, Archaeopress (Oxford 2020) 164–167.
Sáez – Belizón 2020	A. M. Sáez Romero – R. Belizón Aragón, ¿Qué se cuece? Evolución formal, estándares de capacidad y análisis funcional de las cerámicas »de cocina« fenicio-púnicas de Gadir, in: C. Gómez Bellard – G. Pérez – A. Vendrell (eds.), La alimentación en el mundo púnico: producciones, procesos y consumos, Spal Monografías (Sevilla 2020) 197–240.
Sáez et al. 2014	A. M. Sáez Romero – D. Bernal Casasola – A. I. Montero, La producción anfórica tardopúnica de Gadir (s. II–I a.C.). Nuevos datos aportados por el alfar de C/ Asteroides (San Fernando, Cádiz), in: A. M. Arruda (ed.), Fenícios e Púnicos, por terra e mar. Actas do VI Congresso Internacional de Estudos Fenícios e Púnicos II (Lisbon 2014) 866–878.
Sáez – García 2019	A. M. Sáez Romero – E. García Vargas, La producción y comercio de ánforas y conservas de pescado en la Bahía de Cádiz en época fenicio-púnica. Nuevos datos, métodos y enfoques para viejos debates, in: A. Álvarez Melero – A. Álvarez-Ossorio Rivas – G. Bernard – V. A. Torres González (Coords.), Fretum Hispanicum. Nuevas perspectivas sobre el Estrecho de Gibraltar durante la Antigüedad (Sevilla 2019) 23–71.
Sáez – Moreno 2017	A. M. Sáez Romero – E. Moreno Pulido, Contando la historia. Experiencias de cuantificación y análisis volumétrico en centros artesanales púnicos de la Bahía de Cádiz, AEspA 90, 2017, 219–246.
Sáez – Niveau de Villedary 2016	A. M. Sáez Romero – A. Niveau de Villedary, Pellicer D (Costa de Ulterior/Baetica), Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/pellicer-d-baetica-ulterior-coast> (03. 06. 2020).
Sáez et al. 2020	A. M. Sáez Romero – T. Theodoropoulou – R. Belizón Aragón, Atunes púnicos y vinos egeos en una taberna de la Grecia Clásica. Resultados iniciales del Corinth Punic Amphora Building Project, IX Congreso Internacional de Estudios Fenicios y Púnicos/International Congress of Phoenician and Punic Studies (MYTRA 5) (Mérida 2020) 799–818.
Sáez et al. 2021	A. M. Sáez Romero – J. A. Zamora López – F. J. García Fernández – M. F. Palma, Una nueva estampilla púnica procedente de las excavaciones de la Biblioteca Municipal de Mértola (Portugal): Interrogantes y perspectivas en el estudio del sellado anfórico occidental, MM 62, 2021, 388–429.
Sauvage 2006	C. Sauvage, Warehouses and the economic system of the city of Ugarit: the example of the 80 jar deposit and deposit 213 from Minet el-Beida, UF 38, 2006, 1–13.
Stern et al. 2008	B. Stern – C. Heron – T. Tellefsen – M. Serpico, New investigations into the Uluburun resin cargo, JASc 35, 2008, 2188–2203.
Vilaça 2011	R. Vilaça, Ponderais do Bronze Final-Ferro Inicial do ocidente peninsular: novos dados e questões em aberto, in: M. P. García-Bellido – L. Callegarin – A. Jiménez (eds.), Barter, money and coinage in the Ancient Mediterranean (10th–1st centuries BC), Anejo AEspA 58 (Madrid 2011) 139–167.
Wallace 1986	M. B. Wallace, Progress in measuring amphora capacities, in: J.-Y. Empereur – Y. Garlan (eds.), Recherches sur les amphores grecques, BCH Suppl. 13 (Athens 1986) 87–94.
Wallace – Wallace 1982	P. M. Wallace-Matheson – M. B. Wallace, Some Rhodian amphora capacities, Hesperia 51, 1982, 293–320.
Zamora 2000	J. A. Zamora López, La vid y el vino en Ugarit (Madrid 2000).
Zamora 2003	J. A. Zamora López, El ›ánfora cananea‹ y las medidas de capacidad en el oriente mediterráneo de la Edad del Bronce Final, Spal 12, 2003, 231–257.
Zamora 2014	J. A. Zamora López, Un testimonio epigráfico inédito procedente del Puig des Molins (Ibiza): un dipinto fenicio-púnico sobre ánfora con una posible indicación metrológica, in: C. Ferrando – B. Costa (eds.), In amicitia. Miscellània d'Estudis en Homenatge a Jordi H. Fernández (Ibiza 2014) 133–148.

Zapassky et al. 2006 E. Zapassky – I. Finkelstein – I. Benenson, Ancient standards of volume: negevite Iron Age Pottery (Israel) as a case study in 3D modeling, JASc 33, 2006, 1734–1743.

Zapassky et al. 2009 E. Zapassky – I. Finkelstein – I. Benenson, Computing abilities in antiquity: the royal Judahite storage jars as a case-study, Journal of Archaeological Method and Theory 16, 2009, 51–67.

Zapassky et al. 2012 E. Zapassky – Y. Gadot – I. Finkelstein – I. Benenson, An Ancient Relation between Units of Length and Volume Based on a Sphere, PLoS ONE 7 (3): e33895; DOI: 10.1371/journal.pone.0033895

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AMPHORAE FROM BAETICA AND STANDARDIZATION PROCESSES

MODELS AND TRENDS

Abstract
Southern Spain was the area of the Iberian Peninsula where the largest quantities of amphorae were produced during the Roman and Late Antique periods. This vast production is not only evidenced in the huge amount of south Hispanic or Baetican amphorae found in their reception markets but also in the archaeological evidence related to its production in Baetica itself. The number of amphora workshops documented to date from the Punic period to Late Antiquity in the inland and coastal areas finds no comparison in any other ancient region. Those workshops produced many different amphora types used for the commodities exported by the Baetican territories, with olive oil and fish sauces being the most important among them. In this paper, it is our aim to analyze the evolution of their standardizing process, from new forms and the formal success of some of them, seen in the maintenance of certain volumetric, formal, and petrographic characteristics, to some of the most important amphora types of the Roman period, always having in mind the influence of the historical, economic, and social changes suffered by the Roman and Late Antique world. Two essential moments deserve special attention: The Augustan-Tiberian era as the foundation of the early imperial Baetican economy, based on Baetica as the main supplier of the state, and the Tetrarchy as an early step toward a new role for Baetica within the Late Antique economic system.

In the following pages, the most important south Hispanic amphora types are described and selected as case studies for the decisive historical periods. Origin and cause of changes in formal and volumetric characteristics, as well as of scale of production and diversity of markets, are analyzed and seen from the perspective of the close relationship between content and container, with both being necessarily transformed in highly standardized commodities, easily recognizable, and able to penetrate any external market.

INTRODUCTION

Hispania Ulterior, later Baetica, is one of the regions of the Roman Empire best known for its enormous amphora production, with long-lived pre-Roman antecedents (Phoenician-Punic and Turdetanian) and activity extending until the 5th century A.D. and to a lesser degree into the 6th century in some geographical areas. In this huge area, which we commonly treat in a unique and integrated way, diverse economic and productive models are hidden, especially if we take into account its territorial extent and the coexistence of *figlinae* active on the coast and in the interior, which highlight oil production in the valleys of the Guadalquivir and Genil rivers, *garum* on the coast, and wine in both areas. Generalization is therefore not simple, although we can see a process of typological convergence mainly throughout the 1st century B.C., crystallizing during the time of Augustus and continuing until approximately the time of Diocletian. From the 4th century onward, this standardization trajectory reverses, reducing volumes slightly but centering on a model involving distinctly larger and smaller types, similar to the phenomenon seen in African production[1].

In this paper we will analyze in particular the following aspects through sample case studies. Initially focusing on the production of wine as well as *garum* and *salsamenta*, we will highlight the great changes evident from the time of Caesar and during the preceding decades, a period

[1] Bernal-Casasola – Bonifay 2010; Bonifay 2016.

in which both the coast and the interior began mass production of ovoid forms that responded to the demand to meet amphora standards and the ›internationalization‹ of trade. During the 1st and 2nd century A.D., each geographical area improved the efficiency of its amphorae, resulting in a suitable repertoire in which regional differences can be observed with respect to ›families‹ or provincial patterns. The aspect of wholesale exchange – the overall volume of a load rather than the load of an individual jar – must be assessed in detail, given the impossibility – or lack of necessity – of mass production of the containers. Future studies need to address metrology and standards, which are still in a very early stage of inquiry.

We think it is important to abandon the concept of ›prototype‹, commonly used for the first olive oil amphorae of Baetica, in light of evidence from the outset for genuine standard forms with a well-defined commercial purpose. In these standardization processes, the interests of the state are evident (military supply of the German border, among other factors) but so too are the needs of private commercial agents (both in the manufacture of packaging and in its labeling), making it necessary to keep in mind that standardization could serve as a guarantee for the client. In this context, imitations can be associated with the commercial guarantee they offer for the product's marketing (compare, for example, the concept of a patent). Metrological studies show the evolution over time of containers adapting to the changing standards of different historical periods from the 1st century throughout the 2nd century and into the Severan period.

Finally, structural changes in later amphora production occurred in Baetica from the 3rd century A.D., with the appearance of models inspired by foreign models like the so-called La Orden type from Huelva and others. We will also consider the genesis of a typological *koiné* that extends beyond the provincial limits, generating common – or very similar – repertoires in the south-Spanish area (Lusitania-Baetica) and even covering the shores of Mauretania Tingitana. This trend of shared types across regions eventually gives way again to specifically regional shapes.

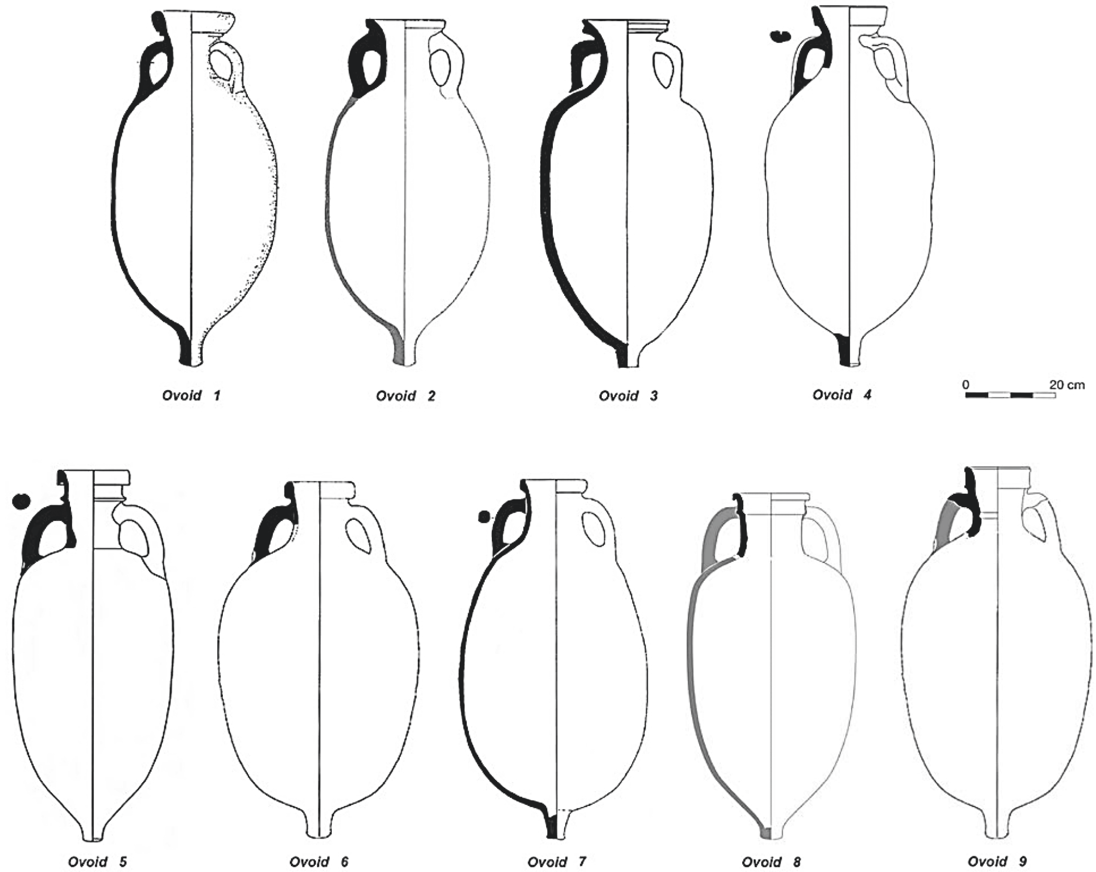
HISPANIA ULTERIOR BAETICA (2ND AND 1ST CENTURY B.C.): A TIME OF EXPERIMENTATION

The complexity of amphorae in Hispania Ulterior and Baetica is such that one hundred years of work have only managed to define the existing types, to assign them a general content, and to suggest an area of production[2]. This reality is complex, not only regarding the types of amphorae produced but also the cultural traditions that predated the full ›Romanization‹ of ceramic repertoires and their ›provincialization‹[3] – if these terms may be used. We can distinguish three such traditions: Punic (on the coast), Turdetanian (in the interior of the Guadalquivir Valley), and Roman (in both locations).

The oldest of these traditions is the Phoenician-Punic[4]. Ongoing work is addressing the volume standards of containers for pre-Roman salted fish products[5]. The types within this group are analyzed by A. Sáez et al. in this volume[6]. Recent work has made the first quantitative estimates concerning the production of pottery workshops in Cádiz before the Roman period[7]. These estimates are based on 2D and 3D reconstructions and aim to establish the productive capacity of each kiln, the total number of workshops in the city, the overall annual capacity of the whole sector, and the volume of product that could be stored.

Research on quantitative issues and the standardization of production on the coast of Baetica and in the Guadalquivir Valley during the Early Empire is less well developed, with the important exception of the oil amphorae in the Guadalquivir Valley (see below). Nevertheless, as a result of

[2] García – Bernal-Casasola 2008.
[3] Almeida 2008; García 2009; García et al. 2011; García et al. 2019.
[4] Ramon 1995; Sáez 2008; 2018; García – Sáez 2018.
[5] Sáez – Moreno 2017.
[6] See infra, chap. 3.
[7] García – Sáez 2019.



1 Ovoid types produced in Ulterior/Baetica (from: García et al. 2019, 100 fig. 22)

recent work[8], we can offer some figures for the productive capacity of pottery workshops in the Cádiz region from the Augustan period onwards. The evidence suggests that during the early imperial period production increased at least six-fold compared to that during the middle centuries of the Punic period (5th to early 2nd cent. B.C.).

In recent years, we have been focusing on the processes of standardization of regional production, especially in relation to Romanization processes during the final century of the Republic[9]. This affected both the interior and the coastal areas. Concerning the coast, we are beginning to have a clearer understanding of the transition between Punic and Roman productions[10]. Here, after a period of predominance of Italian shapes (Greco-Italic and Dressel 1), regional forms inspired by Italian prototypes start appearing in the 2nd century B.C., as the evidence from Baelo Claudia first demonstrates; later, they are recognized in several kiln sites, always in small percentages (less than 10 %)[11]. The same process of transition from pre-Roman Turdetanian to Roman shapes is attested in the interior of the Guadalquivir Valley, where a complex family of ovoid amphorae inspired by Adriatic models, especially those from the Brindisi area, is known from the 1st century B.C. (fig. 1)[12].

8 García – Sáez 2018.
9 García et al. 2011; González et al. 2018; García et al. 2019.
10 García – Sáez 2019.
11 See García 1998; Bernal-Casasola et al. 2003; Bernal-Casasola et al. 2013, 364–366.
12 Almeida 2008; García et al. 2011; García et al. 2019.

The ›Cádiz ovoid amphorae‹ as well as the Guadalquivir ovoid amphorae of the 1st century B.C. follow the trend toward ovoid shapes documented at that time across the whole of the Mediterranean, but especially in the central and western Mediterranean. These are relatively heterogeneous, in terms of both morphology and volume. In the last decades of the 1st century B.C., a tendency towards simplification and formal standardization can be seen both on the coast and in the Guadalquivir Valley[13]:

- In the coastal workshops we find, by the Augustan era, the end of the process leading from ovoid amphorae to the Dressel 7–11 group, which still presents some morphological variability and can be divided into at least four or five well-defined types[14].
- By the end of Julio-Claudian period, the standardization of the last types of the group (Dressel 10 and 11) is developed.
- Finally, the Beltrán II type, already well developed in the 1st and throughout the 2nd century A.D., remains morphologically simpler and standardized thanks to the industrialization of production and growth in the size of ceramic workshops.

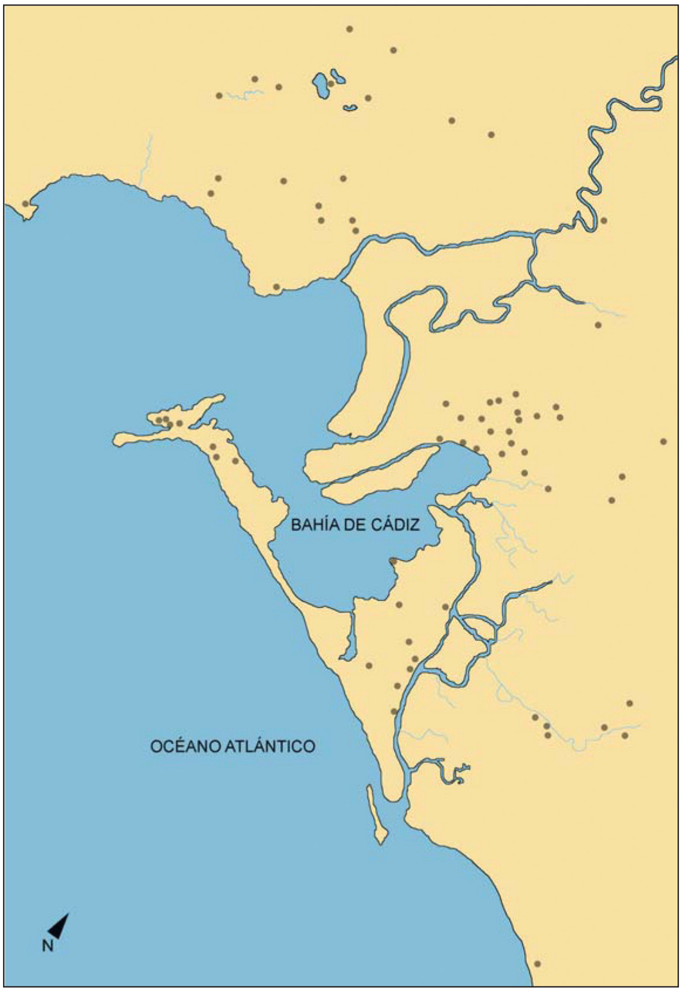
The wide geographical distribution of coastal workshops – extending nearly 800 km from the Guadiana River to the modern province of Almería to the east (fig. 2 a) – introduces some morphological and technological variation[15]. The fact that these amphorae were used to store and transport products that were beyond the control of the imperial *annona* also may have contributed to them being less standardized than, for instance, the Dressel 20 type, which was also from Baetica. Similarly, our current knowledge allows us to track the morphological evolution of coastal containers into the 3rd century and beyond, as is pointed out at the end of this chapter.

A parallel process of formal standardization is attested for the interior of the Guadalquivir Valley. We shall focus here on wine amphorae since oil amphorae will be addressed in the second part of this chapter. From a morphological repertoire inspired by the ovoid fashion (Guadalquivir ovoid shapes), we move on to a highly simplified and standardized picture dominated by the so-called Haltern 70 type. These shapes largely reflect the evolution of the Republican Ovoid 4 shape, which in the Augustan period superseded all other ovoid shapes in the Guadalquivir, with the exception of the Oberaden 83 and Haltern 71 amphorae. Finally, the study of the numerous amphora inscriptions (*tituli picti*) from coastal productions for salted products demonstrates that the same process of standardization also affected epigraphic formulae throughout the 1st century A.D.

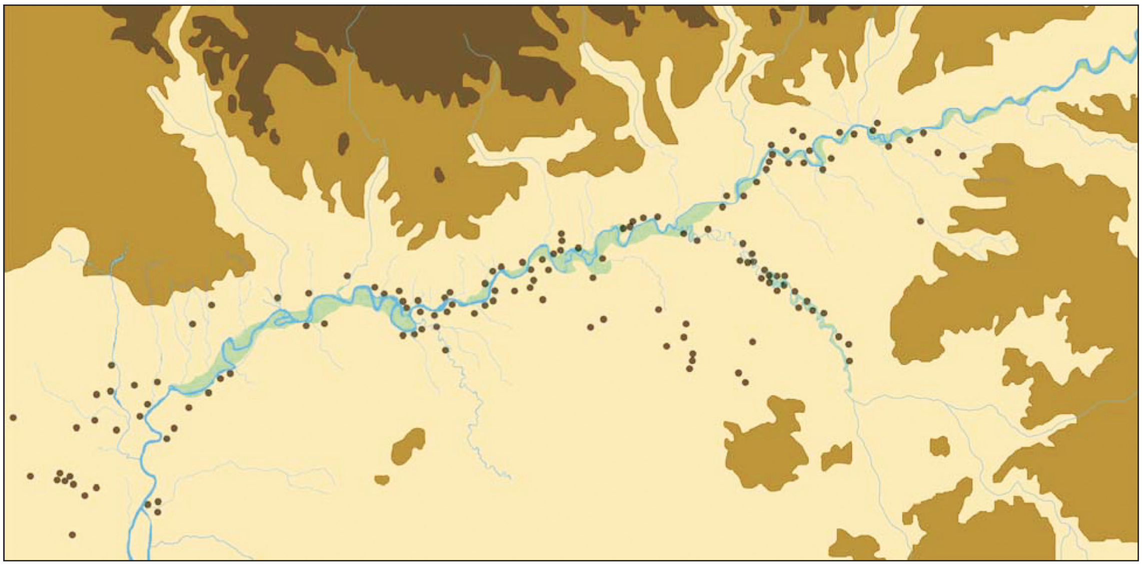
AN EXCELLENT EXAMPLE OF STANDARDIZATION: EARLY IMPERIAL OLIVE OIL AMPHORAE

Baetican amphorae illustrate the massive scale of export of Spanish olive oil during the Roman Empire and can be used as an ideal case study to analyze the phenomenon of standardization and the changes these containers experienced over time. The production of these oil containers spans a period of just over five centuries, between the final years of the Republic and the decades immediately following the collapse of the western Roman Empire[16]. During this time, different olive oil amphorae were produced in a chronological sequence; they have been given different names by researchers, but all of them are connected, and most of them were produced in the same geographical region or even at the same kiln sites. Each type was in production for a certain period of time and presents a gradual morphological evolution punctuated by sharp changes in both shape and size. Some of these transformations were driven by functional (i.e., substitution of an ovoid shape for a globular shape) or metrological considerations (i.e., introduction

13 García 2010.
14 García 1998; García – Sáez 2019.
15 Díaz – Bernal-Casasola 2018, 10 fig. 1.
16 Berni 1998, 24 fig. 3.



A



B

2 Maps showing the highest concentrations of amphora kiln sites in Baetica, either in the Bay of Cádiz (A) and in the Guadalquivir Valley (B), according to maps published by Díaz – Bernal-Casasola 2017, 145 fig. 2; 151 fig. 5

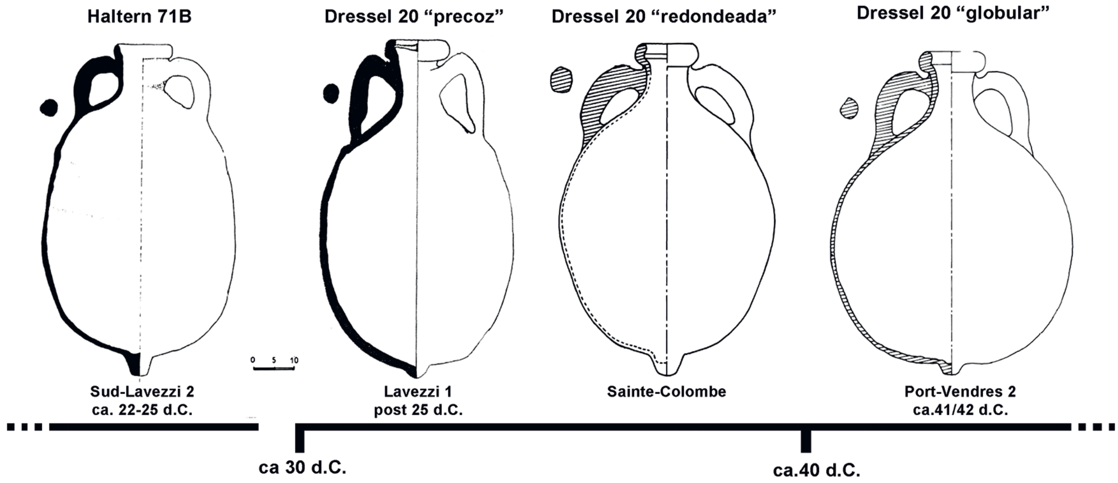
of a smaller capacity and shape, as with the Tejarillo I and Dressel 23 types) caused by market regulations in periods of economic change.

In contrast to other types such as wine amphorae, which were largely traded by private merchants and therefore had no limitations in terms of prices and goods, oil amphorae were subject to tight state regulations from the Augustan period. The reason for this was that a significant proportion of the oil produced was earmarked for military supply for the legions deployed in Germania and Britannia[17]; oil played an important role in the soldiers' provisioning, and its price was thus a political decision. Similarly, important quantities of oil were distributed in Rome by the *praefectura annonae*, which Monte Testaccio clearly attests[18] as a way to regulate prices and prevent the hoarding and speculation of this basic necessity in Rome. The Roman state was the main driver behind the production and commercialization of Baetican oil[19]. By absorbing most oil production, it kept prices low, although the management of some stages in the process was entrusted to semi-private agents. As such, investors, merchants, producers, and freighters made handsome profits, and oil also circulated in large quantities through private commercial channels.

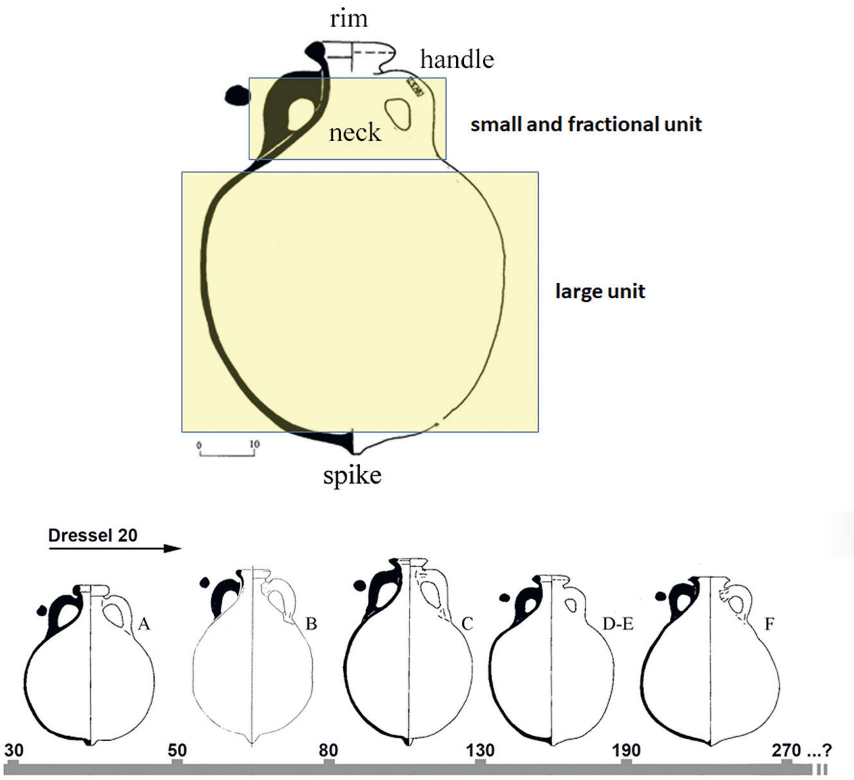
The Early Imperial Dressel 20 globular amphora (ca. A.D. 30–270) was the standard-bearer for trade in Baetican olive oil[20]. Its shape embodies a cultural identity that is inseparable from its origins and the nature of the product it contained. Oil production in Baetica was a large-scale affair (fig. 2 b), with a hundred or so amphora workshops scattered along the banks of the Guadalquivir and Genil rivers[21]. The industrial character of production is reflected in multiple details: a serial manufacturing system reminiscent of modern chain production methods[22], a high degree of specialization in *figlinae*, and a strict system of production control articulated though widespread employment of stamps[23].

The globular Dressel 20 type replaced the ovoid types that had dominated the oil market for approximately seven decades[24] beginning with the Ovoid 6 type, the production of which started in the mid-1st century B.C. and continuing with the Oberaden 83 (ca. 25/20–1 B.C.) and Haltern 71 types (ca. A.D. 1–30), which were selected by the Roman state as a strategic product for military supply in Germania[25]. The functional and morphological transformations of oil amphorae, which crystallized during Tiberius's reign, are therefore rooted in military logistics. Globular shapes are more resistant than the ovoid bodies and could be more safely conveyed to the military camps in the Rhenish frontier[26]. The Dressel 20 type appeared rather suddenly around A.D. 30 (fig. 3). In our opinion, the type did not emerge as a result of a gradual ›natural‹ process but rather as a response to a specific need; it is thus reasonable to argue that it was the result of an ›invention‹. Dressel 20 amphorae can be said to reflect a rounded version of the wide ovoid profile of the Tiberian Haltern 71B type, with which it shares numerous traits like rim, handles, neck, and base. The new shape was sturdier and safer to transport by sea, river, and land. The design of the shape must have been a difficult endeavor because finding a globular amphora capable of holding its shape while not yet dry in the *figlinae* was no easy matter. The ensuing experimentation process is well attested through archaeology (fig. 3)[27]. Dressel[28] referred to the earliest Dressel 20, found in the deposit of Castro Pretorio in Rome and dated to the final part of Tiberius's reign, as »anfore di forma quasi sferoidale«. It was not

17 Remesal 1986; González 2014.
18 Dressel 1878; Rodríguez 1984.
19 Remesal 1990, 360.
20 Berni 2015.
21 Berni 2008; Díaz – Bernal-Casasola 2017.
22 Rodríguez 1993; Berni 2019.
23 Berni 2021; Moros 2021.
24 García et al. 2011.
25 González 2014.
26 Berni (forthcoming).
27 Berni (forthcoming).
28 Dressel 1879, 143.



3 Initial cycle in the gestation of globular Dressel 20 amphorae (from: Berni [forthcoming])

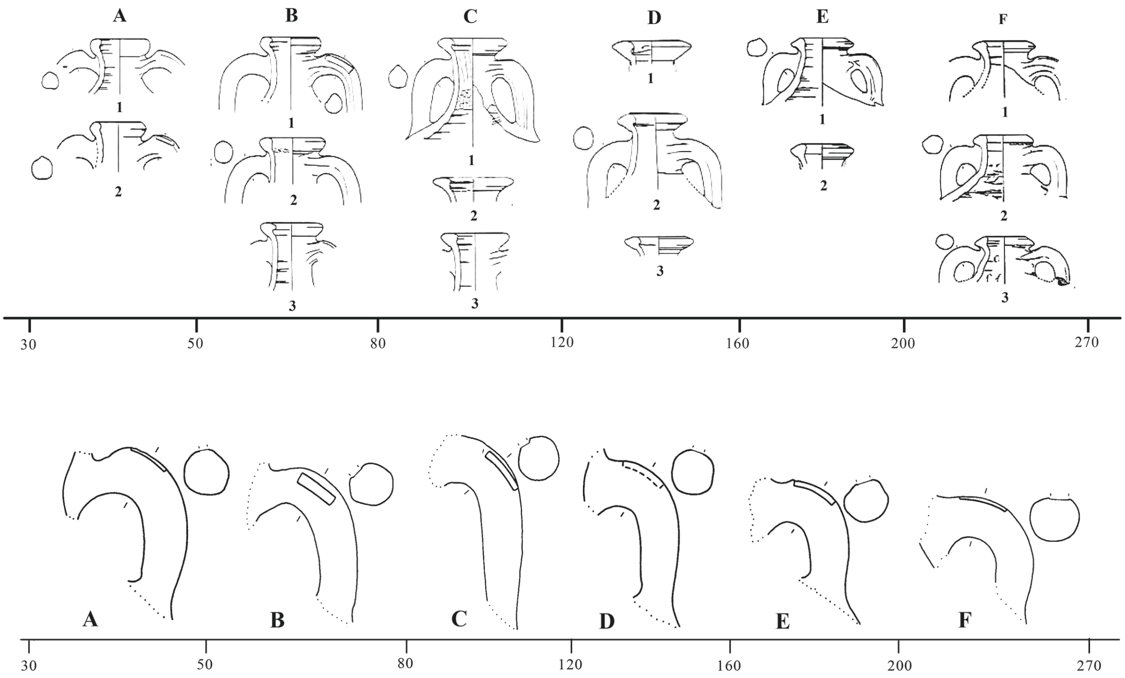


4 Properties and evolution of Dressel 20 amphorae (from: Berni [forthcoming])

until Claudius's reign, however, that we find fully spherical amphorae, such as the Dressel 20 examples found on the French shipwreck of Port-Vendres II[29].

Dressel 20 amphorae were strictly standardized, as they were intended to follow official requirements (fig. 4). State control was therefore behind the standardization of both the container and its contents. While it was the wide globular body that contained most of the oil, the upper bell near the neck could be used to adjust the contents to meet official standards. The technique to cre-

[29] Colls et al. 1977.



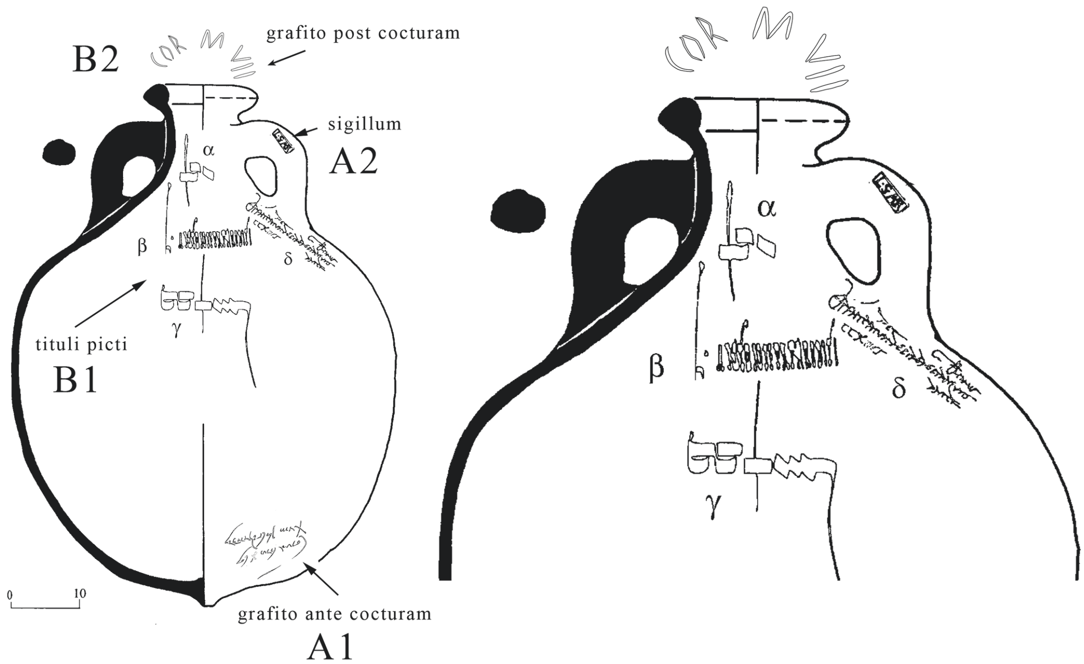
5 Stages of Dressel 20 Amphorae (A–F). Rims and handles (from: Berni 2017, 186 f. fig. 1–2)

ate self-supporting globular bodies was by forming a sort of inverted dome; the walls are thicker at the top and gradually become slimmer towards the bottom. The small base, barely a button, can be used as a pivot to rotate the amphora and absorb shock, giving the container more resistance. The thick handles also make the container more robust during handling, as suggested in a wall painting in Augusta Rauricorum, which depicts two *phalangarii* hauling a Dressel 20 amphora that weighed over 100 kg[30]. The rim, triangular in section and concave on the inside, was designed to facilitate the sealing of the mouth with mortar plugs, which were firmly inserted between the inner groove of the rim and the *operculum*[31].

The highly standardized nature of production during the ca. 250 years in which the Dressel 20 was manufactured makes the type and its different features (handles, rims, bases) excellent chronological markers for the dating of early imperial archaeological contexts[32]. Over time, the type underwent minor functional and metrological changes in response to changing needs (fig. 4) but always within strict official standards. These changes were, at any rate, gradual, and six different chronotypes have been identified[33]: Shape A, Julio-Claudian; Shape B, Neronian and Vespasianic; Shape C, Flavian-Trajanic; Shape D, early Antonine; Shape E, late Antonine; and Shape F, 3rd century. The rims are especially reliable in terms of dating, as they progressively substituted a semi-circular profile for a triangular one (fig. 5, top). Handles are less reliable but still useful when accompanied by stamps; their evolution runs parallel to that of rims – arched elongated handles, long vertical, shorter vertical, and semi-circular ones – as well as the gradual shortening and slimming of necks (fig. 5, bottom)[34].

The period of maximum commercial expansion of Baetican oil coincided with the Antonine dynasty. The 2nd century witnessed the development of the most profitable design of Dressel 20 amphorae, the optimum weight of which was ca. 100 kg, including the tare or total weight of the

30 Martin-Kilcher 1987, pl. 94; Berni 2015.
31 Berni – Gorostidi 2013.
32 Berni 1998; Berni 2008; Berni 2017.
33 Berni 2017, 185–187.
34 Rodríguez 1984, 227–238.



6 Inscription system in Dressel 20 amphorae in the mid-2nd century (from: Berni 2021)

vessel (30 kg or 91 *librae*) and net weight of the product (70 kg or 216 *librae*). This yields a stable ratio of 2.4 kg of oil per 1 kg of clay, which makes the calculation of profits easier.

The labeling of Dressel 20 amphorae is well known following the epigraphic evidence at Monte Testaccio[35]. The inscriptions regularly deal with five main aspects. In contrast with other amphorae, these inscriptions share two key traits: they are written always on the same location of the amphora, and their meanings never change (fig. 6). At the neck, α provides the tare of the amphora (ca. 30 kg); midway up the belly, γ refers to the net weight of the oil (ca.70 kg); on the upper bell, β indicates the owner of both amphora and product, which is generally the oil merchant; the only cursive inscription is δ, written transversally under the right handle, which includes practical information about the bottling process. The cursive inscription δ was an official label written by provincial officials for tax control purposes[36]. It is succinct and full of abbreviations for expediency during the packaging process. The most significant pieces of information within it are the administrative district from which the product originated, the name of the producer and owner (*actores fisci*), the recipients (*aceptores*) of the goods, and the consular date. These and other records were progressively introduced and expanded from single line entries during the Augustan period to increasingly detailed records of two, three, and even four lines from the reign of Hadrian and through the 3rd century[37]. Most *tituli* γ from Monte Testaccio indicate a number of 216 *librae*, a value which, according to Rodríguez Almeida[38], is consistent with the duodecimal systems used by Romans in their standard weights and measures. These γ values also evolved over time, with an average of 180 *librae* in the 1st century A.D. increasing to 216 *librae* in the 2nd–3rd century.

The existence of fixed standards in production and labeling of Dressel 20 amphorae is the result of an interaction between private and state factors or controlling agents. Their extreme standardization provided a legal guarantee for both public agencies (military supply, civilian *annona* in Rome) and entrepreneurs acting on the private market. The transition from Republican

35 CIL XV; Rodríguez 1984.
36 Dressel 1878, 169.
37 Rodríguez 1984.
38 Rodríguez 1984; Rodríguez 1993.

to Imperial production saw an important change in terms of the standardization of the amphorae that from this point onward can clearly be called ›Baetican‹. From containers that were sometimes polyvalent and formally very diversified during the 1st century B.C., the repertoire became quite standardized and, in general, much less ambiguous in terms of communicating the origin and content through formal features.

In the Guadalquivir Valley, this standardization was a rapid process (even with regard to the average volume of the containers) and gave rise to three formalized types in the first part of the 1st century A.D.: Dressel 20 amphorae for oil, which acquired their characteristic spherical shape around the middle of the 1st century A.D. and alternated production of the official standard with series of reduced volume (*parvae*); Haltern 70 amphorae, whose evolution was linear and reflected mainly in the form and height of the lip; and Dressel 28 amphorae, with a flat base and generally spherical body that was in production until the Severan period and evolved through variations that reflected again mainly in the form of the lip.

On the coast, the large variety of amphora types for salted fish and *garum* tended also toward a reduction in number over the course of the 1st century A.D. The Dressel 7 and 8 types evolved into the Beltran IIA as early as the first half of the century, while the Dressel 10 and 11 types gave rise to the Beltran IIB, maintaining the piriform shape of the Dressel 11 and tending perhaps toward two volumetric standards that are poorly known for lack of complete examples. Before the end of the 2nd century, the Beltran IIA type was already evolving toward a late form, Keay XVI, through intermediate types of large capacity such as the so-called Puerto Real 1 and 2. Dressel 12, which originated in the 1st century B.C., remains the only fusiform container that can be traced throughout the 1st century A.D. but not most of the 2nd century A.D., before reappearing in the Severan period in similar forms known as Puerto Real 3.

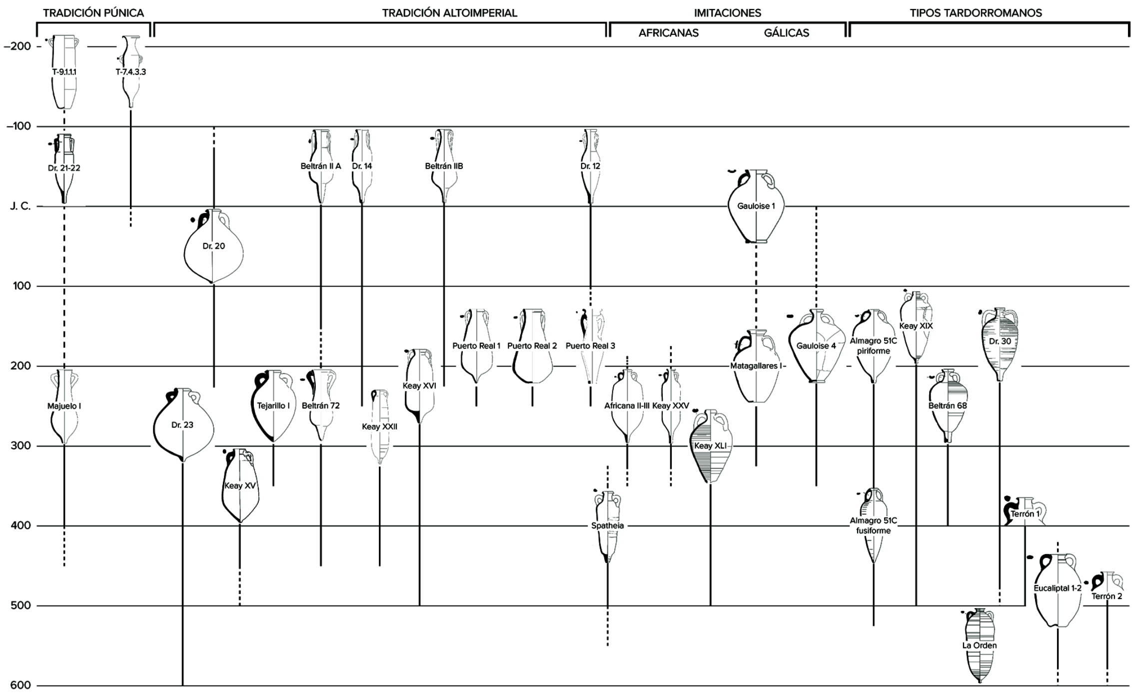
AN OVERVIEW ON LATER ROMAN BAETICA: FROM STANDARDIZATION TO HETEROGENEITY

From the late Antonine and early Severan period, deep political and social changes took place in both the Atlantic and the Mediterranean regions that had a profound effect on the Hispano-Roman economy[39] and on our main archaeological marker of interest for its study here: amphorae. Perhaps the term that best defines the new dynamic is a tendency toward regionalization – or even ›typological anarchy‹ – in the production of amphorae, which stands in stark contrast with the standardization that had characterized the 1st and 2nd centuries.

During the Early Empire, standardized production spanned the whole of Baetica, with the same types of amphorae being produced across wide geographical areas. This includes amphorae for *garum*/*salsamenta* in the coastal regions (the well-known Dressel 7/11 and similar types, such Beltrán IIA, Dressel 12, 14, 17, and other minor types), oil amphorae (Dressel 20), and *olivae* and *defrutum*/*sapa* containers (Haltern 70) that were produced in the Guadalquivir Valley. Other types, such as the flat-bottomed wine amphorae (*urceus* and Dressel 28) had a smaller interprovincial reach[40]. To this, we must add the phenomenon of imitation, which was little more than an attempt to introduce second-rate products for international markets; this is illustrated by the rare Baetican Dressel 2/4 types as well as imitations of the standard types produced in Baetica, like the Dressel 20 type produced on the coast of Málaga or the few examples of Dressel 7/11 from the Guadalquivir Valley. This phenomenon of imitation does nothing but emphasize the general trend: the production of a few standardized shapes across wide geographical regions.

From the 3rd century A.D., the situation changed radically: first, the number of types produced in southern Hispania increased dramatically, with up to 20 or so different shapes now identified (fig. 7), bringing to an end the previous uniformity. Some workshops continued producing the

39 Reynolds 2010; Bernal-Casasola 2019.
40 For a synthesis, see Morais 2017, 353–356.



7 Typology of Late Roman amphorae in Baetica (from: Bernal-Casasola 2019, 583 fig. 14)

traditional shapes, especially for oil amphorae in the Guadalquivir Valley (from Dressel 20 to Dressel 23 and similar types) and fish sauce amphorae in Cádiz; these latter jars seem to derive from mid-imperial *garum* amphorae, namely Puerto Real 1, 2, and 3, and Keay XVI and XXII, possible distant relatives of the Beltrán IIB type. Meanwhile, the imitation of popular international shapes continued, including the flat-bottomed wine amphorae that were probably inspired by Gallic prototypes as well as the African amphorae like Africana II, Keay XXV, and *spatheia*. However, the main trend was the emergence of entirely new shapes that lacked known prototypes: these include wine amphorae like Dressel 30 and Beltrán 68[41], and fish sauce amphorae like the ubiquitous Keay XIX. Especially significant is the case of western Baetican amphorae from the region of Onoba, which emerged in the late 5th century and became common in the 6th century[42]; these amphorae followed typological parameters that were totally foreign to Hispania and were distributed widely from southwest England[43] to Hispalis. These trends, identified decades ago, have been interpreted as a ›typological rupture‹ and as potential evidence for the mobility of craftspeople and for changes in economic trends[44].

Along with this regionalization, the 3rd to 5th century witnessed a process that diametrically opposed trajectories in early imperial productions, particularly the emergence of a ›pan-Hispanic‹ trend in amphora manufacture. To this trend belong imitations of the French Gauloise 4 type, different variants of which started being produced in the whole of the Iberian Peninsula, between Bueu in the northwest and Llafranc in the northeast (fig. 8) from the 3rd century onwards[45]. The simultaneous production of other types, sometimes in significant numbers, now became wide-

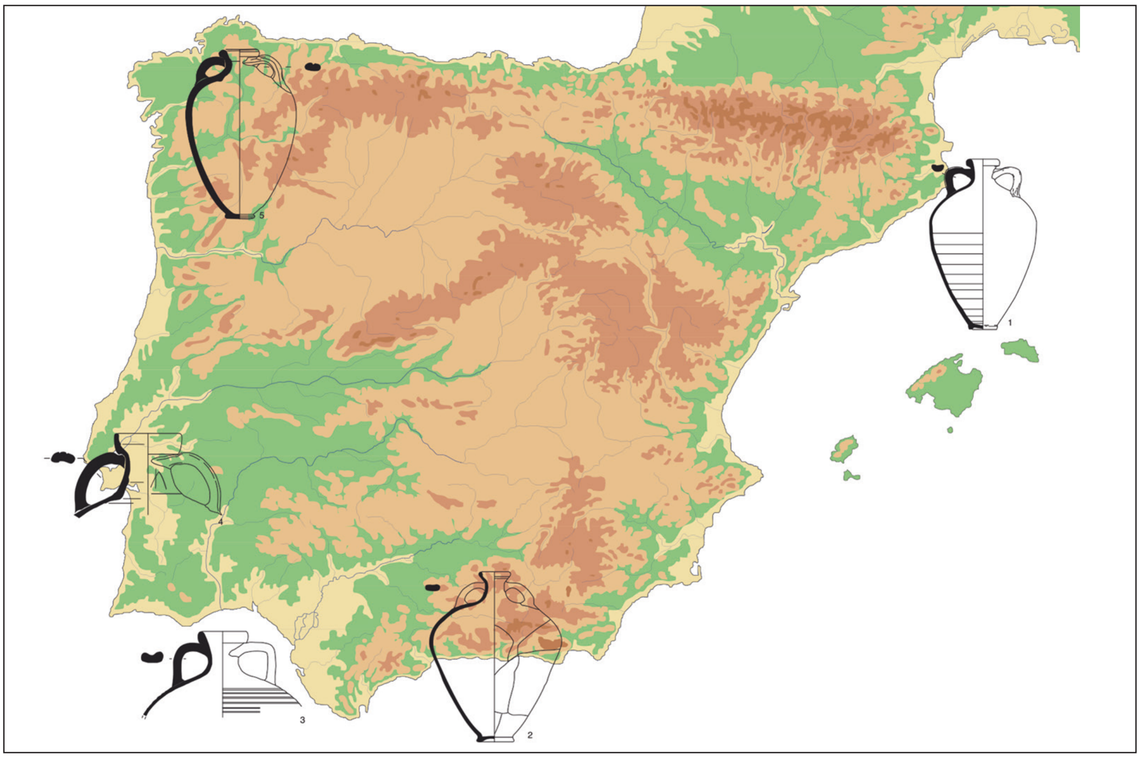
41 In Baetica these types seem to appear without clear ancestors. This is important concerning the Dressel 30, normally seen as a product of Mauretania Caesariensis.

42 O'Kelly 2012.

43 During »Ex Baetica Amphorae 2« (December 2018), A. Fernández Fernández and M. Duggan presented interesting material from Tintagel, with some sherds of amphorae ›Tipo La Orden‹.

44 Bernal-Casasola 2001; Fãbiao 2004.

45 Bernal-Casasola 2008, 44 fig. 8; Bernal-Casasola 2019, 573 fig. 10.



8 ›Pan-Hispanic‹ flat-bottomed wine amphorae (from: Bernal-Casasola 2008, 44 fig. 8)

spread across the whole Iberian Peninsula: for instance, the Almagro 51C and Keay XIX types, which were produced between the Tagus and Sado and the southern coastal region around Cartagena. This led to the emergence of a term, ›south-Spanish amphorae‹, to refer generically to these productions spanning from Portugal to the southern coastal area of Cartaginensis when more typological details were not forthcoming. It is also easy to find specific types produced in different administrative regions or Roman provinces: for example, the Matagallares I type, which was produced on the coast of eastern Baetica or modern Granada[46] and at the same time in southern Cartaginensis[47]. Nothing similar is attested in earlier centuries when shapes and families of shapes were limited to well-defined geographical regions and only imitations in low quantities were produced elsewhere. Also interesting is the emergence of amphorae, such as the Majuelo I and Puerto Real 3 types, which were more limited in production to meet the demand posed by regional and interprovincial markets.

These observations seem to suggest structural changes in the state supervision of Baetican trade, namely the progressive loss of control over peripheral regions that characterized the western Roman Empire from the late 3rd century onwards. The epigraphic system of the *tituli picti* of the Dressel 20 amphoras seems to have been missing with the abandonment of Monte Testaccio during the advanced third quarter of the 3rd century A.D. This is also supported by the decrease in the number of painted inscriptions on Baetican amphorae from the 4th century.

Another important phenomenon in the Late Roman period was a tendency for amphorae to become either very large or very small; this is especially clear in the case of North Africa, where some containers increased in capacity up to 80 (Keay LXI), 90 (Keay XXXV B), and even 100 liters (Hammamet 2); by contrast, others like the *spatheia* 1 type barely reach 6.5 liters[48]. This trend does not fully apply to Baetica, where amphora size tends to decrease somewhat compared to the

[46] Bernal-Casasola 2001.
[47] Berrocal 2012.
[48] Bonifay 2016; Molina – Mateo 2018 tab. 1; for a synthetic table, see Bernal-Casasola 2019, 572 fig. 9.

production of the Julio-Claudian period. Concerning oil containers, as already mentioned, the capacity of Antonine-period Dressel 20 amphorae has been calculated on average as 76.4 liters; this same shape reaches a capacity of 102.2 liters in the Severan period, while the capacity of the Dressel 23 type was approximately 31.1 liters and that of the Tejarillo 1 type 16.4 liters. Regarding the *garum* amphorae, they reached their maximum capacity in the early 3rd century, with the Puerto Real II type (52.9 liters) and the Keay XVI type (41 liters), which were even larger than the earlier Beltrán IIB type (37.5 liters); thereafter, the size of these amphorae decreased gradually to 23 (Almagro 50/Keay XVI), 21.7 (Almagro 51C) and 20.8 liters (Keay XIX)[49]. The largest Baetican amphorae were therefore those produced in the Severan period, after which they decrease progressively in size until the late 5th and first half of the 6th century. There are, however, exceptions, such as the amphorae from Onoba (La Orden type) mentioned above, which could contain as much as 55 liters, seemingly following the trend marked by the larger containers from Tunisia.

On the other hand, we also know of Baetican *spatheia* that responded to broader miniaturization processes, with containers under 10 liters probably being used to package top-quality products[50]. *Parvae* versions of larger late imperial shapes also appear, especially the Keay XIX type[51]; this phenomenon is still poorly understood, but the evidence at our disposal is constantly increasing[52].

Despite all the data provided here, and with few exceptions like the Dressel 20 type, the capacities of most of the Baetican amphorae remain an understudied subject. Some progress has been made in recent years[53], but a detailed study by period and region has yet to be done. In some cases, not even approximate figures exist; a quick search in the »Amphorae ex Hispania« repertoire corroborates this fact[54]. Therefore, studies concerning the net tare-to-capacity ratio of amphorae and their efficiency as items of trade must wait, along with other important questions such as the size range permitted within the production of a certain standardized type.

Another important aspect for Late Antiquity is the role in production and consumption played by the Church, which becomes visible especially from the 5th century in regions of the eastern Mediterranean and North Africa where large numbers of inscriptions attest to the manufacture of amphorae in ecclesiastical workshops. Amphorae stamped with Christian symbols have been found on the well-known shipwreck at La Palud, off the French Midi. In Egypt, Syria, Palestine, and Cyprus, the *tituli picti* often present abbreviated religious formulae, personal names, and allusions to possible monasteries. Initially, it was believed that these amphorae contained products used for liturgical purposes, but now they are interpreted more broadly as items of trade, and it is thought that the inscriptions refer to the ecclesiastical ateliers in which the amphorae were produced[55]. This, in addition to the great fragmentation of Late Antique bishoprics into small production units, from *parrocchiae* to monasteries, led the decline of earlier standardization in Baetica, especially towards the late 5th and 6th centuries.

In terms of volume and standardization, this period in Baetica sees the continuation of the trends already visible in the late 3rd century; from that time onwards, formal heterogeneity and increasingly smaller containers prevail. These trajectories respond to the wider commercial environment, which was affected by increasing pressure from the Byzantine Empire and political disintegration associated with Germanic peoples in the Iberian Peninsula from the 5th century.

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49 For capacities see Molina – Mateo 2018 tab. 1; Bernal-Casasola 2019, 572 fig. 9.
50 Bernal-Casasola 2001.
51 Bernal-Casasola 2019, 568–570.
52 Quevedo 2020.
53 See especially Molina – Mateo 2018.
54 Bernal-Casasola 2019, 572 f.
55 Bernal-Casasola 2010.

BIBLIOGRAPHY

Almeida 2008 R. R. de Almeida, Las ánforas del Guadalquivir en *Scallabis* (Santarém, Portugal). Una aportación al conocimiento de los tipos minoritarios, Instrumenta 28 (Barcelona 2008).

Bernal-Casasola 2001 D. Bernal-Casasola, La producción de ánforas en la Bética en el s. III d.C. y durante el Bajo Imperio, in: D. Bernal-Casasola – E. García Vargas (eds.), Congreso Internacional Ex Baetica Amphorae. Conservas, aceite y vino de la Bética en el imperio romano (Sevilla y Écija, 1998), Actas I (Écija 2001) 239–372.

Bernal-Casasola 2008 D. Bernal-Casasola, Ánforas y vino en la Antigüedad Tardía. El ejemplo de la Hispania meridional, in: J. Blánquez – S. Celestino (eds.), Simposio Internacional/Congreso Arqueológico del vino en época tardoantigua y medieval, Serie Varia 8 (Madrid 2008) 33–60.

Bernal-Casasola 2010 D. Bernal-Casasola, Iglesia, producción y comercio en el Mediterráneo tardoantiguo. De las ánforas a los talleres eclesiásticos, in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds), LRCW 3: Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Comparison between Western and Eastern Mediterranean. 3rd International Conference on Late Roman Coarse Wares, Parma and Pisa 2008, BARIntSer 2185, I (Oxford 2010) 19–31.

Bernal-Casasola 2019 D. Bernal-Casasola, Ánforas tardorromanas en Hispania. Claves de identificación, in: C. Fernández Ochoa – A. Morillo Cerdán – M. Zarzalejos Prieto (eds.), Manual de cerámica romana IV. Producciones cerámicas de época medio-imperial y tardorromana (Alcalá de Henares 2019) 549–670.

Bernal-Casasola – Bonifay 2010 D. Bernal-Casasola – M. Bonifay, Importaciones y consumo alimenticio en las ciudades tardorromanas del Mediterráneo nor-occidental (siglos VI–VIII): la aportación de las ánforas, I Congreso Internacional Espacios urbanos en el Occidente Mediterráneo, s. V–VIII (Toledo, 2009) (Toledo 2010) 91–114.

Bernal-Casasola et al. 2003 D. Bernal-Casasola – A. Arévalo – L. Lorenzo – L. Aguilera, Imitations of Italic amphorae for fish sauce in roman Baetica. New evidence from the salt fish factory at Baelo Claudia, ReiCretActa 38, 2003, 305–313.

Bernal-Casasola et al. 2013 D. Bernal-Casasola – E. García Vargas – A. M. Sáez Romero, Ánforas itálicas en la Hispania meridional, in: G. Olcese (ed.), Ricerche archeologique, archeometriche e informatiche per la ricostruzione dell'economia e dei commerci nel bacino occidentale del Mediterraneo (metà IV ec. a.C. – I sec. d.C.) (Rome 2013) 351–372.

Berni 1998 P. Berni Millet, Las ánforas de aceite de la Bética y su presencia en la Cataluña romana, Instrumenta 4 (Barcelona 1998).

Berni 2008 P. Berni Millet, Epigrafía anfórica de la Bética. Nuevas formas de análisis, Instrumenta 29 (Barcelona 2008).

Berni 2015 P. Berni Millet, Viaje en el tiempo por la producción y el comercio del aceite bético con la iconografía romana, Boletín Ex Officina Hispana 6, 2015, 49–62.

Berni 2017 P. Berni Millet, Amphorae-Epigraphy: Stamps, Graffiti and Tituli Picti from Roman Nijmegen, in: C. Carreras – J. Van den Berg (eds.), Amphorae from the Kops Plateau (Nijmegen): Trade and Supply to the Lower-Rhineland from the Augustan Period to AD 69/70, Archaeopress Roman Archaeology 20 (Oxford 2017) 185–333.

Berni 2019 P. Berni, Calendar graffiti on Dressel 20 amphorae. Asiaticus: another paradigmatic case with a new find from Brijuni, in: T. Bezeczky, Amphora Research in Castrum Villa on Brijuni Island, AForsch 29 = DenkschrWien 509 (Vienna 2019) 125–145.

Berni 2021 P. Berni Millet, Producción anfórica en Hispania. La evidencia de la epigrafía, in: W. Broekaert – A. Delattre – E. Dupraz – M. J. Estarán Tolosa (eds.), Epigraphy on Ceramics: The Instrumentum domesticum, its Textual Genres and its Functions in Ancient Societies (Geneva 2021) 19–46.

Berni (forthcoming) P. Berni Millet, Las otras ánforas del Monte Testaccio. La producción de aceite y de ánforas oleícolas en la Cuenca del Guadalquivir en época romana, Mesa redonda internacional, 29–30 de octubre 2015 (Madrid forthcoming).

Berni – Gorostidi 2013 P. Berni Millet – D. Gorostidi Pi, C. Iulius Valerianus et C. Iulius Iulianus mercatores del aceite bético en un signaculum de plomo para ánforas Dressel 20, JRA 26, 1, 2013, 167–189.

Berrocal 2012 M. C. Berrocal Caparrós, Producciones anfóricas en la costa meridional de Carthago Spartaria, in: D. Bernal-Casasola – A. A. Ribera Lacomba (eds.), Cerámicas hispanorromanas II. Producciones regionales (Cádiz 2012) 255–277.

Bonifay 2016 M. Bonifay, Amphores de l'Afrique romaine: nouvelles avancées sur la production, la typo-chronologie et le contenu, in: R. Járrega – P. Berni (eds.), Amphorae ex Hispania: paisajes de producción y consumo. Actas del III Congreso Internacional de la Sociedad de Estudios de la Cerámica Antigua (SECAH), Ex Officina Hispana 3 (Tarragona 2016) 595–611.

Colls et al. 1977 D. Colls – R. Étienne – R. Lequément – B. Liou – F. Mayet, L'épave Port-Vendres II et le commerce de la Bétique a l'époque de Claude, Archaeonautica 1 (Paris 1977).

Díaz – Bernal-Casasola 2017 J. J. Díaz Rodríguez – D. Bernal-Casasola, De las alfarerías de Baetica. Focos de producción, tecnología y análisis microespacial de las estructuras de producción, A Olaria Romana. Seminário Internacional e Ateliê de Arqueologia Experimental (Seixal, 2010) (Lisbon 2017) 139–174.

Díaz – Bernal-Casasola 2018 J. J. Díaz Rodríguez – D. Bernal-Casasola, El tejido productivo anfórico en el litoral de la Bética: análisis de la organización interna de sus talleres alfareros, in: R. Járrega – E. Colom (eds.), Figlinae Hispaniae. Nuevas aportaciones al estudio de los talleres cerámicos de la Hispania romana. Treballs d'Arqueologia de la Mediterrània Antiga, ICAC (Tarragona 2018) 9–27.

Dressel 1878 H. Dressel, Ricerche sul Monte Testaccio, AdI 50, 1878, 118–192.

Dressel 1879 H. Dressel, Di un grande deposito di anfore rinvenuto nel nuovo quartiere del Castro Pretorio, BCom 7, 1879, 36–112. 143–196 (continuazione e fine).

Fãbiao 2004 C. Fãbiao, Centros oleiros da Lusitania: balanço dos conhecimentos e perspectivas de investigação, in: D. Bernal-Casasola – L. Lagóstena Barrios, Figlinae Baeticae. Talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C.–VII d.C.), BARIntSer 1266 (Oxford 2004) 379–410.

García 1998 E. García Vargas, La producción de ánforas en la bahía de Cádiz en época romana: (siglos II a.C. – IV d.C.) (Écija 1998).

García 2009 E. García Vargas, Las ánforas republicanas de Hispalis (Sevilla) y la »cristalización« del repertorio anfórico provincial, in: R. Cruz-Auñón Briones – E. Ferrer Albelda (eds.), Estudios de Prehistoria y Arqueología en Homenaje a Pilar Acosta Martínez, Servicio de Publicaciones de la Universidad de Sevilla (Sevilla 2009) 437–464.

García 2010 E. García Vargas, Ánforas béticas de época augusteo-tiberiana. Una retrospectiva, in: A. Mª. Niveau de Villedary y Mariñas (ed.), Las necrópolis de Cádiz: apuntes de arqueología gaditana en homenaje a J. F. Sibón Olano (Cádiz 2010) 581–624.

García et al. 2011 E. García Vargas – R. R. de Almeida – H. González Cesteros, Los tipos anfóricos del Guadalquivir en el marco de los envases hispanos del siglo I a. C. Un universo heterogéneo entre la imitación y la estandarización, Spal 20, 2011, 185–283.

García – Bernal-Casasola 2008 E. García Vargas – D. Bernal-Casasola, Ánforas de la Bética, in: D. Bernal-Casasola – A. Ribera Lacomba (eds.), Cerámicas hispanorromanas. Un estado de la Cuestión (Cádiz 2008) 661–687.

García et al. 2019 E. García Vargas – H. González Cesteros – R. R. de Almeida, Ovoid amphorae as first Roman provincial repertoire in Hispania Vlterior (The Guadalquivir Valley), in: E. García Vargas – R. R. Almeida – H. González Cesteros – A. Sáez Romero (eds.), The Ovoid Amphorae in the Central Mediterranean: Between the last two centuries of the Republic and the early days of the Roman Empire, RLAMP 13 (Oxford 2019) 62–111.

García – Sáez 2018 E. García Vargas – A. Sáez Romero, Todo el pescado vendido. Una lectura cuantitativa de la producción púnica y romana de ánforas, sal y salazones en la Bahía de Cádiz, in: J. Remesal Rodríguez – V. Revilla Calvo – J. M. Bermúdez Lorenzo (eds.), Cuantificar las economías antiguas. Problemas y métodos, Instrumenta 60 (Barcelona 2018) 161–214.

García – Sáez 2019 E. García Vargas – A. Sáez, Ovoid amphorae production in the Bay of Cádiz and the Southern coast of Vlterior/Baetica (Late Republic and Early Imperial periods), in: E. García Vargas – R. R. Almeida – H. González Cesteros – A. Sáez Romero (eds.), The Ovoid Amphorae in the Central Mediterranean: Between the last two centuries of the Republic and the early days of the Roman Empire, RLAMP 13 (Oxford 2019) 112–147.

González 2014 H. González Cesteros, Ánforas hispanas en la Germania Inferior antes de la formación de la provincia (20 A.C. – 69 D.C.) (PhD thesis University Rovira i Virgili, Tarragona 2014).

González et al. 2018 H. González Cesteros – E. García Vargas – R.R. de Almeida, Análisis de caso: las ánforas ovoides de la Hispania tardorrepublicana, in: R. Járrega Domínguez (ed.), Ex Officina Hispana. Cuadernos de la SECAH 3 (Madrid 2018) 81–112.

Martin-Kilcher 1987 S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte, I. Die südspanischen Ölamphoren (Gruppe 1), FiA 7, 1 (Augst 1987).

Molina – Mateo 2018 J. Molina Vidal – D. Mateo Corredor, The Roman Amphorae average capacity (AC), OxfJA 37, 3, 2018, 299–311.

Morais 2017 R. Morais, Las ánforas altoimperiales, in: C. Fernández Ochoa – A. Morillo – M. Zarzalejos (eds.), Manual de cerámica romana III. Cerámicas romanas de época altoimperial III: Cerámica común de mesa, cocina y almacenaje. Imitaciones hispanas de series romanas. Otras producciones (Alcalá de Henares 2017) 311–380.

Moros 2021 J. Moros Díaz, Organización productiva de las ánforas olearias béticas (Dressel 20, ca. 30–270 d.C.), Instrumenta 77 (Barcelona 2021).

O'Kelly 2012 J. O'Kelly Sendrós, Las ánforas onubenses de época tardorromana, in: D. Bernal-Casasola – A. Ribera Lacomba (eds.), Cerámicas hispanorromanas II. Producciones regionales (Cádiz 2012) 279–295.

Quevedo 2020 A. Quevedo, Sobre la difusión de las ánforas tardías de Malaca en Carthago Nova, Boletín Ex oficina hispana 11, 2020, 29–31.

Ramon 1995 J. Ramon Torres, Las ánforas fenicio-púnicas del Mediterráneo central y occidental, Instrumenta 2 (Barcelona 1995).

Remesal 1986 J. Remesal Rodríguez, La annona militaris y la exportación de aceite bético a Germania (Madrid 1986).

Remesal 1990 J. Remesal Rodríguez, El sistema annonario como base de la evolución económica del Imperio romano, in: T. Hackens – M. Miró (eds.), Le commerce maritime romain en Méditerranée occidentale. Colloque International (Barcelone, 1988), PACT 27 (Rixensart 1990) 355–367.

Reynolds 2010 P. Reynolds, Hispania and the Roman Mediterranean (AD 100–700). Ceramics and trade (London 2010).

Rodríguez 1984 E. Rodríguez Almeida, Il Monte Testaccio: ambiente, storia, materiali (Rome 1984).

Rodríguez 1993 E. Rodríguez Almeida, Grafitti e produzione anforaria della Betica, in: W. V. Harris (ed.), The Inscribed Economy. Production and Distribution in the Roman Empire in the Light of Instrumentum Domesticum (Rome, 1992), JRA Suppl. 6 (Ann Arbor, MI) 95–107.

Sáez 2008 A. Sáez Romero, La producción cerámica en Gadir en época tardopúnica (siglos –III/-I), BARIntSer 1812 (Oxford 2008).

Sáez – Moreno 2017 A. Sáez Romero – E. Moreno Pulido, Contando la historia. Experiencias de cuantificación y análisis volumétrico en centros artesanales púnicos de la Bahía de Cádiz, AEspA 90, 2017, 219–246.

Catarina Viegas – Carlos Fabião – Rui Roberto de Almeida

STANDARDIZATION OF LUSITANIAN AMPHORAE

BETWEEN CONVERGENCE AND DIVERSITY[1]

Abstract

Amphora production as attested in Lusitania mostly accompanies the exploitation of marine resources. The main amphora workshop areas are located in Peniche, in the Sado and Tagus Valleys, and in the Algarve region. The earlier productions identified date from the Augustan period or slightly before (50–25 B.C.) and cover a set of quite diversified shapes that have been designated as ›ovoid types‹ and ›early Lusitanian‹, which are related to the late Republican ovoid types (mainly the Baetican ones), up to the early imperial Dressel 7/11 and Haltern 70 types. To date, manufacture can be linked to the Sado and Tagus Valleys, as well as to Peniche. From the middle of the 1st century onward, however, the main amphora type known in these regions is the Dressel 14 type. This is also the period when this amphora seems to have achieved an established position in the internal market of Lusitania, with a significant role in both urban and rural areas, as well as in western and central Mediterranean markets.

From the second half of the 2nd century onward, there was a clear modification in both the fish salt production structures and in the amphora shapes, which now diversified, with new ones being related to new products, such as wine. Some forms occur in different modules that correspond to different capacities, as seems to be the case of the Lusitana 3, Almagro 51C, and Algarve 1 type. This reveals how the workshops operated in direct connection with the fish-salting units as well as with the wine producers. The role of market pressure is also discussed in this context.

INTRODUCTION

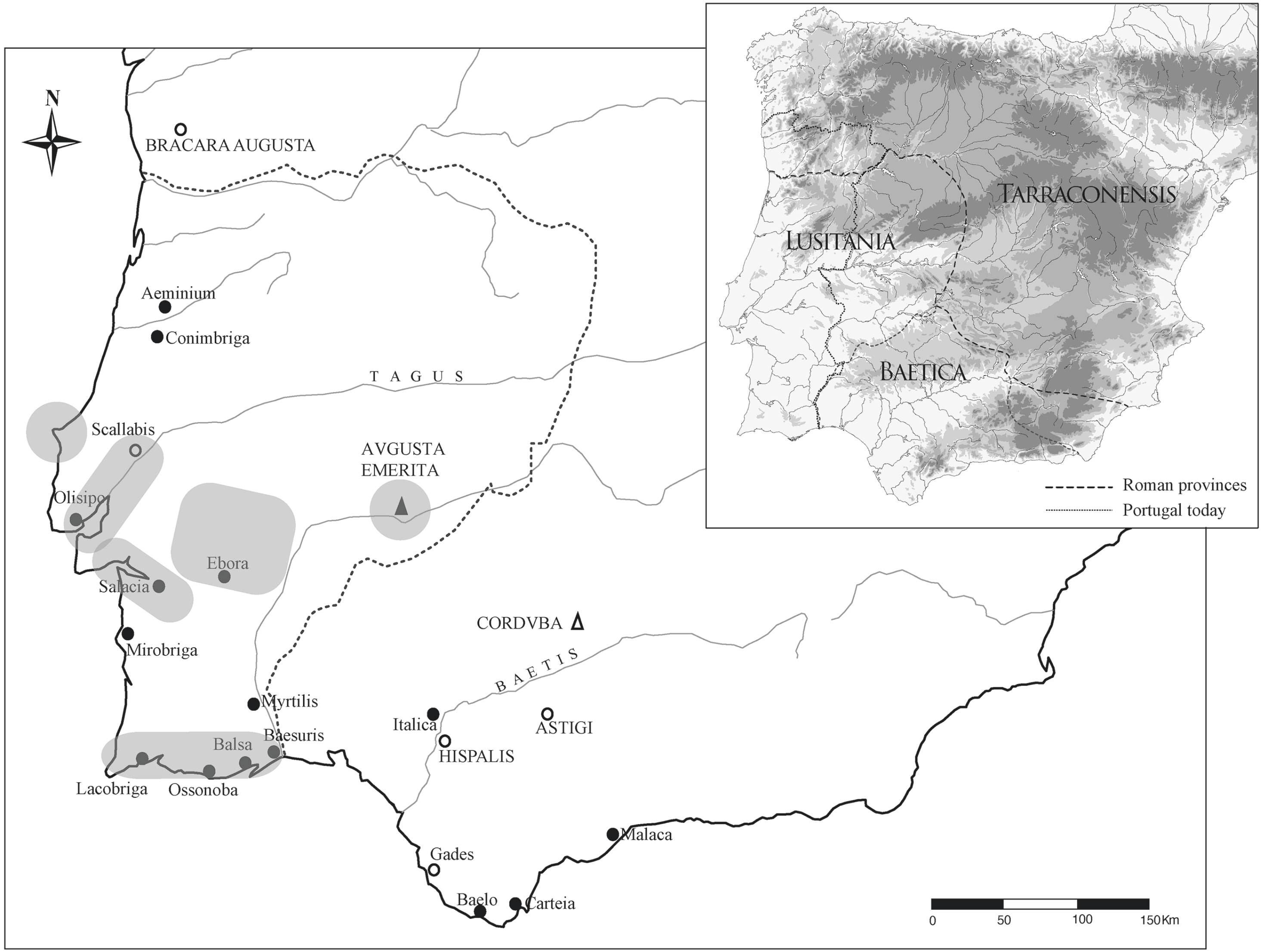
In accordance with the main themes of this volume concerning standardization, we will address the subject from the point of view of the amphora production in the westernmost province of the Roman Empire: Lusitania. From the Augustan period onward, the western part of Hispania Ulterior was integrated into the new province of Lusitania. Amphora production in the region of what is today Portuguese and Spanish territory was related mainly to the fish-salting industries, although minor production and commerce of wine in amphorae also existed. The core of this industry was on the Atlantic coastal areas of central and southern Portugal in the Sado and Tagus estuaries as well as in the Peniche area farther to the north. It also operated in the southernmost region, the Algarve. Production seems to have started slightly after the mid-1st century B.C. and lasted in some regions until at least the first half of the 6th century A.D. (fig. 1).

Our paper will focus on different aspects where standardization in production can be observed. Far from a homogeneous and linear process, we see different evolutionary dynamics converging toward standardized production in certain phases of the overall manufacturing process, while in other periods the opposite trend seems to take place in seeking diversification.

Concerning the characterization of different amphora types made in Lusitania, one should note that recent research into the periodization of the development of production has resulted in a more complex phasing than the previous one[2], which comprised a phase in the early Empire (1st–3rd cent. A.D.) and a second one in Late Antiquity (3rd–5th/6th cent. A.D.). As will be seen in detail below, early production is now attested in Sado and Tagus Valleys from the Late Republican/early Augustan phase (50–25 B.C.), utilizing different shapes designated as ›ovoid types‹ and ›early Lusitanian‹. These forms share common features or are inspired by those from the Ulterior types,

[1] This work was financed by Portuguese funds through FCT – Fundação para a Ciência e a Tecnologia in the framework of the projects UIDB/00698/2020 and UIDP/00698/2020.

[2] Fabião 2004.



1 Map of Hispania, with emphasis on Lusitania, indicating the main geographical and/or pottery-making entities mentioned in the text: 1) Central Atlantic Coast (Peniche); 2) Tagus Valley; 3) Sado Valley; 4) Central Alentejo (?); 5) *Augusta Emerita* territory; 6) Algarve (© by the authors, based on the map in: Va. Aa.1990)

such as the Late Republican ovoid types from the Guadalquivir Valley and the Cádiz region, and Early Baetican imperial forms such as Dressel 7/11 and Haltern 70 types[3].

Production reached a high volume from the middle of the 1st century A.D. onward, both supplying the internal markets in Lusitania (major towns and *villae* in rural areas) and playing an important role in western and central Mediterranean markets[4]. Fish-based products were carried in Dressel 14 amphorae, the main type produced during that period; its production areas extend, though on a limited scale, also into the Algarve region in the south of Portugal. From the beginning of the 2nd century onwards, wine produced mainly in the rural settlements from the Tagus and Sado Valleys came to be marketed in the Lusitana 3 type amphora, not only within all Lusitanian markets[5] but even across its borders, particularly to neighboring Baetica[6].

It is still difficult to understand what caused the major modifications of fish-salting production units (*cetariae*) from the second half of the 2nd or beginning of the 3rd century onward. What can be observed, however, are the consequences of these transformations, which included related changes in the typology of amphorae and also the production of more diversified forms. In addition to the containers of fish-based products (Almagro 51C, Almagro 51A–B, Algarve 1, Almagro 50, Sado 1 [= Keay 78], etc.) new shapes also appear related to wine. This would seem to be the case with Lusitana 9.

The end of amphora production should be closely related to the progressive abandonment of fish-salting units. The first serious disruption came in the second half of the 5th century, as exemplified by the cases of Tróia[7] (despite evidence for some continuity in the occupation of this settlement itself through the 6th cent.[8]), the site in Lisbon at Núcleo Arqueológico da Rua dos Correeiros (NARC)[9] and in Rua dos Fanqueiros[10]. There is, however, evidence for a few fish-salting units still active in the first half of the 6th century, as in Lagos (Algarve)[11], and for the arrival of such late Lusitanian amphorae in provincial markets like Olisipo/Lisbon[12] as well as Hispalis/Seville[13] and Tarraco/Tarragona[14], to mention just some examples[15].

We will discuss different aspects that we recognize can be standardized, like the general shape of the amphora types, the specific shapes of their different parts (rim, neck, handles, body, spike), and their particular capacities. By doing so, we aim to establish a possible correlation with the units of measurement that could be used in antiquity. In this particular aspect, we will look at liquid and solid measurements – as we are not sure which system was used for foodstuffs like the several possible fish products – and attempt to correlate between modern and ancient measurement systems.

This endeavor aims to open case studies for further discussion rather than postulate a final model. The values used here remain approximate at the moment, and many questions remain unanswered. We therefore consider our work as just one new step on a long road still ahead, one contribution toward an understanding of Lusitania's role in the complex and interdependent provincial exchange systems within the Roman Empire.

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3 Morais 2004; Arruda et al. 2006; Morais – Fabião 2007; Fabião 2008; García et al. 2011; Almeida et al. 2014; Morais – Filipe 2016; Filipe 2016; Pinto et al. 2016a; Pimenta 2017; Almeida – Fabião 2019; García et al. 2019b.
4 The main markets for these early imperial Lusitanian types, mainly represented by Dressel 14, were the towns and *villae* in Lusitania (see Raposo – Viegas 2016) as well as the Mediterranean markets as exemplified below: see n. 83.
5 Fabião 2008; Quaresma – Raposo 2016a; Almeida 2016; Filipe 2018.
6 Bernal-Casasola 2011; García 2015; García 2016; Filipe 2018.
7 Étienne et al. 1994; Pinto et al. 2011.
8 Pinto et al. 2016b.
9 Bugalhão 2001; Grilo et al. 2013.
10 Diogo – Trindade 2000.
11 Ramos – Almeida 2005; Ramos et al. 2006; Ramos et al. 2007.
12 Pimenta – Fabião (forthcoming).
13 Amores et al. 2007.
14 Remolà 2000; Remolà 2016.
15 So far, there is no clear proof of these amphorae in markets outside the Iberian Peninsula.

SOME HISTORIOGRAPHY AND CURRENT LINES OF RESEARCH

Research has recently taken place thanks to the teamwork of a relatively large and diverse set of scholars working in close cooperation. The projects undertaken include systematic investigation in the Tagus Valley under the Orest Project[16], with specific research taking place at the Quinta do Rouxinol kilns[17] and at Porto dos Cacos[18] but also involving investigations into where fish-based products were manufactured and consumed[19]. The Sado Project[20] incorporates excavations at the Abul and Pinheiro amphora production centers as well as in Tróia, the largest production center for fish products. In Peniche, the excavation of the pottery workshops allows the identification of relevant amphora production but still not related to any *cetariae*[21]. In the Algarve region, a first attempt at investigating production was made in the 19th century, with the excavation of one kiln in S. Bartolomeu de Castro Marim[22]. During the 20th century, amphora production was identified during preventive archaeological excavations that took place at Quinta do Lago[23]. Manufacture was also identified at S. João da Venda[24], Manta Rota[25], and Salgados[26]. Martinhal, situated on the western coast and suffering from coastal erosion, remains the largest regional production center[27]. More recently, evidence of amphora production was also recovered in contract excavations in Lagos[28].

Apart from new data coming from fieldwork, particularly excavation in the framework of research programs but also preventive and contract archaeology projects such as at Lagos or Portimão (Algarve area), research has also involved the revision of old data retrieved in museum deposits, such as at the National Archaeology Museum in Lisbon. Despite all of these sources, the new information concerning production centers remains small. Some new data concerning kilns and fish-salting contexts is emerging from Lusitania, as in the case of Lagos[29] and Portimão[30] (Algarve region), Parvoíce (Alcácer do Sal)[31], and Joaquim Granjo Street (Setúbal)[32], but most of the recent information has been retrieved in consumption contexts, particularly for the first phases of the process, as at Pedrão (Setúbal)[33], Monte dos Castelinhos (Vila Franca de Xira)[34], and at the Alentejo hill forts and fortresses, like Rocha da Mina (Alandroal) and Caladinho (Redondo)[35]. We also have begun to achieve a general notion of how far some production disseminated, such as that from Peniche, thanks to a combined approach using morphological details, archaeometry, and amphora stamps[36]. In addition, the amphora production in Conimbriga has recently been characterized[37].

16 Amaro 1990; Duarte 1990; Raposo 1990; Raposo et al. 2005; Dias et al. 2001; Dias et al. 2010.
17 Duarte 1990; Raposo et al. 2005; Raposo et al. 2016; Raposo 2017.
18 Raposo 1990; Raposo et al. 2005.
19 Dias et al. 2012.
20 Mayet et al. 1996; Mayet – Silva 1998; Mayet – Silva 2002; Mayet – Silva 2016.
21 Dias et al. 2003a and 2003b; Cardoso et al. 2016.
22 Vasconcelos 1898.
23 Arruda – Fabião 1990; Arruda 2017.
24 Fabião – Arruda 1990.
25 Viegas 2006.
26 Bernardes et al. 2007
27 Silva et al. 1990; Fabião 2004; Bernardes 2008; Bernardes et al. 2013; Bernardes – Viegas 2016.
28 Fabião et al. 2010; Fabião et al. 2017a.
29 Fabião et al. 2017a.
30 Major site intervention by Paulo Botelho and Sónia Ferreira, Botelho – Ferreira 2016.
31 Pimenta et al. 2016.
32 Silva 2018.
33 Mayet – Silva 2016.
34 Pimenta – Mendes 2014; Pimenta 2017.
35 Mataloto et al. 2016.
36 Fabião 2014.
37 Correia et al. 2015.

Typological studies were almost the only concern of research on amphorae in the 1980s and 1990s and, to a certain extent, still today. Since then, major interest has also focused on fabric characterization using both petrography and chemical analysis based on NAA, the latter chiefly undertaken by the Instituto Tecnológico e Nuclear team in close collaboration with archaeologists[38]. This research has already enabled the identification of several amphora workshops from western and southern Lusitania through their chemical fingerprints using NAA. The petrographic study made possible the identification of the major amphora fabric groups from the Sado and Tagus Valleys and also from several southern Lusitanian amphora workshops in the Algarve region. Macroscopic analysis allows broader identifications but alone fails to distinguish the Sado and Tagus basin fabrics. Chemical analysis works if one wants to distinguish the Sado Valley productions from those from the Tejo basin, but the issue is not so relevant for imports to foreign regions since both originate from western coastal Lusitanian workshops.

As most of the amphorae are in direct association with fish-salting units and fish-based products, recent lines of research also take into account the faunal remains (mostly ichthyofaunal) recovered in these contexts that provide valuable information on the exploitation of marine resources[39]. More recently, research into organic residue analysis has also taken the first steps toward a better understanding of certain Lusitanian amphora types and their contents[40]. Other lines of research have focused on general information concerning amphora consumption in sites such as towns, *villae*, and other types of Roman settlements, and also on exploring the role of Lusitanian products versus imports from other provinces[41]. More recently, special attention was also paid to the contexts of transport of Lusitanian amphorae to better understand the rhythms by which these products were exported into the Mediterranean and Atlantic areas[42].

We should mention here that most of the resulting research into Lusitanian amphorae has been presented through conferences and their subsequent publications[43]. Concerning the amphora workshops in the Sado Valley, several monographs have been published that offer a better understanding of some of the main features of amphorae produced in this area[44]. Besides the traditional monographs and relevant syntheses[45], special mention should be made of online databases, as these play a significant role in current research by allowing free access and permanent updating of information. Southampton's database on »Roman Amphorae: a digital resource«[46] and more recently »Amphorae ex Hispania«[47], the online lab based at the Institut Català d'Arqueologia Clàssica (ICAC) concerning the amphorae produced in the whole Iberian Peninsula, have made it possible to summarize the information concerning the main Lusitanian types. Through these digital platforms, one may find the state-of-the-art data and resources concerning Lusitanian amphora types and variants, their chronologies and distributions.

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38 Cabral 1977; Dias et al. 2003 and 2003b; Prudêncio et al. 2003; Prudêncio et al. 2009; Dias – Prudêncio 2016; Mayet et al. 1996.

39 Assis – Amaro 2006; Gabriel et al. 2009; Gabriel – Silva 2016; Gabriel 2018.

40 Morais et al. 2016.

41 The list is long, but see, for example, Filipe 2018 (with extensive bibliography).

42 Bombico 2017.

43 »Lusitanian Amphora Congress« (Conimbriga), published as Alarcão – Mayet 1990; »Romanization of Sado and Tagus estuaries«, published as Filipe – Raposo 1996; International Symposium »Production and commerce of fish sauces during Proto-history and Roman period in the western Iberian Peninsula«, published as Silva – Soares 2006; International Conference »Lusitanian Amphora: Production and distribution«, published as Pinto et al. 2016a; and finally ›International Seminar and Experimental Archaeological Workshop‹, published as Fabião et al. 2017b.

44 Mayet et al. 1996; Mayet – Silva 1998; Mayet – Silva 2002.

45 Fabião 2004; Fabião 2008.

46 <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/index.cfm> (10. 06. 2019).

47 <http://amphorae.icac.cat/amphorae/authors?page.2=> (18. 04. 2023).

SOME CONCEPTS, METHODS AND PRACTICES OF STANDARDIZATION: THE LUSITANIAN CASE STUDY

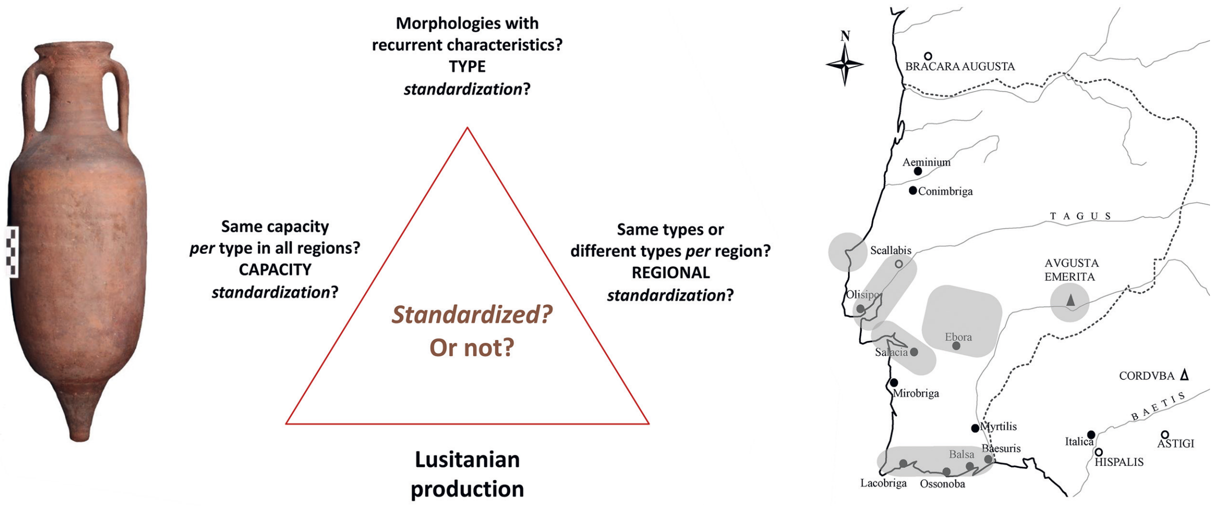
When addressing the subject of Lusitanian amphora standardization, we believe that there are several linked issues here that deserve attention and reflect different aspects of the same reality. What are we referring to when we speak about standardization? We could address this matter from the point of view of standardization of types if we concentrate on morphologies with recurrent characteristics; another approach would be to focus on the standardization of capacity, where we could investigate the consistent volumes of one particular type of amphora even though it was produced in different regions. Also important may be expressions of regional or provincial standardization, which might entail convergence of these aspects within specific types in each of the main producing regions of Lusitania (fig. 2).

In analyzing the shapes of amphorae, their detailed observation and description, the calculation of metric values, and the averaging of values for specific features and morphological details were undertaken in a systematic way. Nonetheless, this was neither a new approach nor an innovative trend in Lusitanian amphora studies but rather one with long history of interest. At the very beginning, some attempts were made following the proposals of J. C. Gardin, as expressed at the Roman Amphora Conference held by the French School at Rome in 1974[48]. Those experiments were made with some amphorae from the Sado area[49]. D. Diogo also made some attempts using a unique method that was several times mentioned but never actually published. However, neither of these attempts achieved significant results; they are now part of the history of research, to be compared with new methodologies proposed in the last decades, particularly given all the changes that have taken place in the world of computing hardware and software (fig. 3).

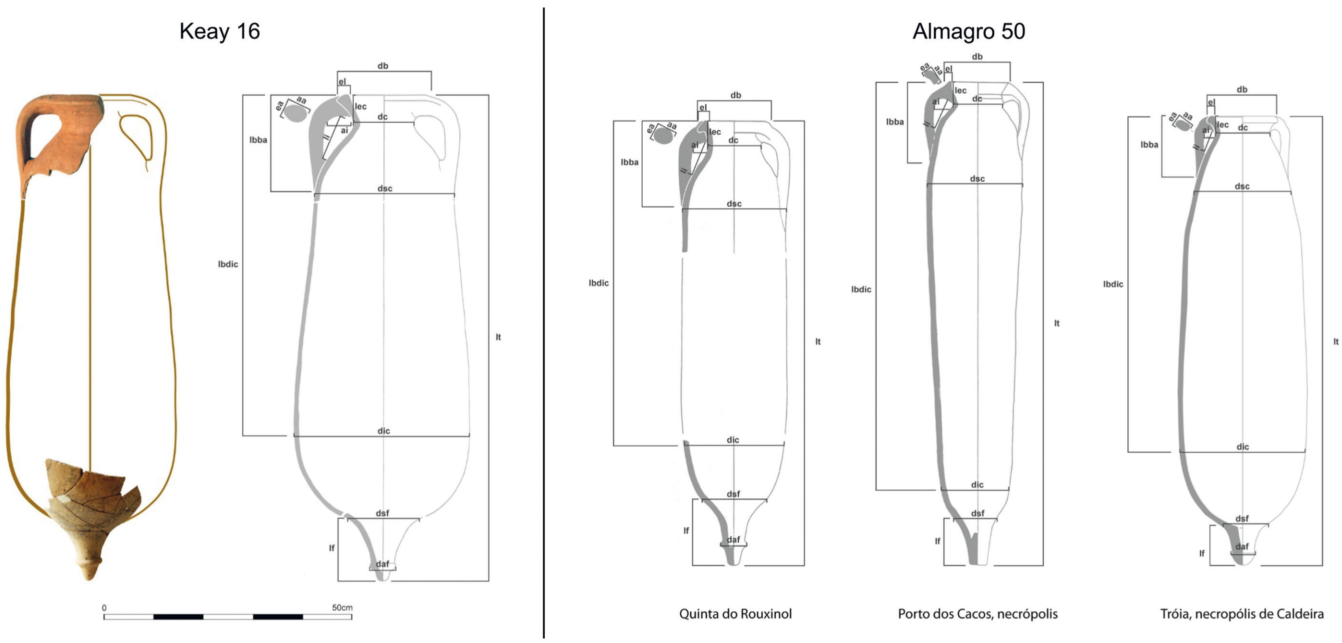
In determining the capacities of different amphora types, we combined traditional measurement methods for several complete amphorae – i.e., the filling of the empty amphorae with polystyrene micro-balls – with systematic 3D modeling based both on already published material as well as contextual data from recent archaeological work. The latter were partly based on published specimens, many of which were revised and redrawn to confirm their reliability. The vector files were then converted (using Adobe Illustrator, CorelDraw or AutoCAD) into 3Ds MAX and Rapidform Xor to obtain 3D volumetric models and internal capacities[50]. We have established a dataset that we consider representative of the standardization processes in Lusitanian amphora production. Nevertheless, one should point out that the larger the sample, the better the results and the more solid conclusions that can be drawn. The empirical dataset should be increased to verify some of the results proposed here. We have also succeeded in estimating the weights of empty forms as another mechanism for assessing the quantity of amphorae in a given sample of fragmentary sherds (fig. 4).

Quantification of volumes of commodities traded in amphorae is not new; it has long been a concern on the scientific agenda and has been tackled by different approaches[51]. E. García Vargas recognized the importance of volumes for studying the goods imported to Seville during the Early Imperial and Late Antique periods[52]. This researcher worked with statistical approaches to estimate the percentages of different goods imported into the city according to origin, but by using information on the volumes of the amphorae and not their MNI as was conventional[53]. More recently, V. Martínez has made attempts to calculate (using AutoCAD software) the volumetric capacities of Lusitanian amphora types as compared with Baetican ones as part of the Palatine

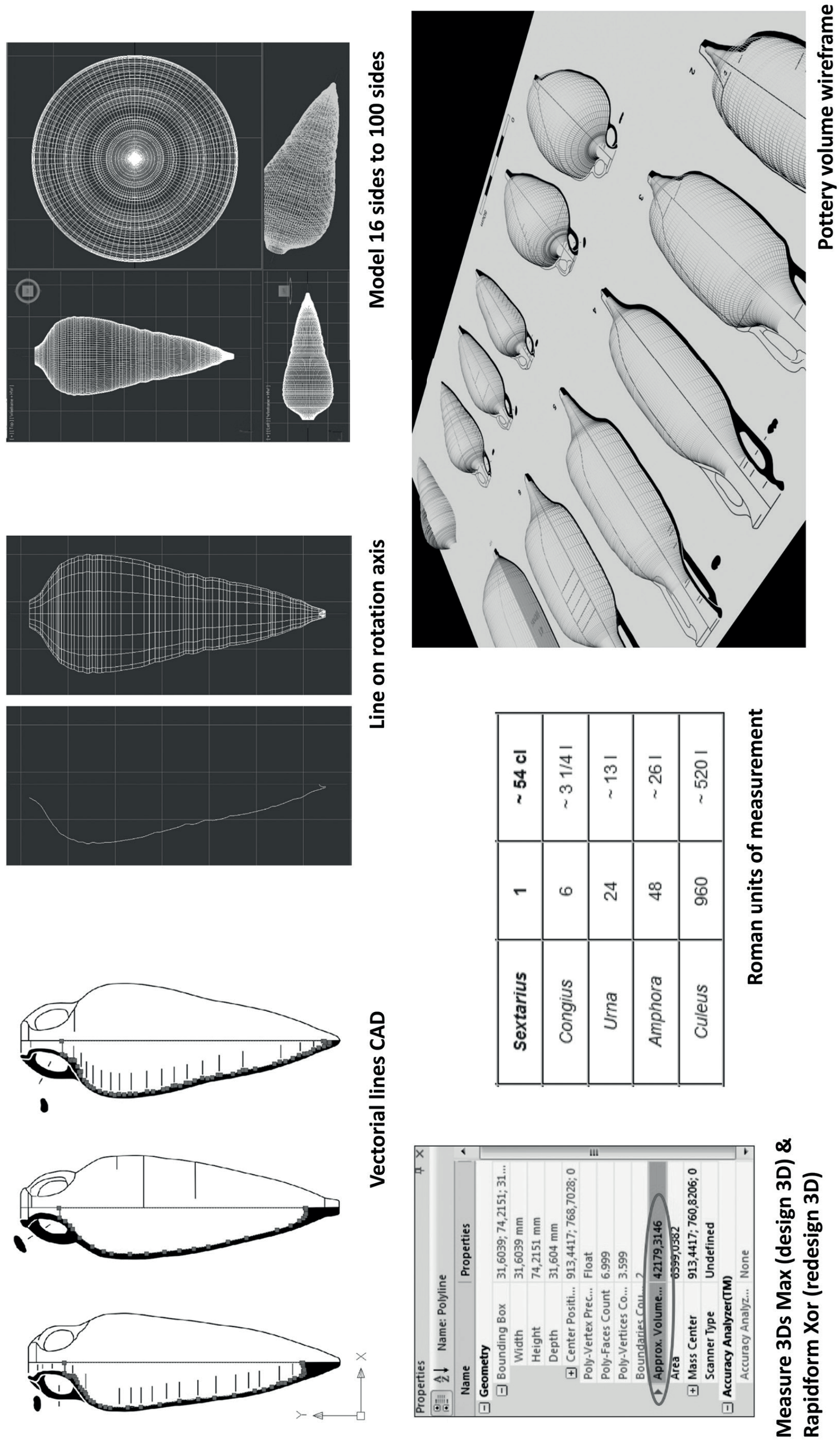
48 Vv. Aa. 1977.
49 Coelho-Soares – Silva 1978; Fabião – Carvalho 1990.
50 This systematic procedure was developed with F. J. López Fraile.
51 Orton et al. 1993; Wilson 2009.
52 García 2007.
53 García 2007, 321. Information on the volumes of different amphora types was obtained from Ejstrud 2002; Tyers 1996; and for late Roman types, Bonifay 2004.



2 Schema synthesizing the main issues concerning standardization of Lusitania amphorae (© by the authors)



3 Figure with examples of systematic measures of several morphological attributes of different amphorae (according to Almeida – Raposo 2016; Raposo – Almeida 2016)



Sextarius	1	~ 54 cl
Congius	6	~ 3 1/4 l
Urna	24	~ 13 l
Amphora	48	~ 26 l
Culeus	960	~ 520 l

4 3D volume calculation procedure. Some aspects of the modeling and calculation process (© by the authors)

East Pottery Project (PEPP)[54]. Based on published drawings and online databases, 48 amphorae were processed. Volumetric models of complete amphorae were obtained mainly for the Lusitanian Dressel 14 and Almagro 51C types (with more than 20 examples of each) and to a lesser extent for the Lusitana 3, Keay 16, Almagro 50, Almagro 51A–B, and Sado 1 types[55]. Only two Baetican Dressel 14 amphorae were considered. The results produced a quite disparate range of values. Dressel 14 ranged in volume from 23.4 to 49.08 liters; overall the Baetican amphorae seemed to be slightly smaller than the Lusitanian ones[56]. Here we must stress that almost all the measurements were taken from drawings of amphorae published at 1 : 10 and other small scales. In our opinion, the problems of accuracy that derive from the reuse of small, published drawings and the lack of measurements based on first-hand drawings are partly responsible for this range of values.

If we accept these estimates as much more reliable than simple rim or MNV (minimum number of vessels) counts for calculating the quantity of commodities imported to one specific place, various technical aspects still remain to be discussed and further developed, such as the quality of line drawings and the point to which the vessel capacity is calculated (i.e., at the top of the neck or below)[57]. Central to this discussion about the quantification of amphorae and the volume of products transported, we must first produce reliable quantification protocols that allow the comparison of different samples across the Roman Empire. Several aspects must be raised as they paved the way for the seminar that took place at the University of Seville (in the framework of the ICAC Project »Amphorae Ex Hispania«), when a team of Portuguese and Spanish researchers proposed a quantification methodology known as the Seville Protocol 2014 (PCRS/14)[58]. Quantification and its related issues have been the subjects of several subsequent scientific meetings, including one held in Barcelona and published as ›Quantifying ancient economies. Problems and methodologies‹[59]. Discussed at this meeting were several methodological approaches to different aspects of the ancient economy through amphorae and related quantification issues. Also worth mentioning is the recent statistical tool proposed by J. Molina Vidal and D. Mateo Corredor: the average capacity (AC). This aims to obtain more reliable data on the volumes of goods transported in amphorae by providing a narrower confidence interval for each type[60].

STANDARDIZATION OF LUSITANIAN AMPHORAE: PRODUCTION AREAS, TYPES AND CHRONOLOGIES

›Early Lusitanian‹ Production

Given the contextual data from consumption sites, we know that the beginning of amphora production in Lusitania took place in the Late Republican period. However, there is not yet data from such early production contexts. The production centers that were identified in the Tagus and Sado estuaries and in the Peniche kilns only provide direct evidence from the last quarter of the last century B.C., that is, from the principate of Augustus. Archaeometric analysis from some of the amphorae from Olisipo allowed the identification of one peculiar fabric apparently coming from a pottery workshop still unknown in the archaeological record[61].

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54 Martínez 2016, 129 f. fig. 1.
55 For detailed information on the features of this Lusitanian types, see below.
56 Martínez 2016, 130.
57 Martínez 2016.
58 Quantification issues have been addressed by the »Protocole de Beauvray«: see Arcelin – Tuffreau-Libre 1998. In the publication of the PCRS/14 in Adroher et al. 2016, there is an extensive bibliography on quantification methods.
59 Remesal et al. 2018.
60 Molina – Mateo 2018.
61 Dias et al. 2012.

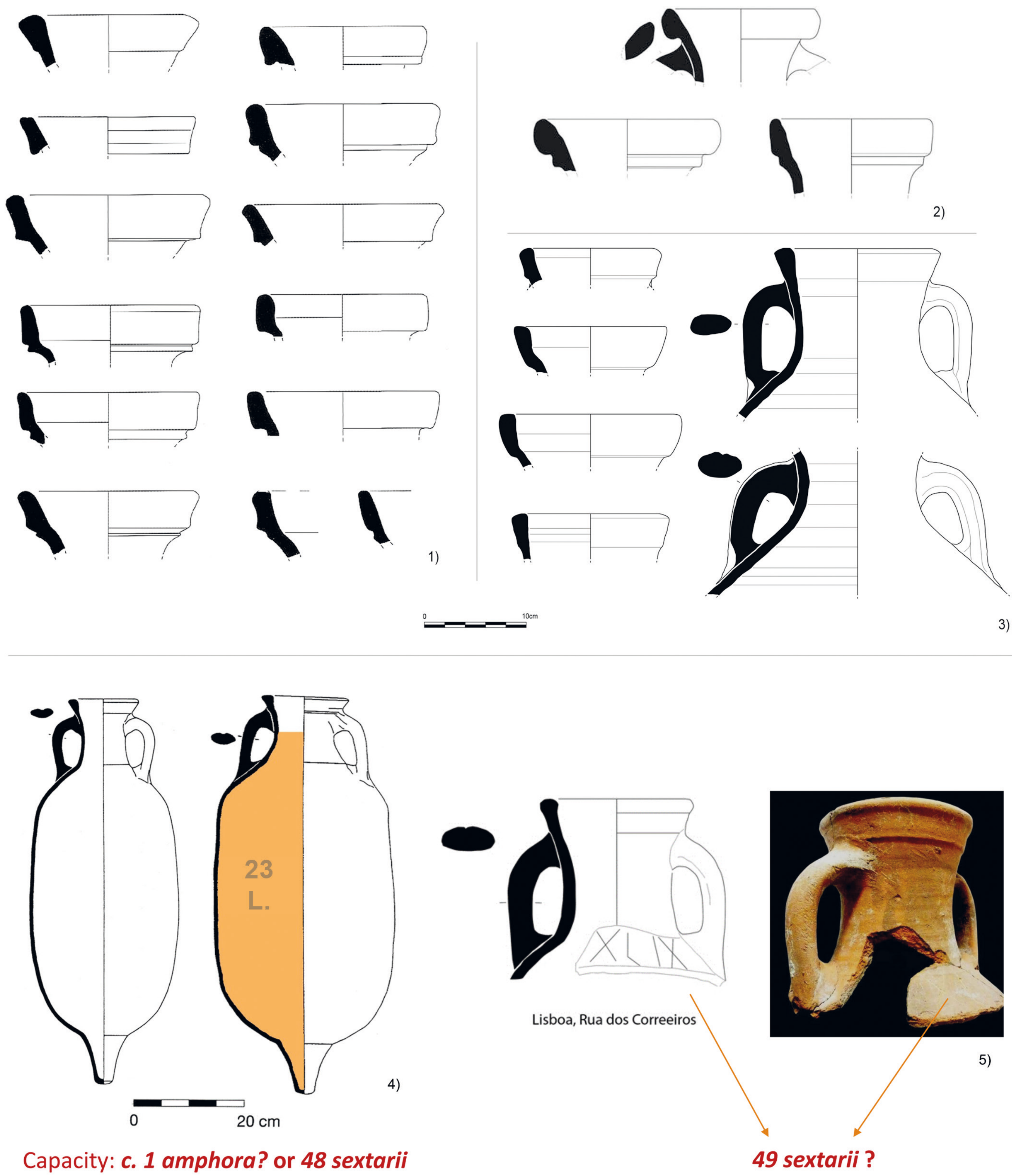
Concerning major typological trends, we observe that there is no reproduction of Italian models as occurred in other provinces in earlier periods such as in Ulterior/Baetica. Rather, morphologies have a clear affiliation with the Baetican Romanized amphorae from the Late Republican and Early Imperial periods, mostly related to the shapes from the Guadalquivir Valley and from the coastal area of Cádiz. As mentioned before, these ›early Lusitanian‹ types, once called Lusitanian ›ovoid types‹[62], characterize the first stage of Lusitanian production. Research from the last decade has shown that the types produced from the second half of the 1st century B.C. to the middle of the 1st century A.D., or at least to the end of the reign of Tiberius, were not all ovoid types. Though some do have an ovoid body shape and appear to copy, reproduce, or simply be inspired by Ulterior types such as the Ovoid 1 and 4 from the Guadalquivir Valley, others do not seem to have an ovoid shape but rather resemble the Baetican Early Imperial types such as Dressel 7–11 or Haltern 70. Nevertheless, based on the available data from very fragmentary specimens and mainly rim fragments, we have come to realize that some of these Lusitanian Late Republican/Early Imperial types are easily identified (as the one similar to Ovoid 1 from Guadalquivir), while others are much more difficult. The problem lies in the fact that several share the same morphological details, such as short handles with a longitudinal groove or molded rims. Therefore, it is quite risky to classify as ›ovoid‹ all these types preceding Dressel 14, as in many cases we currently have only rim fragments[63].

From what we are able to deduce, we can observe that within early Lusitanian production, over a period of almost a century, there emerged a rich and complex universe of shapes, such as (i) various ovoid types copying and reproducing other Ulterior/Baetican types, (ii) likely (but poorly preserved) non-ovoid types, (iii) amphorae copying and reproducing other Baetican types (Haltern 70, Dressel 7–11), and (iv) new provincial amphora forms with Baetican influences or inspiration. Most of the amphorae from the production center in Peniche, which started in Augustan times, belong to this last group[64]. As they form a different corpus both in terms of production context and in variety of shapes that show local originality – with specific types not copied from other amphorae – they should be considered as a separate entity. Their distribution was also mainly in western Lusitania to major towns including the province capital of Augusta Emerita[65].

Concerning the analysis of standardization in capacity, we do not possess a single complete specimen for the oldest Lusitanian type, which resembles a copy or reproduction of the Ovoid 1 type. Accordingly, the first example studied was another early Lusitanian type, also ovoid-shaped, known as Lusitana 12[66]. Its fabric characteristics allowed production to be proposed in the Tagus and/or Sado Valleys, a suggestion that was recently confirmed by the kilns of Parvoíce (Alcácer do Sal)[67] and Setúbal[68]. Two complete examples[69] were used for the volume measurements based on drawings and the digital method described above. Another example from an Olisipo's artisan/industrial context (NARC) shows a *post cocturam* graffito with the numeral XLIX on the lower part of the neck and upper part of the body. It is tempting to consider this to be ›confirmation‹ of its capacity as 49 (*sextarii* [?]), which could be related to one liquid *amphora* or 48 *sextarii* (fig. 5).

The next type for which we were able to perform this assessment was the Lusitanian Haltern 70[70]. The Lusitanian production of this type follows very closely the Guadalquivir model in its general shape, including rim, body, and handles. The petrographic characteristics of the complete

62 Morais 2004; Morais – Filipe 2016.
63 Almeida – Fabião 2019, 184–186.
64 Cardoso et al. 2016.
65 Fabião 2014.
66 Diogo 1987.
67 Pimenta et al. 2016.
68 Silva 2018.
69 Diogo 1987; Diogo – Trindade 1998.
70 Filipe 2016.



5 Fragments of ›Early Lusitanian types‹, including Lusitana 12. 1) Santarém/Scallabis (Arruda et al. 2006); 2) Monte dos Castelinhos (Pimenta – Mendes 2014); 3) Lisbon, Rua dos Bacalhoeiros (Filipe 2008b); 4) Lusitana 12 (Diogo 1987; Diogo – Trindade 1998); 5) Lusitana 12 upper part from Núcleo Arqueológico da Rua dos Correeiros, Lisbon (© by the authors)

specimens are related to both the Tagus and Sado Valley pottery workshops. Of course, wine-related products should be the first contents considered, as with the Baetican prototype. Nevertheless, there is no direct evidence for it content, and the coastal location of its hypothesized workshops suggests it may have been mainly used to transport fish-based products[71].

Comparative analysis of complete Lusitanian Haltern 70 examples from the Berlengas archipelago[72] and from chance finds in the Tagus River allowed further observations concerning morphological standardization[73]. This shows a quite homogeneous pattern for the region, with slightly different features from those of the original model, including a smaller rim and handles. In terms of capacity, calculated again based on the modeled drawings, they replicate the Baetican model in transporting 30 liters[74].

Concerning Haltern 70 production in Mérida, the capital of the province reflects a bizarre location for production of an amphora with a non-flat base, as it is very far from the sea or any navigable river[75]. These amphorae can be considered a copy or local interpretation of the original model[76]. A wine or wine-related content is likely, and the production extends from the late Augustan until the Flavian period. Bearing in mind Pliny the Elder's reference to some famous olives from the Augusta Emerita region (nat. 15, 17)[77], one should not rule out this possibility for the so-called Haltern 70 *emeritensis*[78]; olives were, after all, a common content in Haltern 70 amphorae according to the known *tituli picti* (fig. 6).

The production of these Lusitanian ›early types‹ seems to have begun between 40 and 30 B.C. and run until the Tiberian/early Claudian period; their distribution is attested in several different areas and contexts. On the one hand, they are found in Late Republican military settlements directly related to the process of conquest, with a particular distribution in the Tagus Valley, such as at Monte dos Castelinhos (Vila Franca de Xira)[79] and Santarém[80], but also in other contexts in northern Portugal and modern Galicia[81] during the Augustan period. Then again, there is a significant presence in sites like the so-called fortins (small forts), ›castella‹, and hill forts, as is the cases of Castelo da Lousa (Mourão)[82], Rocha da Mina (Alandroal), and Caladinho (Redondo) in the Alto Alentejo region[83]. This second group of sites in the inland of the future province of Lusitania seems to be related to the control of those territories connected to the emergent provincial capital of Augusta Emerita. In some instances, the amphorae have fabrics that point to a regional production, but the specific area of the workshop(s) has not yet been identified.

By contrast, these types are rare in the Algarve region at present, suggesting that production in this region only began in the Early Imperial period. Only in Monte Molião (Lagos) were a few examples possibly belonging to Lusitanian Haltern 70 rims identified, but the precise area of their production is still unknown[84]. It should also be highlighted that these early types are rare outside Lusitania, surely confirming a primarily local and regional distribution within Ulterior/Lusitania.

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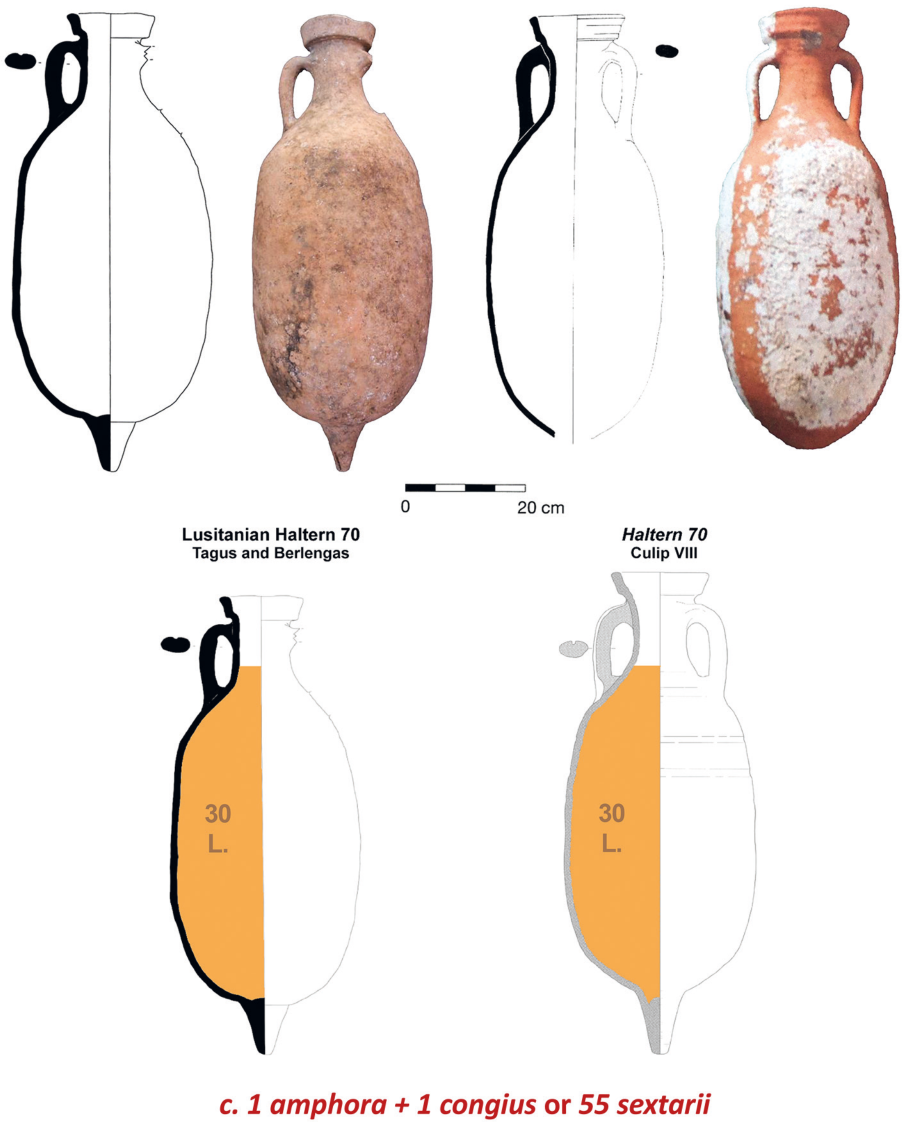
71 Morais – Fabião 2007; Fabião 2008; Filipe 2016.
72 Diogo 2005; Fabião 2014, 163 fig. 5–7; Filipe 2016.
73 Quaresma 2005.
74 For information on the volume of Haltern 70, see Carreras – Berni 2016.
75 One should note that the Gaudiana is only a partially navigable river.
76 Bustamante – Heras 2013; Bustamante – Heras 2016.
77 Guerra 1995, 38.
78 Fabião 2015.
79 Pimenta – Mendes 2014; Pimenta 2017.
80 Arruda et al. 2006.
81 Morais 2004; Morais – Filipe 2016.
82 Morais 2010.
83 Mataloto et al. 2016.
84 Arruda – Viegas 2016, 458 fig. 10.



6 Lusitanian Haltern 70 from the Tagus/Sado Valleys and its capacity (© by the authors)

Early Imperial Production

From the middle of the 1st century A.D. onward, a sort of convergence took place between these traditional early Lusitanian forms and the typical Dressel 14 type. The exact timing and manner of this process is still mostly unknown, and it is possible that different local or regional trends were in place around ca. 40–50 A.D. and continued until the early 3rd century. Throughout this long period, Dressel 14 was the major Lusitanian amphora form produced. Besides the Tagus and Sado Valleys[85], production gradually extended to the southern Algarve region[86] and to the western Atlantic coast (Peniche)[87].

This amphora type established its position in the internal Lusitanian market, being traded in quantities in both urban and rural areas; it was also exported to several areas of the western and central Mediterranean. Even so, we still lack a clear picture of the scale of Lusitanian exports,

[85] Raposo – Viegas 2016.
[86] Viegas 2016.
[87] Cardoso et al. 2016.

as there is still some confusion between the Baetican and Lusitanian production. Furthermore, knowledge of the Lusitanian fabrics remains poor among scholars in the different countries of the former Roman Empire. At Ostia, however, C. Panella identified Lusitanian amphorae in the stratigraphic records of the Terme del Nuotatore[88], and the recent monograph of G. Rizzo put in context the presence and relevance of Lusitanian imports[89]. Rizzo also recently evaluated Lusitanian amphorae in archaeological contexts from Rome[90]. The last conference concerning production and distribution of Lusitanian amphorae gives an up-to-date global view of both aspects[91], but the distribution data makes it clear that this achievement was just the first step in a topic that needs and deserves much more research.

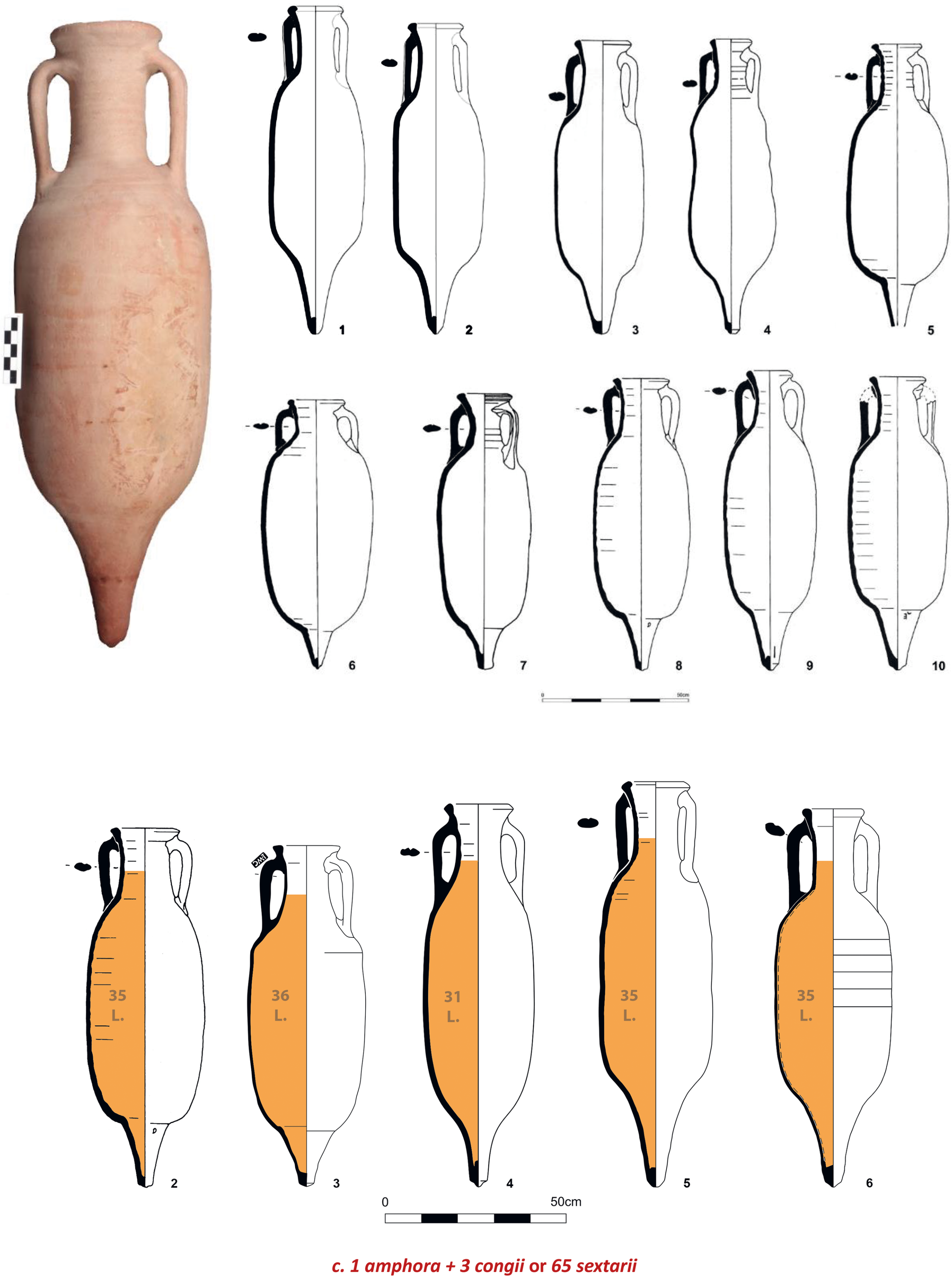
The Dressel 14 type's contents were fish-based products, which is supported by the location of the kilns again in coastal areas and in close connection to fish-salting units, and more importantly by the first confirmed direct archaeological evidence of fish contents[92]. Concerning standardization, the Lusitanian Dressel 14 amphorae share the same overall shape, although some specific regional features should be noted. For instance, the center at Zambujalinho (Palmela), from the Sado estuary area seems to have produced chiefly Dressel 14 with small necks[93], while another center at Garrocheira (Benavente)[94] in the Tagus estuary produced Dressel 14 with longer necks and handles. Unfortunately, we do not have amphorae preserving the complete profile from these pottery workshops, so we cannot confirm if these specific features had some relation to different modules or sizes of amphorae. According to volumetric data obtained from five complete amphorae of this type, the capacities can range from 31 to 36 liters, with most containers transporting 35 liters. Following the ancient Roman measurement system, this could be converted into ca. 1 *amphora* + 3 *congii*, or 65 *sextarii*, or 11 *congii*.

In this period there is also evidence for the Dressel 14 *parva* type (= Beltrán 73)[95] in addition to the normal Dressel 14 size, showing that both are clearly contemporary and traveled together, as evidenced by the Grum de Sal shipwreck (Ibiza)[96]. It is clear that they have the same fabric from the Tagus or Sado Valleys. In the Sado area, a smaller Dressel 14 type was also identified distinct from this *parva* version and called ›Late Dressel 14‹[97], but unfortunately the available data are not sufficient to estimate the overall shape of the amphora or its capacity. Our sample at present is too small to reveal both the chronological changes and the specific features of each area or production center.

It is possible that the products of the Tagus and Sado estuaries have some peculiar dynamics of their own that we do not yet understand. In the Algarve region, Dressel 14 production is attested at S. Bartolomeu de Castro Marim, where the type also shows specific features that differ from those in the Sado and Tagus Valleys[98] (fig. 7).

Besides the large-scale and standardized production during the 1st and 2nd centuries A.D. of the Dressel 14 type, another amphora type begins production in this period: the Lusitana 3 type. According to some authors, its origin and influence may be understood as a Lusitanian interpretation of the Gauloise 4 wine amphora type[99]. Production of the Lusitana 3 type, which is mostly attested at the Tagus workshops, must have started at the end of the 1st century and continued until the

88 Panella 1972.
89 Panella – Rizzo 2014.
90 Rizzo 2016.
91 Pinto et al. 2016a.
92 Alarcão – Mayet 1990; Gabriel 2013; Gabriel – Silva 2016; Gabriel 2018.
93 C. Fabião personal observation.
94 Amaro – Gonçalves 2016.
95 Beltrán 1970; Almeida 2016.
96 Hermanns et al. 2016.
97 Mayet – Silva 1998.
98 Despite a general trend toward standardization, there is also a certain degree of regional variation.
99 Laubenheimer 1985. The link is mentioned by Quaresma – Raposo 2016a.



7 Dressel 14 amphorae and their capacities. 1–2) Porto dos Cacos; 3–4) Setúbal; 5–6) Pinheiro workshop; 7) Tróia; 8–10) Abul workshop (from: Raposo – Viegas 2016 with bibliography)

early 3rd century A.D.[100]. From the late 2nd century on, it was also produced in the Sado estuary[101]. Most researchers accept that this amphora, with an inverted piriform body and flat bottom, could have been used as a wine container[102]. The hypothesis is reasonable considering the agricultural richness of the *ager olisiponenses*, where several *villae* are known, some of which are equipped with *cella vinaria* and installations for production. On the other hand, for researchers working in the Sado area, the huge importance of the salted-fish industries, the locations of pottery centers, and the minority production of the type (in contrast to the Tagus data) could suggest this particular amphora was not a wine container but again (as in case of Lusitanian Haltern 70 type) one devoted to transporting salted-fish products[103].

The distribution of Lusitana 3 amphorae across Lusitania is well known, and the evidence is increasing, chiefly in the major towns[104]. We also know that it was exported elsewhere, namely to Baetica[105]. These recorded exports to other areas will increase with the concomitant improvement of researchers' knowledge about Lusitanian fabrics.

Generally, the capacity of this container must have been around 40 *sextarii* (7 *congii* or 1.6 *urna*), which corresponds to the 20–23 liters obtained in 3D modeling; a minority fall more broadly into the range of just below 18 to over 23 liters. While studying a set of Lusitana 3 amphorae from Tróia, stored in the National Archaeology Museum[106], it was possible to observe, for the first time different modules corresponding to different capacities or volumes (fig. 8).

Table 1 Lusitana 3 specimen from Tróia and correspondence, table of their capacities

Module 1 (1/1)	**Module 2 (3/4)**	**Module 3 (1/2)**
ca. 22 liters	ca. 17 liters	ca. 11 liters
40 *sextarii*	30 *sextarii*	20 *sextarii*
7 *congii*	5 *congii*	3.5 *congii*
1.6 *urna*	1.25 *urna*	0.8 *urna*

Kiln sites in the Tagus and Sado estuaries produced both Dressel 14 and Lusitana 3 amphorae along with many other products, such as coarse wares. This raised questions regarding the nature of these production centers. Their greatest concentration is in estuarine areas, close to both fish-processing factories and relevant towns (sometimes these towns and production centers were the same places). This concentration and easy communication, on the one hand, and the diversity of products observed in each center, on the other, strongly suggest a production model based on the ›urban nucleated industry‹, to draw on the concept of D. Peacock[107]. The volume of amphorae and other ceramics also implies the existence of a high level of specialization, but this would also create some dependency on and vulnerability to market fluctuations, which we will see is an important issue.

Such a production model implies the existence and intervention of middlemen, namely ceramic traders, operating between the pottery workshops and the fish-processing factories. A degree of pressure would be exerted from the demand side concerning volume production or capacities. This situation can be seen, for instance, in the center at Pinheiro, which shifts its production to the Lusitania 3 and other minor forms when the demand for Dressel 14 amphorae declined due to a crisis in local fish-processing factories[108]. The presence of middlemen can be postulated

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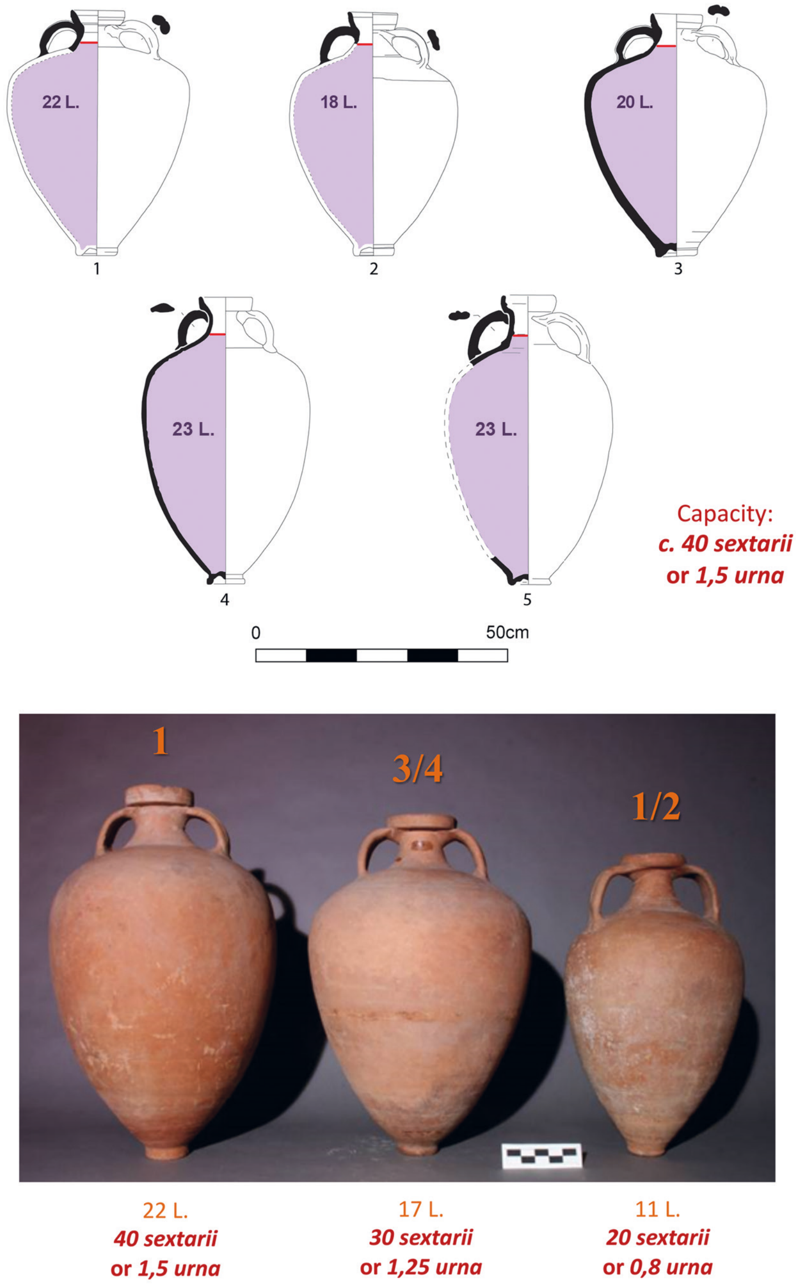
[100] Quaresma – Raposo 2016a.
[101] Mayet – Silva 2016.
[102] Quaresma – Raposo 2016a.
[103] For F. Mayet and her team working in the Sado area, this would be the first variant of the Almagro 51C, so linked to salted-fish contents, see Mayet et al. 1996; Mayet – Silva 1998; Mayet – Silva 2002.
[104] Fabião 1998; Almeida – Sanchéz 2013; Filipe 2018.
[105] García 2015; Bernal-Casasola 2016; García 2016; Quevedo – Bombico 2016.
[106] Work undertaken by C. Fabião .
[107] Peacock 1982, 38–43.
[108] Mayet – Silva 1998, 113–123.



8 Lusitana 3 examples and capacities (above); Lusitana 3 specimen from Tróia (below) (© by the authors)

from the significant variety of amphorae sources noted in some of the fish factories, such as Rua dos Correeiros or Casa do Governador da Torre de Belém, both in the Olisipo area[109]. The implications of this economic model for promoting amphora standardization can only be determined through further research.

[109] Dias et al. 2012. It was postulated that middlemen would acquire the products from the different workshops in the Tagus estuary, without specific preference for any of them, which could explain the diversity observed among the amphorae analyzed within individual sites.

Late Antique Production

From the late 2nd and early 3rd centuries onward, there was a clear modification in structures dedicated to the processing of salted fish and fish-based products (*cetariae*), and some were abandoned[110]. This phenomenon still lacks a clear explanation. Various reasons have been proposed, from ecological changes to political turbulence to the Antonine plague, but no strong evidence has been found to support any of these explanations, and it may make little sense to imagine one single cause. From the 3rd century, a major change can be seen in Lusitanian amphora production. New varieties were made, and there was clearly a contribution by craftsmen coming from outside the Iberian Peninsula, perhaps including some from North Africa, as already suggested. These new amphorae were modeled on no previous local tradition[111].

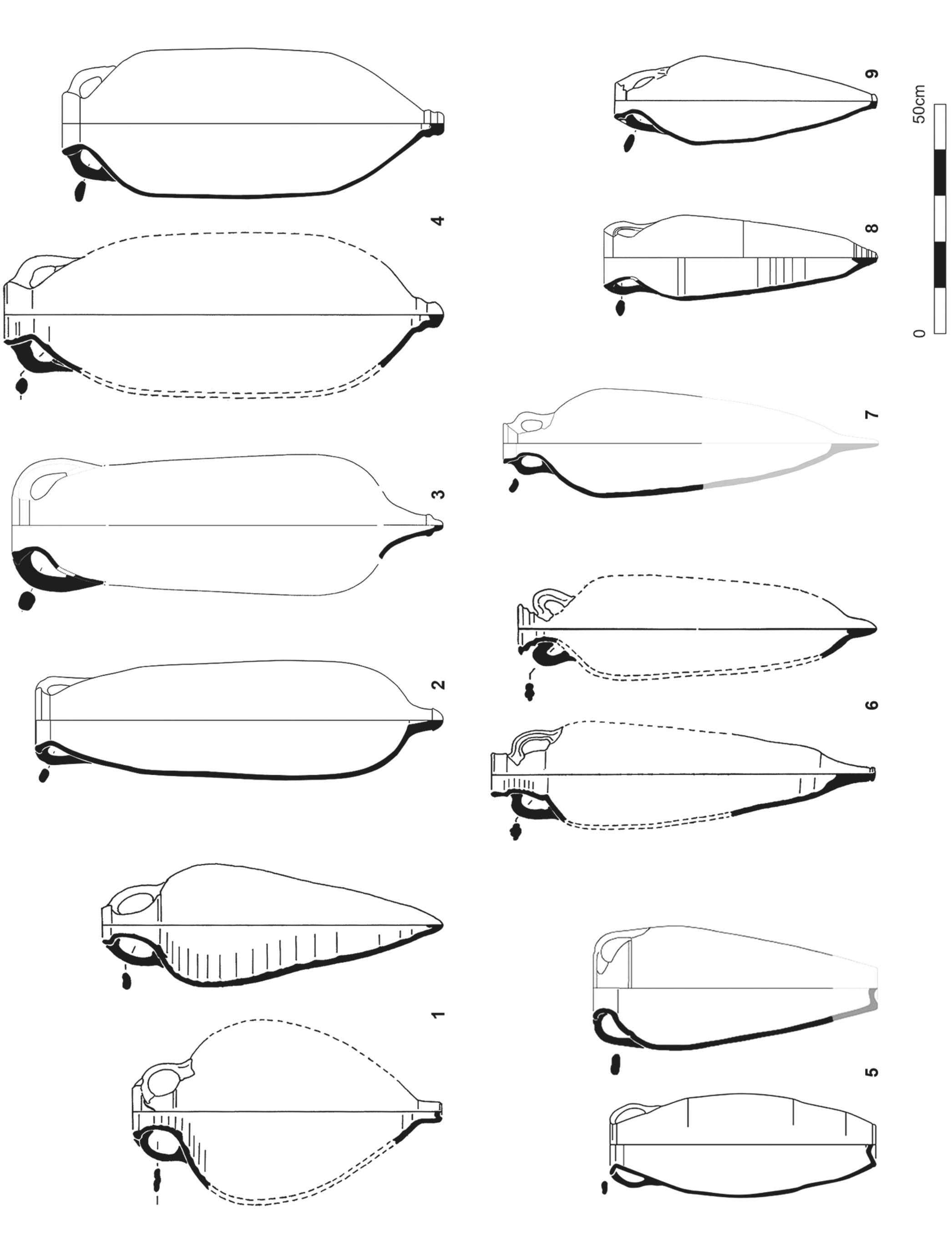
As a result, there is considerable diversification in Late Antique production, especially from the mid-3rd to the late 5th or even 6th century A.D. The most commonly produced and widely distributed types in Lusitania were the Almagro 51C, Almagro 50, Keay 16, Sado 1 (= Keay 78), Almagro 51A–B, Algarve 1, and Lusitana 9; there were also some minority types, like Sado 3, Lusitana 10, and others that still today need to be better characterized and studied[112] (fig. 9).

For this Late Antique production, the major areas are, once again, the Tagus and Sado estuaries. In both areas, some centers continued production as before, while others were abandoned, and new ones also appeared. One important change can be seen in the Algarve, an area that clearly increased its production and relevance in this period. The workshops on the Algarve coast were, from east to west, the major center at Martinhal (Vila do Bispo)[113] and other smaller but also important workshops, such as Lagos[114], Quinta do Lago[115], Salgados[116], and São João da Venda (Loulé)[117].

Concerning amphora morphologies, four main families of types were identified across these production areas: (i) Almagro 51C, (ii) Almagro 50 and Keay 16, (iii) Almagro 51A–B + Algarve 1, (iv) Lusitana 9 (unknown in the Algarve area). But the morphological picture is more complex still, with several other minor and specific regional types, such as those from the Sado region – Sado 1 (= Keay 78), Sado 3, and Lusitana 10 – and those from the Tagus region as well as those from both Tagus and Sado regions together. Taken together, these form components of a related or complementary group that includes both the late NARC small amphorae and those that have been called Beltrán 72 ›related type‹ or *similis*[118]. As these regional variants are much rarer, with more limited circulation and probably also less standardization, we will discuss them but rather concentrate mostly on the major late Roman Lusitanian types.

Starting with the Almagro 51C type[119], the first striking conclusion from the available data for volume was that it had the same capacity as the Dressel 14 and Lusitana 3 types. This form is typically characterized by an inverted piriform body in the 3rd to the 4th century, as seen at Porto dos Cacos[120] (Tagus estuary) as well as Pinheiro[121] and Abul[122] (Sado), while a spindle-shaped body is

110 Fabião – Carvalho 1990.
111 Fabião – Carvalho 1990.
112 For an updated overview of Lusitanian amphora types, see Fabião 2008; »Ex Amphora Hispania«; Pinto et al. 2016a and b.
113 Silva et al. 1990; Bernardes 2008; Bernardes et al. 2013; Bernardes – Viegas 2016.
114 Ramos et al. 2006; Fabião et al. 2017a.
115 Arruda – Fabião 1990; Fabião 2004.
116 Bernardes et al. 2007; Bernardes – Viegas 2016.
117 Fabião – Arruda 1990; Fabião 2004; Bernardes –Viegas 2016; Fabião 2017.
118 This small amphora was distinguished for the first time in the excavations of NARC (see above).
119 Viegas 2016; Viegas et al. 2014.
120 Raposo 1990; Raposo – Duarte 1996.
121 Mayet – Silva 1998.
122 Mayet – Silva 2002.



9 Lusitanian amphorae types from the mid 3rd until the late 5th/early 6th century A.D. 1) Almagro 51C; 2) Almagro 50; 3) Lusitanian Keay 16; 4) Sado 1 (= Keay 78); 5) Lusitana 9; 6) Almagro 51A–B; 7) Algarve 1; 8) Sado 3; 9) Lusitana 10 (© by the authors)

more representative of the 4th and 5th centuries at the Quinta do Rouxinol[123], Porto dos Cacos[124], and Pinheiro workshops[125]. Examples of the 3rd to the 4th century had the capacity to transport 36–38 liters, corresponding to 1 *amphora* + 1 *urna* (70 *sextarii* or 12 *congii*), which is quite similar to the average capacity of the Dressel 14 type; the typical 4th and 5th centuries shapes could contain from as much as 25 liters, which corresponds to 1 *amphora* (48 *sextarii* or 7.5 *congii*), down to 17 liters (32 *sextarii* or 1 *urna* + 1 *congius*), with some smaller modules that had only 10 liters of capacity or 1 *urna* (18–25 *sextarii* or 3–4 *congii*).

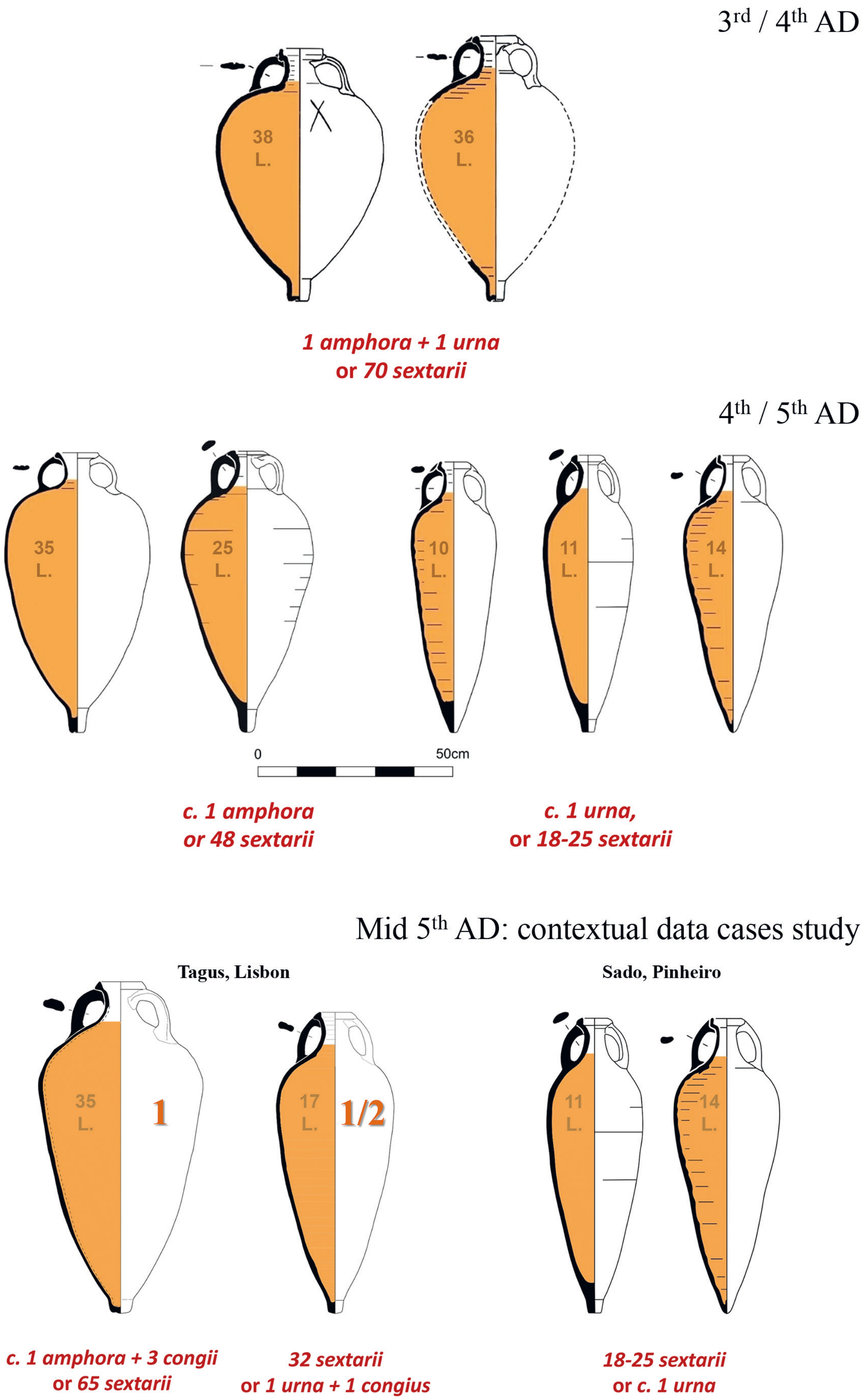
When these Almagro 51C amphorae are compared to both Dressel 14 and Lusitana 3 amphorae, they show the same average capacity of about 35–38 liters. Nevertheless, a closer examination allows some further observations. A case study provided by NARC in Lisbon – where debris covered a fish tank and is dated to the end of fish-sauce production in the mid-5th century[126] – shows that shapes corresponding to 35 and 17 liters (the module and the half-module) were produced and coexisted in the same consumption contexts in the same period. The same situation can be seen at the Tagus Valley production centers, such as Quinta do Rouxinol[127]. At least in the Tagus area, these two shapes or variants were not exclusive to one period or another as it seems to be the case for the Sado workshops; at the Tagus workshops, both variants were used together, but with a predominance of the spindle-shaped amphora, at least until mid-5th century A.D. Whether this is the result of market demand, as we postulated before, remains a question in need of further research.

Comparing the Tagus data with that obtained from the Sado Valley, the Pinheiro workshop demonstrates the existence of the same spindle shape but in a smaller version of the Almagro 51C that here only had the capacity to transport 11–14 liters (18–25 *sextarii*, 3–4 *congii*, or 1 *urna*). On the one hand, it seems there was some intention to implement standardization evident in the Tagus and Sado pottery workshops' products. On the other hand, this desire did not bring about a comparable homogeneity in shape in both regions: in the Sado area, we have just the spindle-shaped variant in the second half of the 4th and 5th century A.D. (fig. 10)[128].

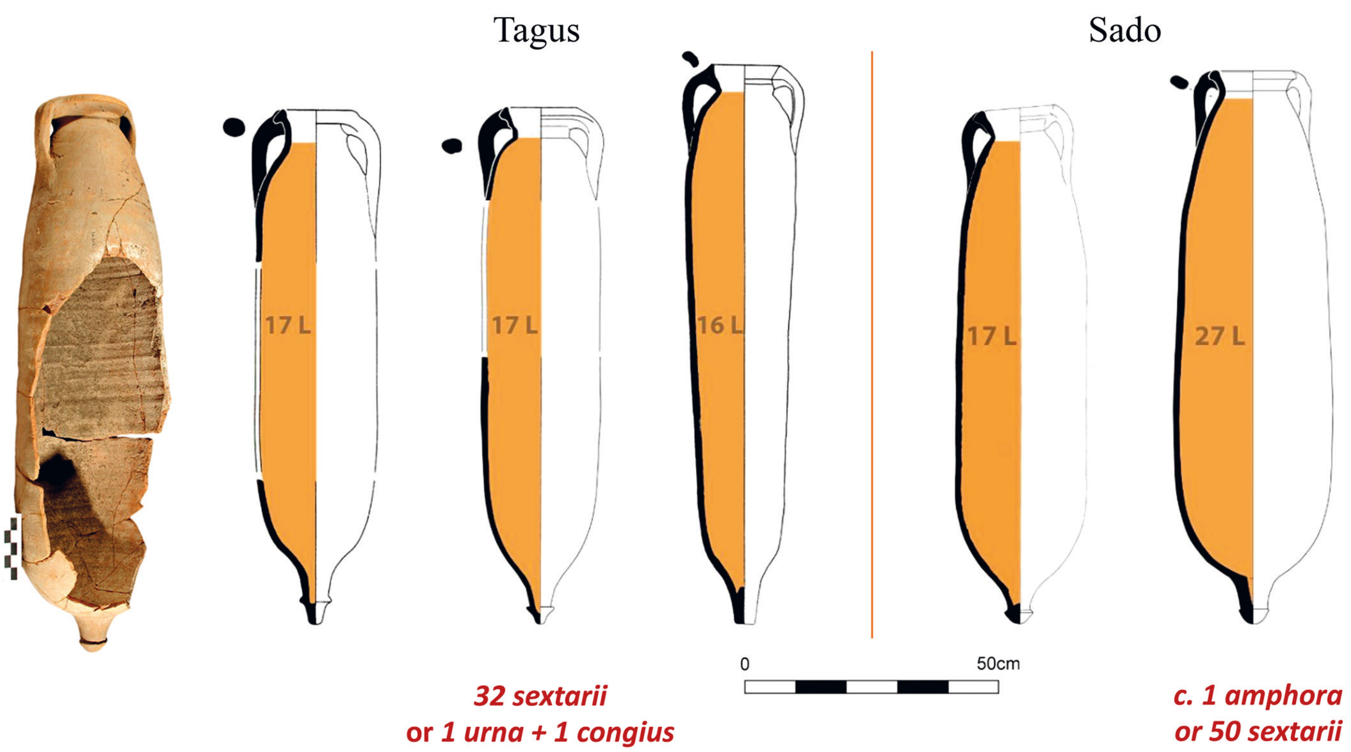
Another significant type in this period was the Almagro 50 amphora[129], which was produced in the Tagus and Sado Valleys as well as in the Algarve workshops from the early 3rd to the end of the 5th century A.D. Despite usually being considered a singular amphora type, there are some morphological peculiarities that apply in each of these regions, and these different forms require further research. Some complete examples from the Tagus workshop at Porto dos Cacos (from the necropolis area) show the type with a transport capacity of 16 liters, 32 *sextarii* (5 *congii* or 1 *urna* + 1 *congius*). The Sado examples from the workshop at Abul II present the same capacity. The cylindrical elongated shape of the Almagro 50 amphora body was particularly suited to being a funerary container, as was the case in Tróia (Caldeira necropolis). In this example, the amphora has a capacity of 27 liters, equivalent to ca. 1 *amphora* (50 *sextarii* or 8 *congii*). Other measured specimens from well-known reference contexts of distribution, like Port-Vendres I (= Anse Gerbal)[130] and Randello[131], fall within this same range (fig. 11).

The Lusitanian Keay 16 type[132] was produced in the same period but only in the Tagus and Sado estuaries and in smaller quantities than the typical Almagro 50 type[133]. When compared

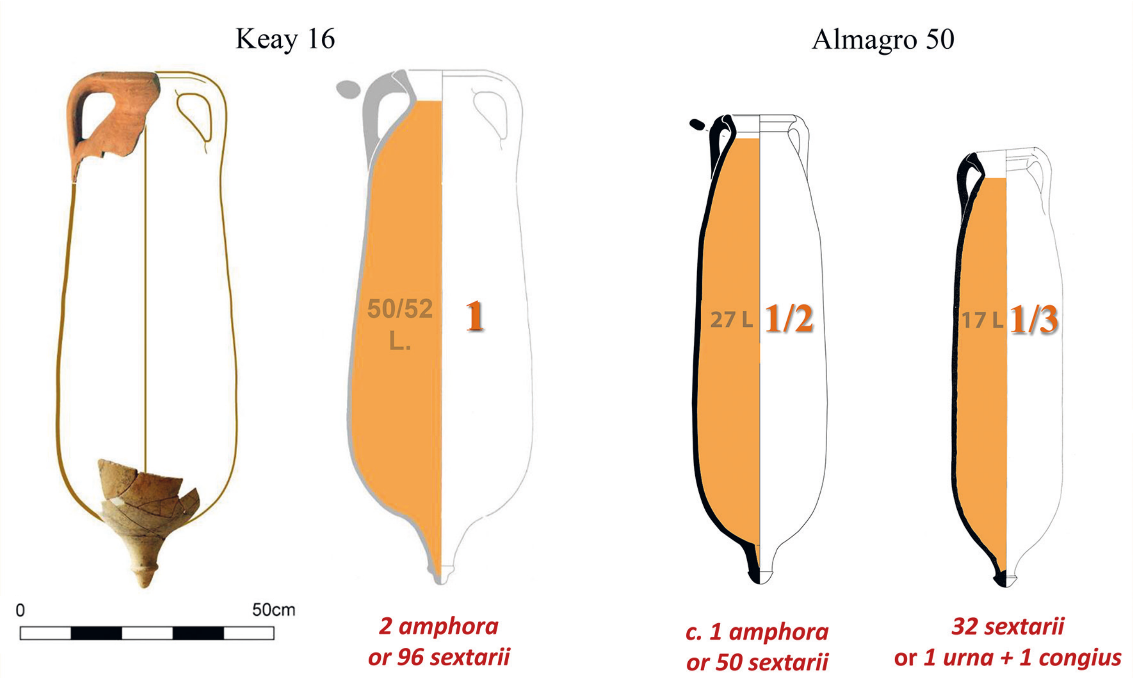
123 Raposo et al. 2016.
124 Raposo – Duarte 1996; Raposo et al. 2016.
125 Mayet – Silva 1998; Mayet – Silva 2016.
126 Bugalhão et al. (in preparation).
127 Raposo et al. 2016.
128 Mayet – Silva 1998; Mayet – Silva 2016.
129 Raposo – Almeida 2016.
130 Chevalier – Santamaria 1971.
131 Parker 1989.
132 Almeida – Raposo 2016.
133 These are often considered equivalents because the Lusitanian Almagro 50 and the Keay 16 share a great number of identical features. Nevertheless, they show different measures and proportions: see Almeida – Raposo 2016



10 Almagro 51C amphorae capacities and Tagus and Sado Valleys compared to contextualised cases (© by the authors, see Viegas et al. 2016 for bibliography)



11 Almagro 50 amphorae capacities (© by the authors, see Almeida – Raposo 2016 for bibliography)



12 Lusitanian Keay 16 capacity and comparative with Almagro 50 (© by the authors, see Almeida – Raposo 2016 for bibliography)

to the Almagro 50 shape, aside from some slight distinctions in the upper part (rim, neck and handles) the main difference seems to be the capacity, as Keay 16 contained almost double the volume of the previous type, for a capacity of 50–52 liters (equivalent to 2 *amphorae,* 96 *sextarii*, or 16 *congii*). It is certainly tempting to see here again two different modules of the same amphora type, but at present we do not have enough empirical data to support this assumption. If this proves to be accurate, then it is probably confined to the 3rd century, as there is no secure evidence for production of a Keay 16 type during the 4th and 5th centuries. Once again, it is possible to see market pressures behind this change (fig. 12).

The Sado 1 (= Keay 78), with its two variants (A and B), became the second most important container for fish products, after Almagro 51C, from the mid-3rd century onward, especially in its variant B between the mid-4th and the mid-5th century. This shape, first identified at Tarragona and assumed then to be an African amphora[134], was later demonstrated to be a Lusitanian product[135]. The morphological characteristics of this type later called Sado 1[136] – the large cylindrical body with very short and narrow (or almost non-existent) neck and the thin body walls – mark a break in the amphora tradition of the Sado Valley. Although affinities with the Almagro 50 type have been recognized, mainly concerning the neck and handles, the Sado 1 morphology must be considered an original Lusitanian creation, most likely by producers from the Sado Valley[137]; however, in its creation and development, an African influence should also be recognized.

This type does not appear in the Tagus Valley, in either production or consumption contexts. It is notoriously absent in Lisbon and also in the capital of Lusitania, and indeed in the central and northern half of the whole province, in direct contrast to what we should expect considering the importance of these markets. It appears chiefly in the southern area, in urban centers, and at *villae* located in the immediate vicinity of, and in regions that can be directly supplied from, the Sado Valley itself and the terrestrial road network directly linked to the river: a significant distribution exists in the rural area of Beja/Pax Iulia, with the best examples coming from the *villae* of São Cucufate (Vidigueira)[138] and Monte da Cegonha (Selmes)[139].

Despite the lack of examples in cities and rural settlements in the southern coastal area of Lusitania (today Algarve), this type's presence is well attested in port contexts of Portimão, along the Arade River and outside the province in shipwrecks indicating external trade routes: for example, Escolletes 1 on the nearby coast of Murcia, Fontanamare A on the southwest coast of Sardinia[140], and at Turris Libisonis also in Sardinia[141]. This distribution indicates that foreign markets, probably those in the western part of the Roman Empire, were the main focus for its exports. Other examples may also not yet have been correctly identified.

The Sado 1 is the largest amphora among those produced in Lusitania. Concerning its capacity, it frequently reaches an average of 42–45 liters (1 *amphora* + 6 *congii*, or 80/81 *sextarii*). But there is also one specimen with a smaller capacity of 35 liters (1 *amphora* + 3 *congii*, or 65 *sextarii*) and one with an enormous capacity estimated at a minimum of 61 liters (2 *amphorae* + 3 *congii*, or 113 *sextarii*). Of interest is one fragment from Tróia showing a *post cocturam* graffito with the numeral LXII on the lower part of the neck and upper part of the body; once again it is tempting to consider this as confirmation of one of the capacities of this type at 62 (*sextarii* [?]), which could be related to a capacity of one *amphora* (65 *sextarii*) since the difference is minimal. The large capacity of this type suggests that it was more important, in terms of quantity of

(Keay 16); Raposo – Almeida 2016 (Almagro 50).
134 Keay 1984, 149–155.
135 Diogo 1987; Mayet et al. 1996; Mayet – Silva 1998; Pinto – Almeida 2016.
136 Mayet – Silva 1998.
137 Pinto – Almeida 2016.
138 Mayet – Schmitt 1997; Pinto – Lopes 2006.
139 Pinto – Lopes 2006.
140 Bombico et al. 2014; Bombico 2017.
141 Villedieu 1984.

transported goods, than the comparatively small number of individuals quantified in consumption contexts might suggest (fig. 13).

The Almagro 51A–B type was produced in the Tagus and Sado Valleys from the second half of the 4th to probably the late 5th century A.D. As far as we know, this type was much more frequent in the Sado pottery workshops than in those from the Tagus estuary. Although there are no complete examples, the reconstruction of one amphora from the Sado workshops points to a vessel of about 15–16 liters (30 *sextarii*, 5 *congii*, or 1 *urna* + 1 *congius*) or a little less at 13 liters (24 *sextarii*, 4 *congii*, or 1 *urna*). In the Algarve workshops at Martinhal (Vila do Bispo), Lagos and S. João da Venda (Loulé), and probably also at Salgados (Loulé), a regional and specific variant of this form with peculiar morphological features that are easy to identify and recognize in the archaeological record was produced from the middle of the 4th to the first half of the 6th century A.D. It was recently classified as Algarve 1[142], as it was produced at several pottery workshops of the region rather than just in one specific center (fig. 14).

It seems plausible to consider the existence of a modular system here, with the same overall shape used for a larger module, although this is difficult to confirm since there is no complete example from a Lusitanian pottery workshop. An average of 15 liters (perhaps equivalent to 24 *sextarii*, 4 *congii*, or 1 *urna*) is proposed based on the reconstruction of an incomplete example from Lagos. A smaller module of only 8 liters (arguably equivalent to 14 *sextarii*, 2.5 *congii*, or ⅓ *amphora*) is documented in a complete example from Martinhal (Vila do Bispo)[143]. It must also be stressed that these two types, Almagro 51A–B and Algarve 1, share the same general shapes, although they show differences in the rim, the handles (profile and position), as well as the neck. Concerning the Algarve 1 type and its different modules, the Sud-Lavezzi 2 shipwreck provides a relevant case study[144]. It seems possible that the amphorae from that wreck belong to the Algarve 1 type[145], with the larger module corresponding to one unit, while the medium represents half of the unit, and the smaller size three quarters of the unit. It is possible that this standardization based on capacity was also related to the commercialization and circulation of the products traded since they enabled easy loading and storage within ships (fig. 15)[146].

The flat-bottomed Lusitana 9 type is assumed to have transported wine products and was produced in both the Tagus and Sado estuaries from the middle of the 3rd to the middle of the 5th century, but it seems likely to have had a more limited circulation than other types[147]. Nonetheless, we know that it was transported not only to *villae* located throughout inland provincial areas[148] but also to the capital of the province, Augusta Emerita[149], as well as to Baetica[150]. Its capacity seems to vary from around 13–14 liters (about 1 *urna*, 24 *sextarii*, or 4 *congii*) to 16 liters (1 *urna* + 1 *congius*, 32 *sextarii*, or 5 *congii*) (fig. 16).

In the later phases of production, there seems to be a lower degree of standardization across all Lusitanian manufacturing regions compared with the situation in the 1st and 2nd centuries A.D.; each of these main areas now follows its own path, developing in their repertoires specific variants of certain shapes and also some unique forms. To the first group belong the Almagro 51A–B type for the Sado Valley (as its production is not yet known in the Tagus workshops) and the Algarve 1 for the region's coastal area. To the second belongs the complex universe of examples related to or inspired by the Baetican Beltrán 72 type, as well as some late smaller and miniature shapes which include Sado 3 and Lusitana 10, apparently only produced in the Sado workshops.

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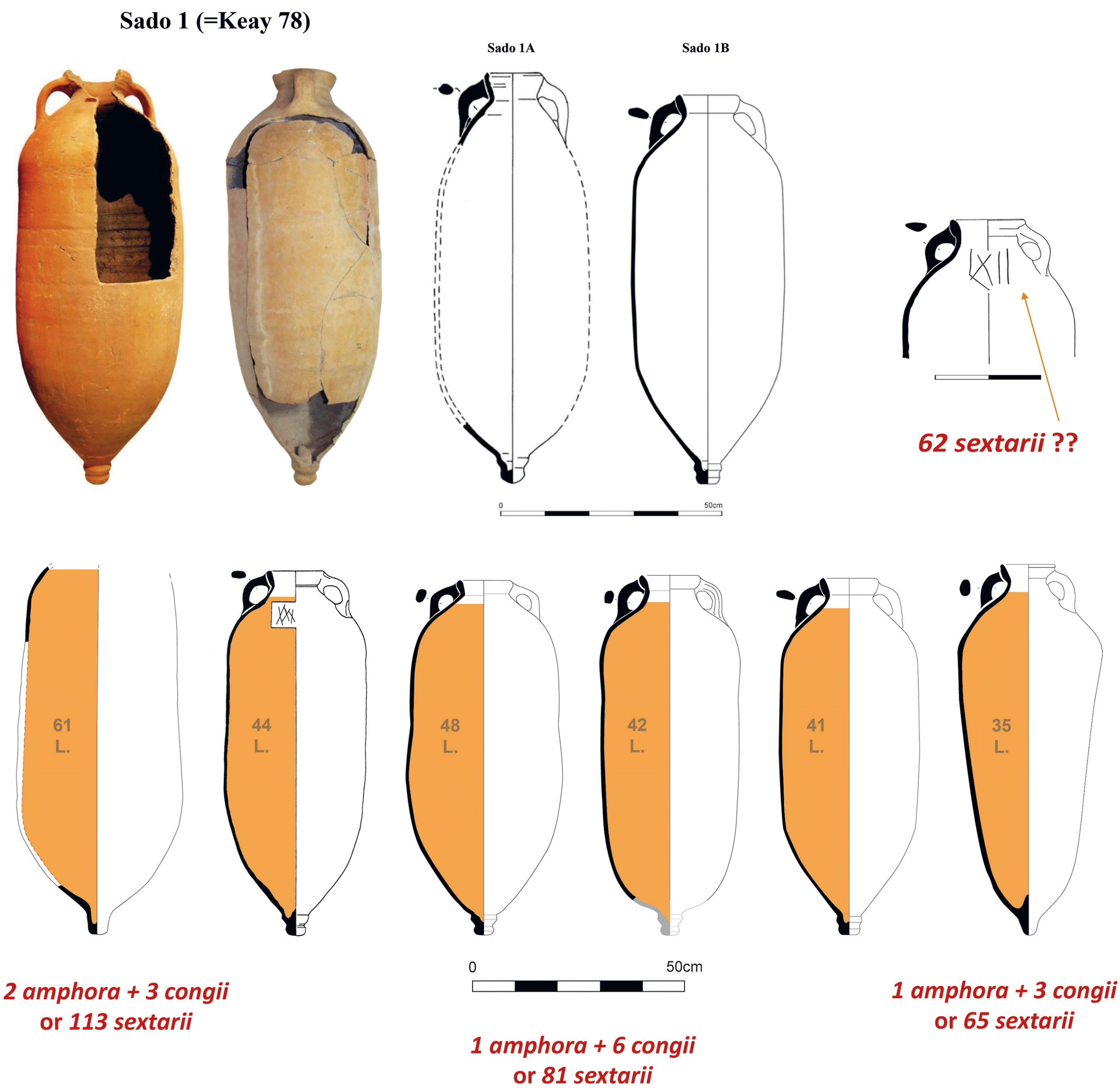
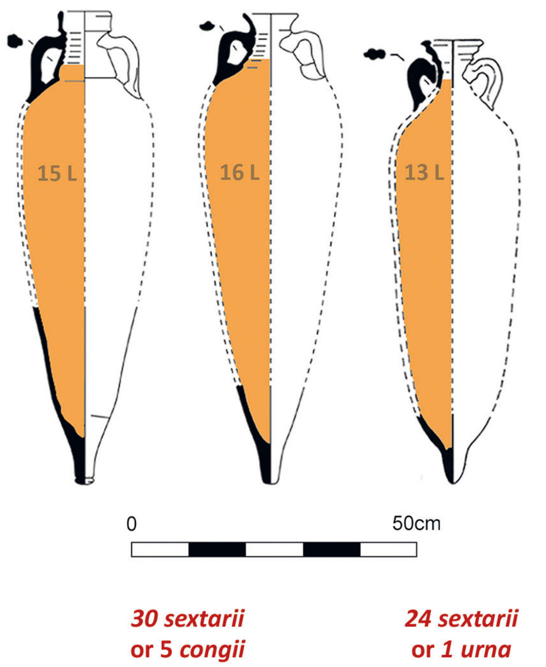
142 Fabião et al. 2010; Fabião et al. 2017a.
143 Cf. Fabião et al. 2017a.
144 Liou – Domergue 1990.
145 A Lusitanian provenance was confirmed by Bombico et al. 2014, 367.
146 Pinto – Almeida 2016.
147 Quaresma – Raposo 2016b.
148 Pinto – Lopes 2006.
149 Almeida 2016.
150 Fabião (forthcoming).



13 Sado 1 (= Keay 78) amphorae and their capacities (© by the authors, see Pinto – Almeida 2016 for bibliography)



14 Almagro 51A–B amphorae and their estimated capacities (© by the authors)

It is commonly assumed in the latest overviews on Lusitanian amphorae that the production of Beltrán 72 did not take place around the central part of Portugal, nor in the Algarve, together with Keay 16[151]. Nevertheless, there are some incomplete amphorae with petrological characteristics typical of the Tagus and Sado regions that resemble this Baetican type: at Quinta do Rouxinol[152] in the Tagus estuary, and in the Sado estuary at Quinta da Alegria[153], Abul (in layers dated to the second quarter or mid-3rd cent. A.D.)[154], and Pinheiro (in contexts of both the early 4th cent.[155] and end of the 4th or beginning of the 5th cent. A.D.[156]). Within this group, the best-preserved examples come from the fill layers of a vat in a presumed fish factory at Rua dos Fanqueiros, in the center of Lisbon, dated to the second half of the 5th century A.D.[157], and from the riverbed of the Rio Arade in the Algarve[158]. We suggest that these are not Lusitanian copies of Beltrán 72, as with the Lusitanian Keay 16 type, but rather represent a related Lusitanian form inspired by the Baetican one[159]; this form needs to be properly characterized and studied as a type (fig. 17).

At the same time, there are some examples we could consider as ›miniatures‹ that have been identified over the last two decades but have yet to be properly studied. These are only recently being properly recognized and described. Most of the known examples represent rims, upper parts with handles, or bodies and bottoms. This is the case for some examples from consumption contexts in the Tagus and Sado areas, such as at the NARC in Lisbon[160] and Tróia[161], but also at Mérida, the capital of the province[162], showing their role in larger trade routes and outside markets (fig. 18).

Also unusual in consumption contexts are other late types such as Lusitana 10 and Sado 3. Both seem to have started to be produced in the first half of the 5th century, particularly in its second quarter, but only in the Sado estuary as far as we can assess from the Pinheiro workshop's stratigraphy and contexts[163]. The end of their production can be dated to the beginning of the 6th century. Both types appear to be related to the Almagro 51C and are difficult to distinguish if only as fragments. For both types, the proposed contents are fish-based products. The late Lusita-

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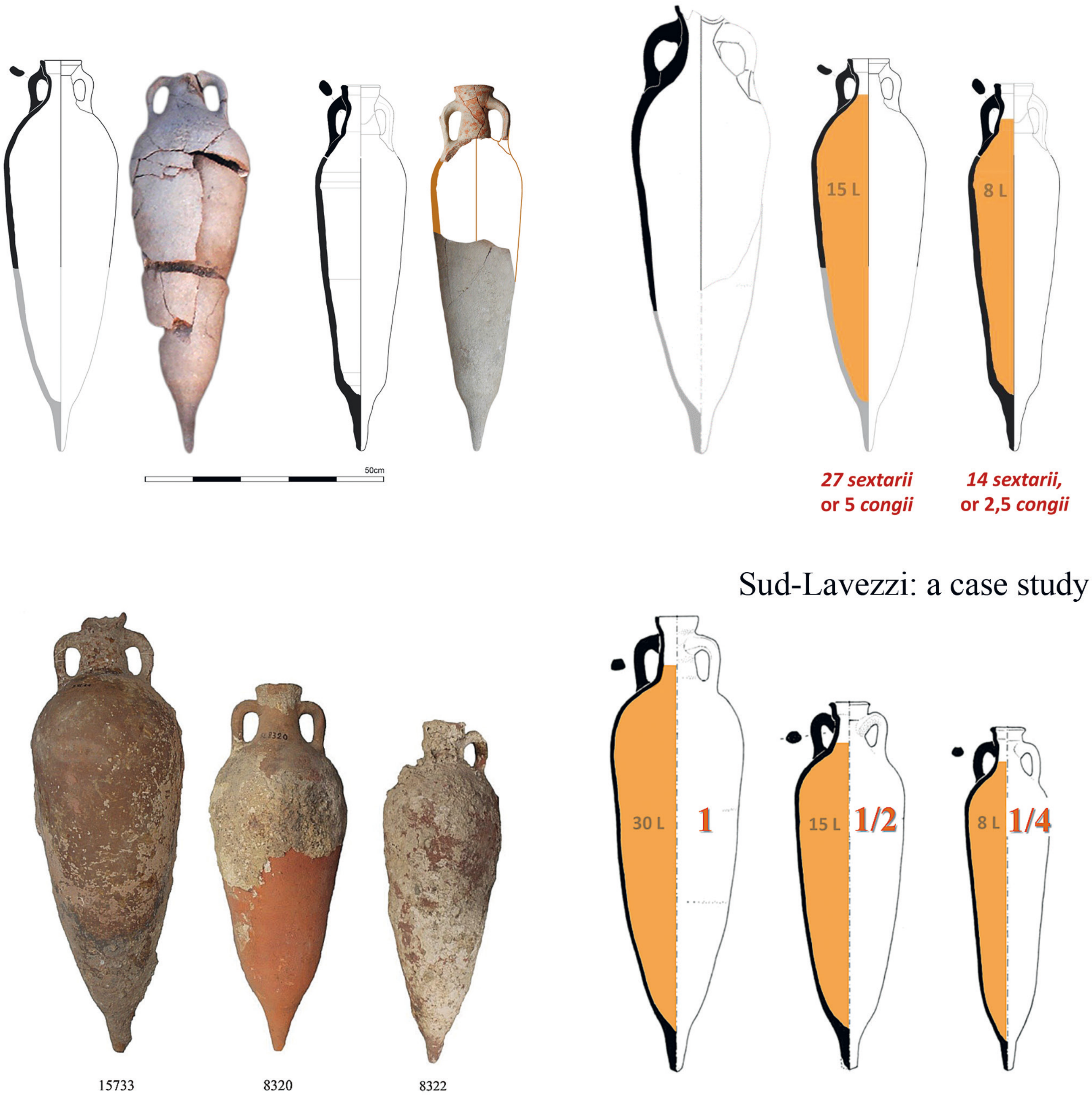
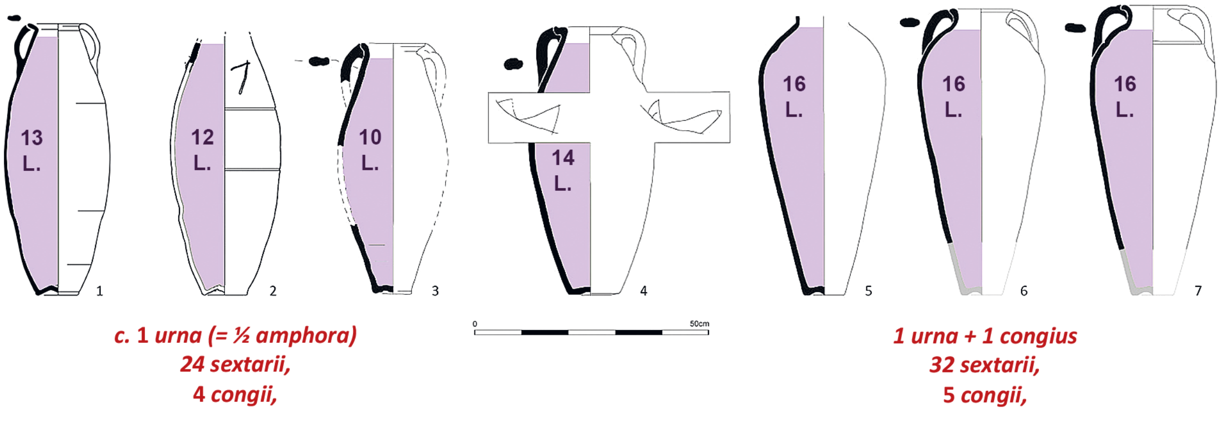
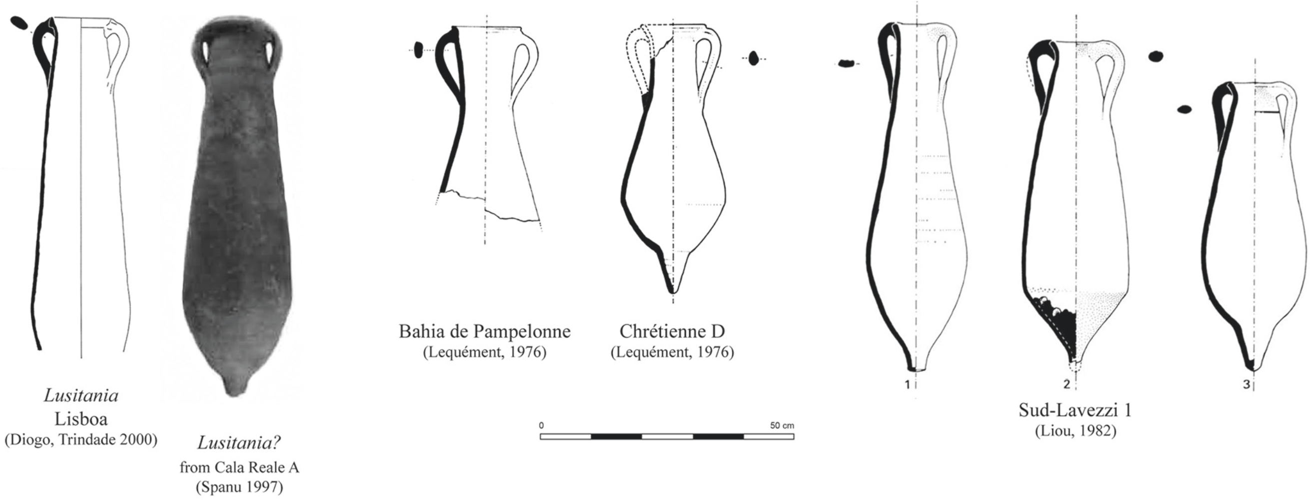
151 Fabião 2004, 397; Fabião 2008; González et al. 2016.
152 Raposo – Duarte 1996, fig. 6 nos. 8. 9.
153 Mayet et al. 1996, fig. 55 nos. 193.
154 Mayet – Silva 2002, 196 fig. 101 nos. 33. 37. 39. 40.
155 Classified as ›unusual forms‹ by Mayet – Silva 1998, fig. 91 no. 113.
156 Classified as ›indeterminate‹ by Mayet – Silva 1998, fig. 120 no. 47.
157 Diogo – Trindade 2000.
158 Cardoso 2013, 113 no. 5817.01.06.
159 Almeida et al. 2014, 418; González et al. 2016, 214–216; Pinto et al. 2016a, 190.
160 Bugalhão 2001, 89 fig. 63; 138 fig. 92.
161 Almeida et al. 2014, 418; Pinto et al. 2016a, 190 fig. 15.
162 Almeida 2016, 204–206 fig. 11.
163 Mayet – Silva 1998, 286–291.



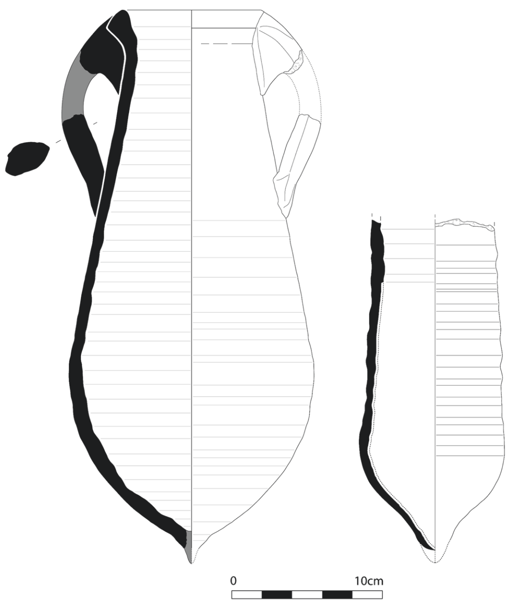
15 Algarve 1 amphorae examples, estimated capacities and a case study based on the Sud-Lavezzi shipwreck (© by the authors)



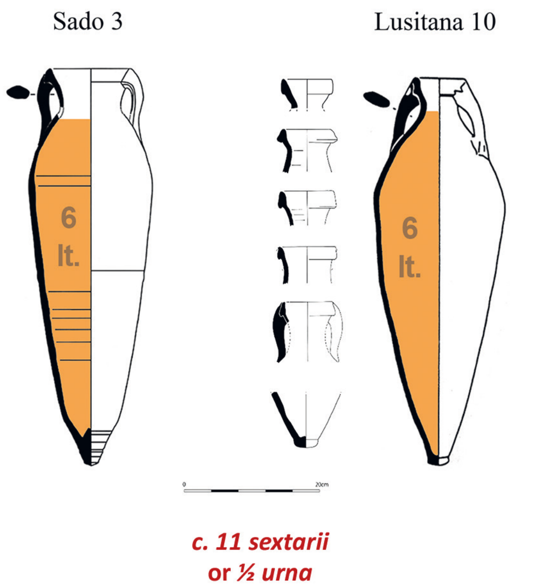
16 Lusitana 9 and their capacities (© by the authors, see Quaresma – Raposo 2016 for bibliography)



17 Late Lusitanian types: ›Beltrán 72‹ related (?) (© by the authors)



18 Late Lusitanian ›miniaturized‹ forms appeared in Mérida (according to Almeida 2016, fig. 11)



19 Sado 3 and Lusitana 10 amphorae and capacities (© by the authors)

na 10[164] is a small amphora, distinguished from the Almagro 51C by its shorter size, narrow neck, and rim now without an internal groove. It appears always in very limited numbers and certainly did not play an important role in Lusitanian production[165]. The Sado 3 amphora, first identified at the workshop of Pinheiro[166], is another small and late type of minor circulation: it differs from Lusitana 10 and Almagro 51C by its wider neck (7–9 cm) and mouth (11–14 cm width), almost the same diameter of body, short handles in an S-shape profile and very close to the neck[167]. An almost complete example was collected at Scallabis/Santarém, a Roman town in the Tagus Valley[168]. Both types have an average capacity of 6 liters (11 *sextarii* or a half *urna*) (fig. 19).

164 Diogo 1987.
165 Almeida et al. 2014, 419; Pinto et al. 2016a, 183.
166 Mayet – Silva 1998; Fabião 2008, 742 f.
167 Mayet – Silva 1998, 289.
168 Arruda et al. 2006, 249 fig. 6.

What is quite remarkable and worth stressing here is that these supposedly ›minority‹ forms were exported not only to nearby provinces but also outside the Iberian Peninsula, and they even arrived at some markets of the western Empire, including Rome. At least this may be inferred from the type's presence in several shipwrecks. The first, Cale Reale A[169], dated at the second half of the 4th or beginning of the 5th century A.D., contained a Lusitanian cargo of Sado 3 and Beltrán 72 related forms traveling together with spindle-shaped Almagro 51C and Almagro 51A–B. The second wreck, Sud-Lavezzi 1, also dated to the late 4th or early 5th century[170], contained a mixed cargo of Lusitanian Algarve 1, Almagro 51C, and Beltrán 72 related types[171] along with other Baetican types. Information concerning imports to other markets must also be evaluated since some of the major Lusitanian types were also produced in other regions, and we must look at fabrics rather than rely on only typological classification. Given its location off Sicily, the Randello ship was probably heading to some eastern destination[172].

The same trend away from standardization can be detected in the Algarve region at both consumption centers and kiln sites. At the *villa* of Vale da Arrancada (Portimão), the Late Antique amphora assemblage shows several examples of Lusitanian forms that may have their provenience in Martinhal (Vila do Bispo) – or in other kiln centers not yet identified – along with different forms that could not be linked to a specific type and were accordingly labeled as ›undetermined‹[173]. These signs of experimentation and the African influence in amphora morphologies are features observed at Martinhal, where the Keay 25 type was being locally produced[174].

STANDARDIZATION: ONE OR MANY? WHY SO AND WHEN?

The first questions one may pose relate to whether there was standardization and, if so, who was demanding it: the producers, the transporters, or the consumers (i.e., the market)? The answer seems both simple and complex, depending on what sort of answer we are looking for. Some form of standardization, if it existed, could have been in a way ›imposed‹ by one or many link(s) in the chain of production and distribution. Did the potters need to respond to some sort of demand, perhaps from those transporting the jars, that the amphorae should fit the particular configuration of space available within a ship? That is, it may have served not only commercial accuracy but also to make shipment easier. Perhaps the producers of the salted-fish products benefited also from some form of standardization, as it made the management of prices and evaluation of quantities in commercial agreements easier. We must not see this standardization process as a matter of mm-level precision but as a more general trend, where different regional traditions could come into play.

One must be aware of chronological issues too. Standardization may have different meanings or constraints depending on the chronological context in which the producers or exporters operated. Those times when the Roman Empire was stronger and more interconnected could have seen different trends from other times when there was no strong political unity and the different regions or communities operated more independently. The available data show that from the late 5th century onward, Lusitanian amphorae almost disappear from archaeological contexts. That means reduced production and less connectivity among regions from the Lusitanian point of view. But these are just common-sense observations that merit further investigation.

Based on the relevant set of data from both workshops and consumption centers, we have tried to address the subject from the point of view of typological standardization, which has led us to identify capacities and volumes for different types of vessels. Regional variation in this phe-

[169] Spanu 1997, 113 f.; Bombico et al. 2014, 366–369; Bombico 2017, 159. 225.
[170] Liou 1982; Massy 2013.
[171] A Lusitanian provenance was confirmed by Bombico et al. 2014, 367.
[172] Parker 1989.
[173] Fabião et al. 2016, figs. 3. 10.
[174] Bernardes et al. 2013.

nomenon was also taken into account, alongside chronological variation. Even if trends revealed through the systematic analysis of several complete examples are real and valid, one should be careful not to rush to definitive conclusions, as the empirical base must first be enlarged. Once this happens satisfactorily, it will allow us to confirm or reject some of the trends identified in this paper.

As capacities and modules are recognized for certain types, they allow us to suggest that they represent different parts of one unitary system. We were also able to confirm that smaller and larger modules coexisted in the same (mainly commercial and consumption) contexts and during the same period rather than representing a chronological change; that is, the smaller versions are not later than the larger. Another important matter should also be stressed here, though: different modules are quite difficult to identify from rims alone since their diameters do not show the same pattern of variation as the bodies. For example, if only the rim was preserved from the spindle-shaped Almagro 51C amphora, which has the capacity of an *urna* (12 liters), it could easily be confused with that of common ware.

As part of an artisan system, pottery production is subject to everyday variations. Even so, the degree of standardization that some types have shown is surprising. On this topic, we must look also to other categories of pottery that were often produced in the same workshops in an effort to understand the degree of standardization they may have achieved. Experimental archaeology related to the manufacture and firing conditions of amphorae at Quinta do Rouxinoul has allowed better understanding of traditional techniques, demonstrating that standardization and repetition of the same models were not difficult tasks[175]. When asked to reproduce Roman amphorae, the potter made a simple template with small clay balls and pieces of cane. With that very simple system, the potter was able to produce several amphorae of the same shape and volume. Such a template is impossible to track in the archaeological record. It is not hard to imagine that a craftsman growing up in a workshop with its specialized labor force, from apprentice to master potter, would be able to replicate many amphorae of almost the same shape and volume. Moreover, his perceptions regarding the shape and volume of an amphora are not necessarily what we might have in mind when looking for standard models.

For Late Antique production, the increase in diversity among amphora shapes is obvious. If one conceptualizes each shape as representing a single product, then one might think that all these different amphorae were designed for different products. All of them, or almost all of them, though, were for fish-based products but not necessarily the *exact* same product[176]. In most of the Almagro 51C amphorae, it is impossible to store a more solid product, as its mouth and neck are both too narrow to permit easy access. For the Keay 16, Almagro 50, or Sado 1 types, by contrast, this is quite possible. Can we therefore suggest fish sauce, for example *liquamen* and *hallec* for the Almagro 51C type and salted fish for the other types? This is just one possibility. All archaeozoological studies of residues from the fish products contained in amphorae from the periods considered here and in the deposits at the inner base of the processing vats (*cetariae*) gave the same result: sardines, not sliced and diced but whole sardines[177]. This is perhaps not a surprising result. When one thinks of salted sardines, one assumes whole fish. But if one thinks of a compound of sardines and salt, macerated to obtain a sauce as mentioned in ancient literary sources, the whole sardine would still be used, while the final product would be a sauce rather than salted sardines.

If we assume that standardization resulted from market pressure – the most logical hypothesis as there is no evidence of an *annona* context for Lusitanian products – one can identify some general trends. There is one trend that extends from the 1st to the 3rd or 4th century, in which we can-

[175] Fabião et al. 2017b. These simple ›tools‹ can be seen in Raposo et al. 2013, fig. 3 and in the video »Arqueologia Experimental_Quinta do Rouxinol« (4'18'' onward) at <https://www.youtube.com/watch?v=vFSvOgRvsuY&t=561s> (19. 05. 2019).

[176] For the different types of fish products, see Curtis 1991; García et al. 2019a.

[177] Gabriel et al. 2009; Gabriel – Silva 2016.

not see any change in the general shape or volume of the amphorae for fish products, despite the presence of some smaller modules possibly related to different fish products or simply different contexts of distribution. Some difference, though, can be noticed in the capacity of the Lusitana 3 amphora that is assumed to have transported wine. But within the different modules recorded in some of the rarer amphorae, it is possible to see a sort of standardization within the three different capacities following the proportional relationship of one, one half, and three quarters. Again, this is an intriguing result, but we must bear in mind the currently limited sample that needs future confirmation.

Addressing the subject of standardization in Lusitanian amphora production also calls for special attention to the observation of regional trends. In the Sado and Tagus Valleys, the production of amphorae seems to be clearly separated from the fish-product workshop units. This could explain a certain degree of fabric standardization evident in these regions, with a quite stable use of what seems to have been the same sources of clay throughout a long period of production from the 1st to the late 5th century. In the Algarve area, the situation is quite diverse, with a few examples of amphora workshops occurring in the same settlements as the fish-salting units, sometimes in the context of the Roman *villa*. It is possible that these different modes of production could help to explain the local diversity in some amphora types.

In Late Antiquity, it is also possible to see some standardization around different modules, within a context of miniaturization that meant less volume per amphora. Whether that translates to a higher unit cost for the transported product or, on the contrary, a greater distribution of these fish-based products is also a question that requires further research. One thing seems clear, though: the different modules were exported together both in the earlier times, as we can see in the Grum del Sal wreck, and also in Late Antiquity, as in the Sud-Lavezzi 3 wreck. This is certainly not a peculiarity of Lusitanian products but rather the general pattern observed for amphorae on Mediterranean wrecks.

Despite all the questions that remain to be answered concerning standardization, the general framework of amphora production can be summarized as follows: the early Lusitanian types produced from the Augustan period onward seem to derive from the Baetican ones. From the middle of the 1st to the mid-3rd century, the Dressel 14 type was the most common amphora transporting fish products not only from the coastal areas to the inland towns and *villae* of Lusitania but also to the wider markets of the Mediterranean. Most of the Lusitanian amphorae were destined for fish products, but the distribution of Lusitana 3 shows that other commodities, such as wine, were also being exported from the middle of the 2nd or early 3rd century onward. This is also the period when major changes occurred in the manufacture of salted-fish products, with modifications being made in the *cetariae* and consequently also in the amphora shapes. From this period onward, there is diversity in forms: Almagro 51C was the most successful container for fish-based products for both internal and external markets, but other forms are also present, such as Almagro 50, Almagro 51A–B, and Lusitana 9, to mention just the most common. In later phases, minority types occur, as well as forms that are difficult to ascribe to any particular type, showing a lower degree of standardization in this late phase.

With the ultimate goal of examining the social and economic framework behind amphora production in the different regions of Lusitania from the Augustan period until the late 5th or early 6th century A.D., a major effort is underway to fully characterize both their forms and fabrics. With better identification of Lusitanian amphorae by scholars working across the ancient world, the distribution map of Lusitanian products will become more complete. This, in turn, will contribute to a clearer and more nuanced understanding of the economic role of Lusitania in the larger framework of the Roman Empire and the Late Antique world that followed.

BIBLIOGRAPHY

Adroher et. al. 2016 A. M. Adroher Auroux – C. Carreras Monfort – R. R. de Almeida – A. Fernández Fernández – J. Molina Vidal – C. Viegas, Registro para la cuantificación de cerámica arqueológica: estado de la cuestión y una nueva propuesta. Protocolo de Sevilla (prcs/14), Zephyrus 78, 2016, 87–110.

Alarcão – Mayet 1990 A. Alarcão – F. Mayet (eds.), Ânforas Lusitanas. Tipologia, produção, comércio, Actas das Jornadas de estudo (Coimbra 1990).

Almeida 2016 R. R. de Almeida, On the way to *Augusta Emerita*. Historiographical overview, old and new data on fish-product amphorae and commerce within the trade to the Capital of Lusitania, in: Pinto et al. 2016a, 195–218.

Almeida – Fabião 2019 R. R. de Almeida – C. Fabião, The ›early production‹ of Roman amphorae in Ulterior/Lusitania. State of play of a universe (still) under construction, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. M. Sáez Romero (eds.), The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire (Oxford 2019) 175–190.

Almeida et al. 2014 R. R. de Almeida – I. V. Pinto – A. P. Magalhães – P. Brum, Ânforas piscícolas de Tróia: contextos de consumo versus contextos de produção como base para algumas precisões crono-tipológicas, in: R. Morais – A. Fernández Fernández – M. J. Sousa (eds.), As produções cerâmicas de imitação na Hispania. II Congresso Internacional da Secah [Braga 2013], Ex Officina Hispana 2 (Madrid 2014) 405–423.

Almeida – Raposo 2016 R. R. de Almeida – J. Raposo, ›Keay 16 (Lusitania Occidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/keay-16-western-lusitania>(20 julio 2016) (25. 5. 2019).

Almeida – Sanchéz 2013 R. R. Almeida – F. Sánchez Hidalgo, Las Ánforas del Cuartel de Hernán Cortés. Nuevos datos para el estudio de la importación y consumo en Augusta Emerita, in: D. Bernal – L. C. Juan – M. Bustamante – J. Díaz – A. M. Sáez (eds.), Hornos, Talleres y Focos de Producción Alfarera en Hispania. Cádiz. II, I Congreso Internacional de la SEC-AH Ex Officina Hispana) (Cádiz 2013) 48–59.

Amaro 1990 C. Amaro, Ocupação romana na margem sul do estuário do Tejo: um (des)alinhar de ideias, in: Alarcão – Mayet 1990, 71–85.

Amaro – Gonçalves 2016 C. Amaro – C. Gonçalves, The Roman *figlina* at Garrocheira (Benavente) in the Early Empire, in: Pinto et al. 2016a, 47–58.

Amores et al. 2007 F. Amores Carredano – E. García Vargas – D. González Acuña, Ánforas tardoantiguas en Hispalis (Sevilla, España) y el comercio mediterráneo, in: M. Bonifay – J.-C. Tréglia (eds.), LRCW 2. Late Roman coarse wares, cooking wares and amphorae in the Mediterranean: archaeology and archaeometry, BARIntSer 1662 (Oxford 2007) 133–146.

Arcelin – Tuffreau-Libre 1998 P. Arcelin – M. Tuffreau-Libre, La quantification des céramiques. Conditions et Protocole. Glux-en-Glenne: Centre Archéologique européen du Mont Beuvray (Bibracte 1998).

Arruda 2017 A. M. Arruda, As ocupações antigas da Quinta do Lago (Almansil), in: A. Carvalho – D. Paulo – R. R. de Almeida (coord.), Loulé. Territórios, Memórias, Identidades. Catálogo da Exposição [Museu Nacional de Arqueologia, Lisboa] (Lisbon 2017) 292–300.

Arruda – Fabião 1990 A. Arruda – C. Fabião, Ânforas da Quinta do Lago (Loulé), in: Alarcão – Mayet 1990, 199–213.

Arruda – Viegas 2016 A. M. Arruda – C. Viegas, As ânforas alto-imperiais de Monte Molião, in: R. Járrega Domínguez – P. Berni Millet (eds.), Amphorae ex Hispania: paisajes de producción y consumo. Actas del III Congreso Internacional de la Sociedad de Estudios de la Cerámica Antigua (SECAH), Ex Officina Hispana 3 (Tarragona 2016) 446–463.

Arruda et al. 2006 A. M. Arruda – C. Viegas – P. Bargão, Ânforas lusitanas da Alcáçova de Santarém, in: Silva – Soares 2006, 233–252.

Assis – Amaro 2006 C. Assis – C. Amaro, Estudo dos restos de peixe de dois sítios fabris de *Olisipo,* in: Silva – Soares 2006, 123–144.

Beltrán 1970 M. Beltrán Lloris, Las Ánforas romanas de España, Monografías Arqueológicas 8 (Zaragoza 1970).

Bernal-Casasola 2011 D. Bernal-Casasola, Vinos lusitanos del Porto dos Cacos en Carteia, Boletin de la SECAH 3, 2011, 11 f.

Bernal-Casasola 2016 D. Bernal-Casasola, Lusitanian amphorae in the Strait of Gibraltar: interprovincial food supply, in: Pinto et al. 2016a, 299–310.

Bernardes 2008 J. P. Bernardes, O Centro Oleiro do Martinhal, Xelb 8, 2008, 191–212.

Bernardes et al. 2007 J. P. Bernardes – F. Dias – M. Santos – S. Carrusca – V. Mendonça, Salgados – um sítio com produção de ânforas. Contributo para o estudo da ocupação romana no estuário da Ribeira de São Lourenço (Almancil – Loulé – Faro), Promontoria, Ano 5, Nº 5, 2007, 227–243.

Bernardes et al. 2013 J. P. Bernardes – R. Morais – I. V. Pinto – R. Dias, A olaria baixo-imperial do Martinhal, Sagres (Portugal), in: D. Bernal Casasola – L. C. Juan Tovar – M. Bustamante Álvarez – J. J. Díaz Rodríguez – A. M. Sáez Romero (eds.), Hornos, talleres y focos de producción alfarera en Hispania, I Congreso Internacional de la SECAH (Cádiz 2013) 317–329.

Bernardes – Viegas 2016 J. P. Bernardes – C. Viegas, Roman Amphora Production in the Algarve (Southern Portugal), in: Pinto et al. 2016a, 81–92.

Bombico et al. 2014 S. Bombico – C. Nervi – E. Piccardi – F. Allégrini-Simonetti, A caminho de Roma? A Sardenha e a Córsega nos fluxos de circulação das ânforas lusitanas no mediterrâneo ocidental, in: R. Morais – A. Fernández Fernández – M. J. Sousa (eds.), As produções cerâmicas de imitação na Hispania. II Congresso Internacional da SECAH [Braga 2013], Ex Officina Hispana 2 (Madrid 2014) 361–377.

Bombico 2017 S. Bombico, Economia marítima da Lusitânia romana: exportação e circulação de bens alimentares (PhD thesis Universidade de Évora 2017) <https://www.academia.edu/34597268/ECONOMIA_MARÍTIMA_DA_LUSITÂNIA_ROMANA_EXPORTAÇÃO_E_CIRCULAÇÃO_DE_BENS_ALIMENTARES_-_Vol._I_Maritime_Economy_of_Roman_Lusitania_Export_and_Circulation_of_food_products> (25. 05. 2019).

Bonifay 2004 M. Bonifay, Etudes sur la céramique romaine tardive d'Afrique, BARIntSer 1301 (Oxford 2004).

Botelho – Ferreira 2016 P. Botelho – S. Ferreira, Evolução urbana da zona ribeirinha da cidade de Portimão. Exhibition Arqueologia em Portugal. Recuperar o passado em 2016 (unpubl. exhibition poster Lisbon 2016).

Bugalhão 2001 J. Bugalhão, A indústria romana de transformação e conserva de peixe em Olisipo. Núcleo Arqueológico da Rua dos Correeiros, TrabArq 15 (Lisbon 2001).

Bugalhão et al. (in preparation) J. Bugalhão – C. Fabião – R. R Almeida, As ânforas do Núcleo Arqueológico da rua dos Correeiros (in preparation).

Bustamante – Heras 2013 M. Bustamante Álvarez – F. J. Heras Mora, Producción anfórica en *Augusta Emerita* (Mérida, Badajoz) y los nuevos hallazgos del solar de la Escuela de Hostelería, in: D. Bernal Casasola – L. C. Juan Tovar – M. Bustamante Álvarez – J. J. Díaz Rodríguez – A. M. Sáez Romero (eds.), Hornos, talleres y focos de producción alfarera en Hispania, I Congreso Internacional de la SECAH, Cádiz 2013 (Cádiz 2013) 331–345.

Bustamante – Heras 2016 M. Bustamante Álvarez – F. J. Heras Mora, ›Haltern 70 (Lusitania Oriental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/haltern-70-eastern-lusitania> (20 julio 2016) (25. 05. 2019).

Cabral 1977 J. M. P. Cabral, Caracterização de cerâmicas arqueológicas mediante análise por activação com neutrões térmicos. Classificação das cerâmicas por métodos de taxonomia numérica, Conimbriga 16, 1977, 103–137.

Cardoso 2013 J. P. Cardoso, Ânforas romanas recuperadas em meio subaquático em Portugal. S.L. 2013 [author digital edition].

Cardoso et al. 2016 G. Cardoso – S. Rodrigues – E. Sepúlveda – I. Ribeiro, Production during the Principate in Peniche (Portugal). Raw materials, kilns and amphora typology, in: Pinto et al. 2016a, 3–18.

Carreras – Berni Millet 2016 C. Carreras Monfort – P. Berni Millet, ›Haltern 70 (Guadalquivir Valley)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/haltern-70-guadalquivir-valley> (25. 05. 2019).

Chevalier – Santamaria 1971 Y. Chevalier – C. Santamaria, L'épave de l'anse Gerbal à Port-Vendres, RStLig 1, 13, 1971, 7–11.

Coelho-Soares – Silva 1978 A. Coelho-Soares – C. T. Silva, Ânforas romanas da área urbana de Setúbal, Setúbal Arqueológica 4, 1978, 171–201.

Correia et al. 2015 V. H. Correia – I. Buraca – R. Triães – A. Araújo – C. Oliveira, Identification of a Production of Roman Amphorae in Northern Lusitania, in: C. Oliveira – R. Morais – A. Morillo Cerdán (eds.), ArchaeoAnalytics. Chromatography and DNA analysis in archaeology (Esposende 2015) 169–184.

Curtis 1991 R. I. Curtis, Garum and Salsamenta. Production and commerce in materials medica, Studies in Ancient Medicine 3 (Leiden 1991).

Dias – Prudêncio 2016 M. I. Dias – M. I. Prudêncio, Geochemical fingerprints of Lusitanian amphora production centres: Tagus, Sado, Algarve and Peniche, in: Pinto et al. 2016a, 95–103.

Dias et al. 2001 M. I. Dias – M. I. Prudêncio – J. Raposo – M. A. Gouveia – C. Fabião – A. Guerra – J. Bugalhão – A. L. Duarte – A. Sabrosa, Caracterização química por AAN das formas de ânfora de um centro de produção do estuário do Tejo: Quinta do Rouxinol (Portugal), in: C. Roldán (ed.), Actas do IV Congreso Nacional de Arqueometria (València 2001) 88–93.

Dias et al. 2003a M. I. Dias – M. I. Prudêncio – G. Cardoso – A. M. Gouveia – S. Rodrigues, Chemical characterisation of pottery from the kilns of Peniche (Portugal). A provenance study, in: S. Di Pierro – V. Sernneels – M. Magetti (eds.), Ceramic in the Society. Proceedings of the 6th European Meeting on Ancient Ceramics 2001 (Fribourg 2003) 99–108.

Dias et al. 2003b M. I. Dias – M. I. Prudêncio – F. Rocha, Amphorae production at occidental Lusitania: identification of raw material and production, in: J. L. Pérez-Rodríguez (ed.), Applied studies of cultural heritage and clays (Madrid 2003) 187–200.

Dias et al. 2010 M. I. Dias – M. I. Prudêncio – M. A. Gouveia – M. J. Trindade – R. Marques D. Franco – J. Raposo – C. Fabião – A. Guerra, Chemical tracers of Lusitanian amphorae kilns from the Tagus estuary (Portugal), JASc 37, 2010, 784–798.

Dias et al. 2012 M. I. Dias – M. J. Trindade – C. Fabião – A. Sabrosa – J. Bugalhão – J. Raposo – A. Guerra – A. L. Duarte – M. I. Prudêncio, Arqueometria e o estudo das ânforas lusitanas do Núcleo Arqueológico da Rua dos Correeiros (Lisboa) e de centros produtores do Tejo, in: Actas do IX Congresso Ibérico de Arqueometria, Estudos Arqueológicos de Oeiras 19 (Oeiras 2012) 57–70.

Diogo 1987 A. M. D. Diogo, Quadro tipológico das ânforas de fabrico lusitano, APort 4, 5, 1987, 179–191.

Diogo 2005 A. M. D. Diogo, Vestígios de um possível naufrágio romano ao largo da Ilha do Farilhão, in: Actas do Congresso A Presença Romana na Região Oeste (Bombarral 2005) 103–107.

Diogo – Trindade 1998 A. M. D. Diogo – L. Trindade, Uma perspectiva sobre Tróia a partir das ânforas. Contribuição para o estudo da produção e circulação das ânforas romanas em território português, APort 4, 16, 1998, 187–220.

Diogo – Trindade 2000 A. M. D. Diogo – L. Trindade, Vestígios de uma unidade de transformação do pescado descobertos na Rua dos Fanqueiros, em Lisboa, RPortA 3, 1, 2000, 181–205.

Duarte 1990 A. L. C. Duarte, Quinta do Rouxinol. A produção de ânforas no vale do Tejo, in: Alarcão – Mayet 1990, 97–115.

Ejstrud 2002 B. Ejstrud, Size matters: Estimating trade of wine, oil and fish-sauce from amphorae in the first century AD, in: T. Bekker-Nielsen (ed.), Ancient fishing and fish processing (Aarhus 2005) 171–181.

Étienne et al. 1994 R. Étienne – Y. Makaroun – F. Mayet, Un grand complexe industriel a Tróia (Portugal) (Paris 1994).

Fabião 1998 C. Fabião, O vinho na Lusitânia: reflexões em torno de um problema arqueológico, RPortA 1, 1, 1998, 169–198.

Fabião 2004 C. Fabião, Centros oleiros da Lusitania: balanço dos conhecimentos e perspectivas de investigação, in: D. Bernal Casasola – L. Lagóstena Barrios (eds), Figlinae Beticae: talleres alfareros y producciones cerámicas en la Bética romana (ss. II a.C – VII d.C.) (Cádiz, Noviembre 2003). Actas del Congreso Internacional 2, BARIntSer 1266 (Oxford 2004) 379–410.

Fabião 2008 C. Fabião, Las ánforas romanas de Lusitania, in: D. Bernal Casasola – A. Ribera i Lacomba (eds), Cerámicas hispanorromanas: un estado de la cuestión (Cádiz 2008) 725–745.

Fabião 2014 C. Fabião, La Lusitania: una Provincia romana atlántica, in: J. Álvarez Martínez – T. Nogales Basarrate – I. Rodà de Llanza (eds.), XVIII Congreso Internacional Arqueología Clásica. Actas 2 (Mérida 2014) 1657–1664.

Fabião 2015 C. Fabião, Lusitania en el contexto de la globalización romana, in: J. M. Álvarez Martínez – A. Carvalho – C. Fabião (eds.), Lusitania Romana. Origen de dos pueblos/Lusitânia Romana. Origem de dois povos [Catálogo de Exposição], Studia Lusitana 9 (Mérida 2015) 201–205.

Fabião 2017 C. Fabião, 225– 233. Ânforas Algarve 1 de produção local, para preparados piscícolas, in: A. Carvalho – D. Paulo – R. R. de Almeida (coords.), Loulé. Territórios, Memórias, Identidades. Catálogo da Exposição (Lisbon 2017) 386 f.

Fabião – Arruda 1990 C. Fabião – A. M. Arruda, Ânforas de S. João da Venda (Faro), in: Alarcão – Mayet 1990, 215–224.

Fabião – Carvalho 1990 C. Fabião – A. Carvalho, Ânforas da Lusitânia: uma perspectiva, in: Alarcão – Mayet 1990, 37–63.

Fabião et al. 2010 C. Fabião – I. Filipe – S. Brazuna, Produção de ânforas em época romana em Lagos: os dados resultantes das intervenções de contrato realizadas no âmbito do Projecto URBCOM, Xelb 10, 2010, 323–336.

Fabião et al. 2016 C. Fabião – C. Viegas – V. Freitas, The Lusitanian Amphorae from the Roman Villa of Vale da Arrancada (Portimão, Algarve, Portugal), in: Pinto et. al 2016a, 257–269.

Fabião et al. 2017a C. Fabião – R. R. de Almeida – I. Filipe – S. Brazuna, Produção de Ânforas em Lagos na Antiguidade Tardia. Ensaio de caracterização de um novo tipo: Algarve 1, in: C. Fabião – J. Raposo – A. Guerra – J. Silva (eds.), Olaria Romana. Seminário Internacional e Ateliê de Arqueologia Experimental/Roman Pottery Works: international seminar and experimental archaeological workshop, Actas de seminário/ateliê/Proceedings of seminar/workshop (Lisbon 2017) 175–194.

Fabião et al. 2017b C. Fabião – J. Raposo – A. Guerra – J. Silva (eds.), Olaria Romana. Seminário Internacional e Ateliê de Arqueologia Experimental/Roman Pottery Works: international seminar and experimental archaeological workshop, Actas de seminário/ateliê/Proceedings of seminar/workshop (Lisbon 2017).

Fabião (forthcoming) C. Fabião – R. R. Almeida, J. Amphoren. Öl, Wein und Fischpräparate in Munigua, in: T. G. Schattner – G. Ovejero Zappino – J. A. Pérez Macías (eds.), MULVA 8. Die wirtschaftlichen Grundlagen von Munigua, MM (forthcoming).

Filipe 2008b V. Filipe, Importação e exportação de produtos alimentares em Olisipo: as ânforas romanas da Rua dos Bacalhoeiros, Revista Portuguesa de Arqueologia 11, 2 (Lisbon 2008) 301–324.

Filipe 2016 V. Filipe, »Haltern 70 (Western Lusitania)«, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/haltern-70-western-lusitania> (20 julio 2016) (10. 05. 2019).

Filipe 2018 V. Filipe, Olisipo, o grande porto da fachada atlântica. Economia e comércio entre a República e o Principado (unpubl. PhD Thesis, Universidade de Lisboa 2018) <http://hdl.handle.net/10451/38619> (10. 05. 2019).

Filipe – Raposo 1996 G. Filipe – J. Raposo (eds.), Ocupação Romana dos Estuários do Tejo e do Sado. Actas das Primeiras Jornadas sobre Romanização dos Estuários do Tejo e do Sado (Lisbon 1996).

Gabriel 2013 — S. Gabriel, A produção de preparados piscícolas em Tróia (Grândola). Estudo de três amostras provenientes da Oficina 2. Trabalhos do LARC 1 (unpubl. technical report, Direcção Geral do Património Cultural 2013).

Gabriel 2018 — S. Gabriel, Restos de preparados de peixe em ânfora Dressel 14, in: C. T. Silva (coord.), Caetobriga. O sítio arqueológico da Casa dos Mosaicos, SetúbalA 17 (Setúbal 2018) 107–110.

Gabriel et al. 2009 — S. Gabriel – C. Fabião – I. Filipe, Fish remains from the Casa do Governador – a Roman fish processing factory in Lusitania. The 15th Meeting of the ICAZ Fish Remains Working Group (September 3–9, Poznan & Torun), Environment and Culture 7 (Poznan 2009) 117–119.

Gabriel – Silva 2016 — S. Gabriel – C. T. Silva, Fish bones and amphorae: new evidence for the production and trade of fish products in Setúbal (Portugal), in: Pinto et al. 2016a, 111–116.

García 2007 — E. García Vargas, Hispalis como centro de consumo desde época tardorrepublicana a la Antigüedad Tardía. El testimonio de las ánforas, AnCord 18, 2007, 317–360.

García 2015 — E. García Vargas, Ánforas vinarias de los contextos severianos del Patio de Banderas de Sevilla, in: I. Aguilera Aragón – F. Beltrán Lloris – M. J. Dueñas Jiménez – C. Lomba Serrano – J. A. Paz Peralta (eds.), De las ánforas al museo. Estudios dedicados a Miguel Beltrán Lloris (Zaragoza 2015) 395–412.

García 2016 — E. García Vargas, Amphorae circulation in the Lower Guadalquivir Valley in the Mid Imperial period: the Lusitana 3 type, in: Pinto et al. 2016a, 285–298.

García et al. 2011 — E. García Vargas – R. R. de Almeida – H. González Cesteros, Los tipos anfóricos del Guadalquivir en el marco de los envases hispanos del siglo I a.C. Un universo heterogéneo entre la imitación y la estandarización, Spal 20, 2011, 185–283.

García et al. 2019a — E. García Vargas – E. Roselló Izquierdo – D. Bernal-Casasola – A. Morales Muñiz, Salazones y salsas de pescado en la Antigüedad. Un primer acercamiento a las evidencias de paleocontenidos y depósitos primarios en el ámbito euro-mediterráneo, in: D. Bernal-Casasola – R. Jiménez-Camino Álvarez (eds.), Las cetariae de Ivlia Tradvcta. Resultados de las excavaciones arqueológicas en la calle San Nicolás de Algeciras (20012006) (Cádiz 2019) 287–312.

García et al. 2019b — E. García Vargas – R. R. de Almeida – H. González Cesteros – A. Sáez Romero (eds.), The Ovoid Amphorae in the Central and the Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019).

González et al. 2016 — H. González Cesteros – R. R. de Almeida – J. Curbera, Special Fish Products for the Jewish Community? A Painted Inscription on a Beltrán 72 Amphora from Augusta Emerita (Mérida, Spain), Herom 5, 2016, 197–236.

Grilo et al. 2013 — C. Grilo – C. Fabião – J. Bugalhão, Um contexto tardo-antigo do Núcleo Arqueológico da Rua dos Correeiros, (NARC), Lisboa, in: J. M. Arnaud – A. Martins – C. Neves (eds.), Arqueologia em Portugal – 150 Anos (Lisbon 2013) 849–857.

Guerra 1995 — A. Guerra, Plínio-o-Velho e a Lusitânia, Arqueologia & História Antiga 1 (Lisbon 1995).

Hermanns et al. 2016 — M. Hermanns – S. Bombico – R. R. de Almeida, Reevaluando un documento del comercio lusitano de época altoimperial. Estudio preliminar del pecio de Grum de Sal (Eivissa/Ibiza), in: R. Járrega Domínguez – P. Berni Millet (eds.), Amphorae ex Hispania: paisajes de producción y consumo. Actas del III Congreso Internacional de la Sociedad de Estudios de la Cerámica Antigua (SECAH), Ex Officina Hispana 3 (Tarragona 2016) 394–406.

Keay 1984 — S. J. Keay, Late Roman Amphorae in the Western Mediterranean. A typology and economic study: the Catalan evidence, BARIntSer 136 (Oxford 1984).

Laubenheimer 1985 — F. Laubenheimer, La production des amphores en Gaule Narbonnaise (Paris 1985).

Liou 1982 — B. Liou, Direction des recherches archéologiques sous-marines, Gallia 40, 1982, 437–454.

Liou – Domergue 1990 — B. Liou – C. Domergue, Le commerce de la Bétique au Ier siècle de notre ère. L'épave Sud-Lavezzi 2 (Bonifacio, Corse du Sud), Archaeonautica 10, 1990, 11–123.

Massy 2013 J.-L. Massy, Archéologie sous-marine en Corse antique, CahASubaqu 20 (2013).

Mataloto et al. 2016 R. Mataloto – J. Williams – C. Roque, Amphorae at the origins of Lusitania: transport pottery from Western Hispania Ulterior in Alto Alentejo, in: Pinto et al. 2016a, 139–151.

Mayet – Schmitt 1997 F. Mayet – A. Schmitt, Les amphores de São Cucufate (Beja), in: F. Mayet – R. Étienne (eds.), Itinéraires Lusitaniens (Paris 1997) 71–109.

Mayet et al. 1996 F. Mayet – A. Schmitt – C. T. Silva, Les amphores du Sado (Portugal). Prospection des fours et analyse du matériel (Paris 1996).

Mayet – Silva 1998 F. Mayet – C. T. Silva, L'atelier d'amphores de Pinheiro (Portugal) (Paris 1998).

Mayet – Silva 2002 F. Mayet – C. T. Silva, L'atelier d'amphores d'Abul (Portugal) (Paris 2002).

Mayet – Silva 2016 F. Mayet – C. T. Silva, Roman Amphora Production in the Lower Sado Region, in: Pinto et al. 2016a, 59–71.

Martinez 2016 V. Martinez, Do we have the capacity to understand the economy of Lusitanian commodities? Volumetric calculations of Lusitanian amphora types, in: Pinto et al. 2016a, 129–136.

Molina– Mateo 2018 J. Molina Vidal – D. Mateo Corredor, The roman amphorae average capacity (AC), OxfJA 37, 3, 2018, 299–311.

Morais 2004 R. Morais, Problemàtiques i noves perspectives sobre les àmfores ovoides tardo-republicanes. Les àmfores ovoides de producció lusitana, in: Culip VIII i les àmfores Haltern 70, Monografies del CASC 5 (Girona 2004) 36–40.

Morais 2010 R. Morais, Ânforas, in: J. Alarcão – P. Carvalho – A. Gonçalves (eds.), Castelo da Lousa: Intervenções Arqueológi-cas de 1997 a 2002 (Mérida 2010) 181–218.

Morais – Fabião 2007 R. Morais – C. Fabião, Novas produções de fabrico lusitano: problemáticas e importância económica, in: L. Lagóstena Barrios – D. Bernal-Casasola – A. Arévalo González (eds.), CETARIAE. Salsas y salazones de pescado en Occidente durante la Antigüedad. Actas del congreso Internacional de Cádiz, BARIntSer 1686 (Oxford 2007) 127–133.

Morais – Filipe 2016 R. Morais – V. Filipe, ›Ovoid Lusitanian (Western Lusitania)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/ovoid-lusitan-western-lusitania> (08. 05. 2019).

Morais et al. 2016 R. Morais – C. Oliveira – A. Araújo, Lusitanian amphorae of the Augustan Era and their contents: organic residue analysis, in: Pinto et al. 2016a, 105–109.

Orton – Tyers – Vince 1993 C. Orton – P. Tyers – A. Vince, Pottery in Archaeology, Manuals in Archaeology (Cambridge 1993).

Panella 1972 C. Panella, Annotazioni in margine alle stratigrafia delle Terme ostiensi del Nuotatore, Recherches sur les Amphores Romaines (Rome 1972) 69–106.

Panella – Rizzo 2014 C. Panella – G. Rizzo, Ostia 6. Le Terme del Nuotatore (Rome 2014).

Parker 1989 A. J. Parker, Amphores Almagro 50 de l'épave de Randello (Sicile), in: Amphores romaines et histoire économique. Dix ans de recherches. Actes du colloque de Sienne (22–24 mai 1986), Collection de l'École Française de Rome 114 (Rome 1989) 650–653.

Peacock 1982 D. P. S. Peacock, Pottery in the Roman world: an ethnoarchaeological approach (London 1982).

Pimenta 2017 J. Pimenta, Em torno dos mais antigos modelos de ânfora de produção lusitana: os dados do Monte dos Castelinhos (Vila Franca de Xira), in: Fabião et al. 2017b, 195–206.

Pimenta – Fabião (forthcoming) J. Pimenta – C. Fabião, Ânforas orientais em Vlixippona (Lisboa): a vitalidade da rota atlântica em época pós-romana, in: Simpósio A costa portuguesa no panorama da rota atlântica durante a época romana (Peniche, 16–18 de Novembro de 2006) (forthcoming).

Pimenta – Mendes 2014 J. Pimenta – H. Mendes, Monte dos Castelinhos-Vila Franca de Xira: um sítio singular para o estudo da romanização do vale do Tejo, in: R. Mataloto – V. Mayoral – C. Roque (eds.), Los paisajes agrários de la romanización, arquitectura y explotación del territorio. II Reunión científica, Anejos del AEspA 70 (Madrid 2014) 125–142.

Pimenta et al. 2016 J. Pimenta – M. Ferreira – A. C. Cabrita, The Roman kilns at Estrada da Parvoíce, Alcácer do Sal (Portugal), in: Pinto et al. 2016a, 73–79.

Pinto – Almeida 2016 I. V. Pinto – J. P. Almeida, ›Sado 1 (Lusitania Occidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/sado-1-western-lusitania> (09 julio 2016) (25. 05. 2019).

Pinto et al. 2016a I. V. Pinto – R. R. de Almeida – A. Martin (eds.), Lusitanian Amphorae: Production and Distribution, Roman and Late Antique Mediterranean Pottery 10 (Oxford 2016).

Pinto et al. 2016b I. V. Pinto – A. P. Magalhães – P. Brum, Tróia na Antiguidade Tardia, in: J. d'Encarnação – M. C. Lopes – P. C. Carvalho (coords.), A Lusitânia entre Romanos e Bárbaros (Coimbra 2016) 309–333.

Pinto et al. 2011 I. V. Pinto – A. P. Magalhães – P. Brum, O complexo industrial de Tróia desde os tempos dos Cornelii Bocchii, in: J. L. Cardoso – M. Almagro Gorbea (eds.), Lucius Cornelius Bochus. Escritor Lusitano da Idade de Prata da Literatura Latina (Lisbon 2011) 133–167.

Pinto – Lopes 2006 I. V. Pinto – M. C. Lopes, Ânforas das villae romanas de São Cucufate (Vila de Frades, Vidigueira), Monte da Cegonha (Selmes, Vidigueira) e Tourega (Nossa Senhora da Tourega, Évora), in: Silva – Soares 2006, 197–224.

Protocole Beuvray 1998 Protocole de quantification des céramiques, in: Arcelin – Tuffreau-Libre 1998, 142–157, spéciale de I à XVII.

Prudêncio et al. 2003 M. I. Prudêncio – M. I. Dias – J. Raposo – M. A. Gouveia – C. Fabião – A. Guerra – J. Bugalhão – A. L. Duarte – A. Sabrosa, Chemical characterisation of amphorae from the Tagus and Sado estuaries production centres (Portugal), in: S. Di Pierro – V. Serneels – M. Magetti (eds.), Ceramic in the Society. Proceedings of the 6th European Meeting on Ancient Ceramics 2001 (Fribourg 2003) 245–253.

Prudêncio et al. 2009 M. I. Prudêncio – M. I. Dias – M. A. Gouveia – R. Marques – D. Franco – M. J. Trindade, Geochemical signatures of Roman amphorae produced in the Sado River estuary, Lusitania (Western Portugal), JASc 36, 2009, 873–883.

Quaresma 2005 J. C. Quaresma, Ânforas romanas de naufrágios no Tejo, depositadas no Museu Municipal de Vila Franca de Xira, Revista Portuguesa de Arqueologia 8, 2, 2005, 403–428.

Quaresma – Raposo 2016a J. C. Quaresma – J. Raposo, ›Lusitana 3 (Lusitania Occidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/lusitana-3-western-lusitania> (20 julio 2016) (20. 05. 2019).

Quaresma – Raposo 2016b J. C. Quaresma – J. Raposo, ›Lusitana 9 (Lusitania Occidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/lusitana-9-western-lusitania> (08 julio 2016) (25. 05. 2019).

Quevedo – Bombico 2016 A. Quevedo – S. Bombico, Lusitanian Amphorae in Cartago Nova (Cartagena, Spain): distribution and research questions, in: Pinto et al. 2016a, 311–322.

Ramos – Almeida 2005 A. C. Ramos – R. R. de Almeida, O complexo industrial conserveiro de época romana da Rua Silva Lopes. Principais resultados de uma intervenção de emergência no Centro Histórico de Lagos, Xelb 5, 2005, 101–118.

Ramos et al. 2006 A. C. Ramos – R. R. Almeida – T. Laço, O Complexo Industrial da Rua Silva Lopes (Lagos). Uma primeira leitura e análise das suas principais problemáticas no quadro da indústria conserveira da Lusitania meridional, in: Silva – Soares 2006, 83–100.

Ramos et al. 2007 A. C. Ramos – T. Laço – R. R. de Almeida – C. Viegas, Les céramiques communes du VIe s. du complexe industriel de salaisons de poisson de Lagos (Portugal), in: M. Bonifay – J.-C. Tréglia (eds.), LRCW 2. Late Roman coarse wares, cooking wares and amphorae in the Mediterranean: archaeology and archaeometry, BARIntSer 1662 (Oxford 2007) 85–97.

Raposo 1990 J. Raposo, Porto dos Cacos: uma oficina de produção de ânforas no vale do Tejo, in: Alarcão – Mayet 1990, 117–151.

Raposo 2017 J. Raposo, As olarias romanas do estuário do Tejo: Porto dos Cacos (Alcochete) e Quinta do Rouxinol (Seixal), in: Fabião et al. 2017b, 113–138.

Raposo – Almeida 2016 J. Raposo – R. R. de Almeida, ›Almagro 50 (Lusitania Ocidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/almagro-50-western-lusitania> (20 julio 2016) (25. 05. 2019).

Raposo – Duarte 1996 J. M. C. Raposo – A. L. C. Duarte, O forno 2 de Porto dos Cacos (Alcochete), in: G. Filipe – J. M. C. Raposo (eds.), Ocupação romana dos estuários do Tejo e do Sado, Actas das Jornadas (Lisbon 1996) 249–266.

Raposo – Viegas 2016 J. Raposo – C. Viegas, ›Dressel 14 (Lusitania Occidental)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/dressel-14-western-lusitania> (20 julio 2016) (10. 06. 2019).

Raposo et al. 2005 J. Raposo – C. Fabião – A. Guerra – J. Bugalhão – A. L. Duarte – A. Sabrosa – M. I. Dias – M. I. Prudêncio – A. Gouveia, OREsT Project: Late Roman pottery productions from the Lower Tejo, in: J. M. Gurt i Esparraguera – J. Buxeda i Garrigós – M. A. Cau Ontiveros (eds.), LRCW I: Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry, BARIntSer 1340 (Oxford 2005) 37–54.

Raposo et al. 2013 J. Raposo – J. Coroado – R. Triães – C. Fabião – J. Almeida – C. R. Santos, Restitución Formal y Funcional de un horno romano de la Alfarería de Quinta do Rouxinol (Seixal, Portugal): Arqueología Experimental, Control De Condiciones De Cocción y Análisis Del Material Cerámico, in: A. Palomo – R. Piqué – X. Terradas (eds.), Experimentación en arqueología. Estudio y difusión del pasado, Sèrie Monogràfica del MAC – Girona 25, 2 (Girona 2013) 477–485.

Raposo et al. 2016 J. Raposo – C. Santos – O. Antunes, Roman pottery workshop of Quinta do Rouxinol (Seixal): quantification and classification of amphorae production, in: Pinto et al. 2016a, 19–46.

Remesal et al. 2018 J. Remesal Rodríguez – V. Revilla Calvo – J. M. Bermúdez Lorenzo (eds.), Cuantificar las Economías Antiguas. Problemas y Métodos, Col lecciò Instrumenta 60 (Barcelona 2018).

Remolà 2000 J. A. Remolà Valverdú, Las Ánforas Tardo-Antiguas en Tarraco (Hispania Tarraconensis), Instrumenta 7 (Barcelona 2000).

Remolà 2016 J. A. Remolà Valverdú, Lusitanian amphorae in Tarraco (3rd–5th century AD), in: Pinto et al. 2016a, 333–342.

Rizzo 2016 G. Rizzo, Lusitanian Amphorae in Rome, in: Pinto et al. 2016a, 409–417.

Silva 2018 C. T. Silva, As ânforas, in: C. T. da Silva (coord.), Caetobriga. O sítio arqueológico da Casa dos Mosaicos, Setúbal Arqueológica 17 (Setúbal 2018) 161–174.

Silva et al. 1990 C. T. Silva – A. Coelho-Soares – V. Correia, Produção de ânforas romanas no Martinhal (Sagres), in: Alarcão – Mayet 1990, 225–246.

Silva – Soares 2006 C. T. Silva – J. Soares, Produção e comércio de preparados piscícolas durante a proto-história e a época romana no Ocidente da Península Ibérica. Homenagem a Françoise Mayet, Setúbal Arqueológica 13 (Setúbal 2006).

Spanu 1997 P. G. Spanu, Il relitto «A» di Cala Reale (Asinara), in: Atti del convegno Nazionale di Archeologia Subacquea (An-zio, 30–31 maggio e 1 giugno 1996) (Bari 1997) 109–119.

Tyers 1996 P. Tyers, Roman amphoras in Britain, Internet Archaeology 1; DOI: 10.11141/ia.1.6 <https://intarch.ac.uk/journal/issue1/tyers_index.html> (20. 05. 2019).

Vv Aa 1977 Vv Aa, Méthodes classiques et méthodes formelles dans l'étude des amphores (Rome 1977).

Vasconcelos 1898 J. L. Vasconcelos, Olaria luso-romana em S. Bartolomeu de Castro Marim, APort 4, 1898, 329–336.

Viegas 2006 C. Viegas, O Forno romano da Manta Rota (Algarve), in: Silva –Soares 2006, 177–196.

Viegas 2016 C. Viegas, ›Dressel 14 (Lusitania Meridional)‹, Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/dressel-14-meridional-lusitania> (20 julio 2016).

Viegas et al. 2014 C. Viegas – J. M. C. Raposo – I. V. Pinto, Almagro 51C (Lusitania occidental), Amphorae ex Hispania. Paisajes de producción y de consumo <http://amphorae.icac.cat/amphora/almagro-51c-western-lusitania> (January 2014) (10. 06. 2019).

Villedieu 1984 — F. Villedieu, *Turris Libisonis:* fouille d'en site romain tardif a Porto Torres. Sardaigne, BARIntSer 224 (Oxford 1984).

Wilson 2009 — A. Wilson, Approaches to Quantifying Roman Trade, in: A. Bowman – A. Wilson (eds.), Quantifying the Roman Economy: Methods and Problems (Oxford 2009) 213–265.

Digital Resources

Amphorae ex Hispania. Landscapes of production and consumption. Online Catalogue of Amphoras <http://amphorae.icac.cat/amphora> (10. 06. 2019).

Roman Amphorae: a digital resource. University of Southampton, 2005 (updated 2014) <http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/cat_amph.cfm> (10. 06. 2019).

Video: Arqueologia Experimental_Quinta do Rouxinol (4'18'' onward) available at: <https://www.youtube.com/watch?v=vFSvOgRvsuY&t=561s:> (10. 06. 2019).

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THE TARRACONENSIS PARADIGM*

VOLUMES, MEASURES, AND FORMAL CHANGES IN THE LATE REPUBLICAN AND EARLY IMPERIAL AMPHORAE OF THE NORTHEAST IBERIAN PENINSULA

Abstract
This paper analyzes the development of amphora production in a specific region in the northern Mediterranean coastal corner of Hispania Citerior, ancient Layetania. The purpose is to search for the aims and reasons behind the achievement of a high standardization level as seen upon analysis ranging from the first stages of production in the late 2nd century B.C. to its decline in the late 1st century A.D. The central Catalan coastal region must be regarded as a special case study due to the current large archaeological knowledge based on the amphora epigraphy, the petrographical studies, the large number of excavated kiln sites, as well as the presence of its amphorae in their most important import places and shipwrecks. This large quantity of evidence provides the foundation for an in-depth analysis of the formal and volumetric standardization achieved by Layetanian amphora production. However, we believe our study would be unsuccessful if we were not to pay attention to the essential economic, social, and politic factors that were reflected and determined the production and standardization level of these transport vessels. These factors were closely linked to the development of the western Roman economy and were much broader than the geographical limits of central Catalonia, including not only other regions in the Iberian Peninsula but Gallia Narbonensis and Thyrrenian Italy as well.

The observed standardization process of the Layetanian amphorae was not a lineal development but something that we can perceive in two relevant moments. The first took place in the central decades of the 1st century B.C. when the production of Italic or pre-Roman Iberian amphora types was gradually replaced by the first provincial amphorae. These first amphorae seem to have lacked a formal and volumetric standardization and can be regarded as transitional types that developed into the Pascual 1 type at the beginning of the Augustan era. The second moment of change took place from late Augustan times and can be regarded as something exceptional when compared with the development of amphora production in most of the Roman provinces during early imperial times. Even if the production of Pascual 1 continued for some decades, in the workshops around the recently founded colony of Barcino a ›new‹ amphora type, the so-called Dressel 3-2, based once again in Italian types, started to be produced. We argue that this shift in the formal production of transport vessels in Layetania was motivated by the introduction of new owners of Italian origin, who settled in and around Barcino, and also by the mutation of the main import markets, which from now on would be placed in the central area of western Italy.

We are persuaded that Layetanian amphora production and its standardization is one of the most suitable examples for understanding the interconnectedness of the Roman economy of late Republican and early imperial times. Future data will surely nuance the current state of research, but in the following pages, a general overview of the standardization process can be seen, with its causes, consequences, and general repercussions on the provincial economies.

INTRODUCTION: STATE OF RESEARCH, GEOGRAPHICAL AND CHRONOLOGICAL LIMITS

The northeastern region of the Iberian Peninsula offers a special and up-to-date case study for investigating standardization and its social and political implications. At present, the extensive body of research about amphora production in this region provides a large number of complete amphorae, reliable petrological studies, substantial epigraphic remains, and many excavated pottery workshops, farms and rural settlements where wine and sometimes amphorae were produced[1]. Moreover, we also have in-depth knowledge of the sites of consumption for most of the

* We are grateful to J. Leidwanger for his help with different aspects of the article and his useful suggestions.
1 Miró 1988a, 12–59; Revilla 1995; Tremoleda 2000; Tremoleda 2008; Revilla 2011/2012; Martínez 2014; Revilla 2015, 1–17.

1 Central Catalonian coastal area (ancient Layetania) within the Iberian Peninsula (© by the authors)

amphorae produced in Hispania Tarraconensis[2], closed contexts with Tarraconensian amphorae at Carthage, Rome, and the German border[3], and many shipwreck cargos where these amphorae are the most important or only component[4]. Ancient authors mentioned some of the wines produced in Tarraconensis, such as those of Layetania[5] and Tarraco, the provincial capital. Finally, a large number of publications and several conferences on this subject have periodically taken place since the 1980s[6].

Nevertheless, despite the large volume of archaeological and historical evidence concerning Tarraconensian amphorae and wine, two essential points are worth noting. The first concerns geography. Hispania Citerior Tarraconensis was, from the period of Augustus to that of Diocletian, one of the largest Roman provinces, embracing most of the central and northern territories of the Iberian Peninsula as well as much of the Mediterranean Iberian coast and the Balearic Islands. The production of amphorae is documented in different areas of this vast territory at different times. In this article, we limit our attention almost exclusively to the central coastal area of today's Catalonia (fig. 1), an ancient region normally referred to as Layetania, home of the pre-Roman population of the Laetani. We are aware that other areas within the huge geographical expanse of this province produced and exported agricultural surpluses in amphorae, and the last decade has seen important advances in knowledge about their production. This is particularly significant for other areas such as northern Catalonia, the territory of Tarraco, and the lower Ebro Valley, and also for some areas in modern Valencia and Ibiza, an island with a pottery tradition rooted in its Punic past that continued producing amphorae during the Roman and early Byzantine periods[7]. Hence, the vast amphora production in Tarraconensis included large territories and different traditions and was linked to different trade routes. Our focus specifically on Layetania make sense since one cannot cover such a large and heterogeneous series of productions, but there are also other reasons that make the central Catalan coast a special case study for the analysis of standardization.

From a practical point of view, we have chosen this region primarily because in recent years we have been working intensely in this area[8], and also because it offers a large amount of historical and archaeological information, much larger than available in other areas of Tarraconensis[9]. The extraordinary volume of archaeological evidence is in part the result of the urban development of the metropolitan area of Barcelona and its continuous geographical expansion since the mid-20th century, which drove the constant archaeological excavations and the resulting discoveries of archaeological structures. In the case of written sources referring to agricultural production, both

2 Miró 1988a, 119–208; Etienne – Mayet 2000, 217–230; Martínez 2015.

3 Carthage: Freed 1998; Martin-Kilcher 1998; Martin-Kilcher 2005. Rome: Tchernia – Zevi 1972; Hesnard 1980, 145 f.; Contino et al. 2013; Rizzo 2014, 197–200; Rizzo 2018; Olcese et al. 2017, 201–203; Járrega et al. 2020. Germany: Martin-Kilcher 1994; González 2014; González 2015; González – Berni 2018, 34–38.

4 Corsi-Sciallano – Liou 1985; Liou 1987; Nieto – Raurich 1998; Dell'Amico – Pallarés 2011; Geli 2020.

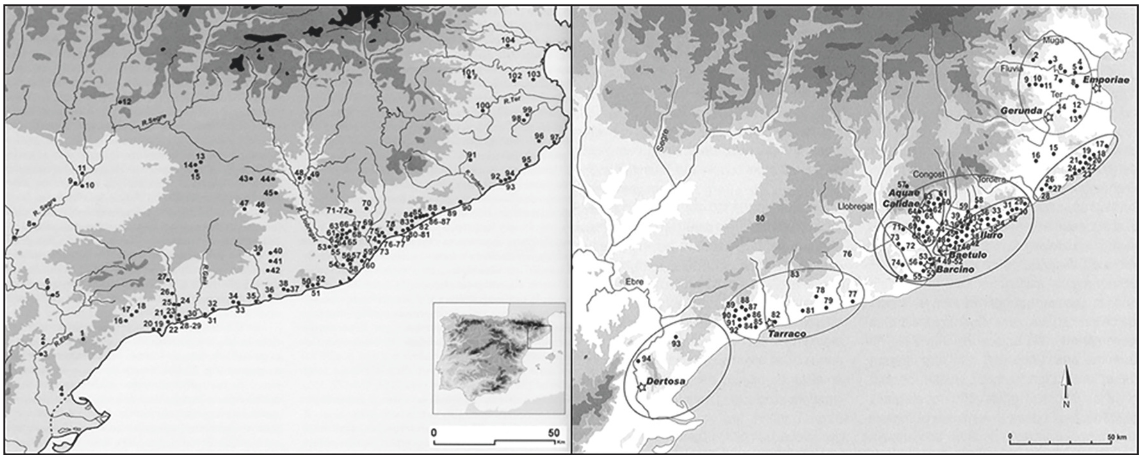
5 Miró 1985.

6 El vi a l'antiguitat 1987; El vi a l'antiguitat 1998; López – Aquilué 2008; Prevosti – Martín 2009.

7 Northern Catalonia: Tremoleda 2000; Nolla 2008; Castanyer et al. 2009; Tarraco: Járrega – Otiña 2008; Revilla 2008; Járrega 2009; Járrega – Berni 2015. Ebro Valley: Beltrán 2014; Revilla 1993; Revilla 2008. Valencia: Aranegui 2008; Gisbert 2009; Mateo 2018; Mateo et al. 2021. Ibiza: Ramon 2008; Ramon 2012.

8 Berni – Miró 2013; Berni – Miró 2020; Berni – Miró (forthcoming).

9 Pascual 1977; Carreras – Berni 2002; Dell'Amico – Pallarés 2007; Comas – Carreras 2008; Olesti – Carreras 2008; Martínez 2014; Martínez 2015; Martín – Revilla 2019.



2 Comparison between presses and storage buildings in northeastern Hispania Citerior Tarraconensis (left: from Revilla 2011/2012, fig. 2), and amphora production centers (right: from Tremoleda 2008, fig. 2). Research in the last decade has increased the number of both presses and amphora workshops, but has not changed the main vision about the regions with a higher clustering/concentration of both facilities

literary and epigraphic, they more often refer to this geographical area than to other parts of Hispania Citerior Tarraconensis. Nevertheless, there are also other essential historical reasons behind our choice. The central Catalan area was very fertile, well connected by sea and land routes, and from early Roman times emerged as the center for wine production and its related industries in the province, especially the production of amphorae used for the distribution of wine to the main consumer markets. The economic impact of wine in this region was extraordinary and directly reflected in the epigraphic evidence that has highlighted the involvement of the regional and even imperial elites in its production and trade[10]. This prevalence of wine in the region's economy can also be seen in the amphora production. We can be certain that from the 1st century B.C., the central Catalan area was the original focus of a specific production related to a new provincial identity. New types were created, but also, in an idiosyncratic way, external types were adapted and quickly developed into new local forms. Other areas of the province never achieved this to the same extent; even if some of them produced their own types, none seem to have reached the same scale of production or the same success, as is evident not only in the amphora record but also in the quantities of documented workshops and Roman *villae*[11] (fig. 2). For these reasons, the economic weight of the agricultural products and export of other areas could never compare quantitatively with that of central Catalonia.

The second point concerns the specific time frame of analysis that extends to just two centuries: from the early 1st century B.C. to the late 1st century A.D. We know that previous production existed, the main actors in which were local Iberian populations. There was also continuity in amphora production during the 2nd and early 3rd century A.D. and even later[12]. However, these amphorae belong to different economic and political circumstances, and we argue that they should not serve as examples for the study of standardization processes, the best case study of which is beyond doubt the period between the mid-1st century B.C. and the Flavian dynasty. Within these geographical and chronological limits, we can try to affix the standardization process to up-to-

10 Berni et al. 2005; Rodà 2010; Cabrelles 2013; Járrega 2018; Olesti 2020; Járrega – Colom 2020; Revilla 2020.

11 See fig. 2 based in Revilla 2011/2012 and Tremoleda 2008. New workshops of the last decades B.C. have been documented all around Catalonia, but in general the picture provided by this map has not changed. The huge difference in workshop concentration cannot only be related to the different urban development of the 4 million-population metropolis of Barcelona and of smaller cities, such as Tarragona or Girona, but to a productive reality of the Roman period.

12 Carreras – Berni 1998; Járrega – Otiña 2008.

date and well-known models of production and trade. In general, this period represents the Roman economic zenith (even if the first part of the 2nd cent. is excluded), the period when documented exchange and consumption levels were at their highest[13]. Furthermore, this period coincides with the rise in provincial production, especially in the western Mediterranean, and with the two centuries when the number of shipwrecks in the Mediterranean reached a peak[14], which seems to offer a reliable index for connectivity and trade.

FACTORS OF STANDARDIZATION IN HISPANIA CITERIOR TARRACONENSIS

The production of transport amphorae can never be disconnected from the production of the commodities which these ceramic vessels carried. They cannot be examined just as pottery vessels; their significance goes further and reflects the intensity of agricultural production in their regions. This simple – and at the same time, often forgotten – assertion is fundamental for understanding the standardization process.

Throughout antiquity, several areas of the Iberian Peninsula produced and exported their terrestrial and marine commodities, with northeastern Spain being one of the most fertile and well-connected. The natural conditions of the central Catalan area made possible the easy production and export of agricultural surpluses, among which the most important was wine. The large numbers of presses and other remains of wine production throughout this geographical region clearly point to the relevance of the ›wine industry‹ here[15]. At the same time, the literary sources also testify to the existence of intensive wine production, with its different qualities[16] linked epigraphically to the provincial and imperial elites of the late 1st century B.C. and the 1st century A.D.[17].

Even if production of wine was well known in pre-Roman times[18], the development of mass production only started from the 1st century B.C., as the exponential growth in the archaeological remains has indicated. This process of mass production seems to have its origins in the establishment of Italian immigrants and the consequent installation of new urban centers or the promotion and restructuring of old Iberian ones. These changes brought new organization and administration of land which from that point onward was within the framework of the Roman system of centuriation and the rapid spread of agricultural practices based on the *villa* system.

In the 1st century B.C., especially the first part of the century, the slave mode of production was still at its peak in Italy. Slavery was linked to the *villa* system[19] and thus also to the peak of production and export of Campanian and Etruscan wines in Dressel 1 amphorae. In our opinion, the production of imitations of Dressel 1 in Catalonia could be seen as the first reflection of this system in the region. However, the existence of what seems to be two systems of production, at least in the first part of the 1st century B.C.[20], suggests that the local non-Roman elites were also involved in the early stages of this process, probably at the same time as the new Italian settlers[21].

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13 Many authors have seen this period as the peak of trade and consumption of the Roman society. Among others: Jongman 2007; Morley 2007; Scheidel 2009; Tchernia 2011; Molina 2020.

14 Wilson 2011 fig. 2, 1–6.

15 Wine production in Tarraconensis has drawn the attention of numerous scholars. The archaeological remains discovered in the second part of the 20th cent. and the last two decades have fortunately in most cases been excavated and published accurately. For this topic, see, among others, Revilla 1995; Peña 2010; Revilla 2011/2012.

16 Miró 1985.

17 Pena 1999; Berni – Miró 2013.

18 Olesti 1998; Gorgues 2010.

19 Carandini 1989.

20 See further infra.

21 Gorgues (2010) mentions the term ›Criolisation‹, referring to the transitional economic phase that would start in northeastern Spain from the last quarter of the 2nd cent. B.C. This phase was characterized by the existence of a mixed community and material culture that can be rightly described as neither indigenous nor Roman, but it has particularities of both, with an indigenous interpretation of Italic cultural elements as well as an Italic interpretation of indigenous culture. For Gorgues, this process starts with the establishment of the colony of Narbo in 118 B.C. and the especial intensity of the Roman military conflicts in the Iberian Peninsula.

Based on epigraphic evidence from amphorae, it seems that the process of integration of the pre-Roman elites into the new Roman economic system expanded throughout most of the 1st century B.C. Some authors have paid attention to the role played by the indigenous communities and their integration into this economic process[22]. How they integrated, though, still remains unclear, and we can only assume, based on the archaeological and epigraphic remains, that from at least the last quarter of the 1st century B.C. the economy of the central Catalan area was firmly integrated into the Roman economic system and already under the control of the Roman oligarchies that would greatly benefit from the export of Layetanian wine[23].

Recent studies have suggested that the *villa* system and its related slave labor were not predominant in the agricultural production of the region[24]. We cannot completely deny this hypothesis, but the epigraphic evidence related to amphora production in the Tarraconensis workshops clearly suggests the involvement of the local, provincial, and imperial elites, and the control of the production process by their slaves and freedmen[25]. Even so, the archaeological and epigraphic evidence points to the existence of a production system based on an intensive specialization of labor, and together with a dedicated organization and division of production in the workshops, this situation surely influenced the level of standardization achieved by the most important amphora producers in central Catalonia.

The labor organization and division in the workshops, and probably in the agrarian estates too, were directly linked to the increase in the consumption of commodities from Tarraconensis in the markets that received these goods. Amphorae were produced as utilitarian vessels to meet the necessary transport of a given commodity to its places of consumption. Initially, the Roman amphorae produced in the region had consumer markets in their own province, given the increase and changes in the population tied to the arrival of soldiers and settlers from Italy, but soon external markets for these goods also grew, mainly in southern Gaul and later in the central Mediterranean.

Together with a massive and well-organized production and consumption of the amphora contents, the third of these factors behind standardization is the adaptability of the vessels to the vehicles and transport systems and to their related technological developments. In the case of the Tarraconensis amphorae, we can follow the formal development from the early stages of this production to the late 1st century A.D. However, if a formal and somehow linear evolution can be traced from the Dressel 1 and ovoid forms to the Pascual 1, the beginning of the Dressel 3-2 production marked a sharp break with the re-adoption of ›new‹ Italian types. This change seems to have been caused by a shift in the main consumption markets from southern Gaul to western Italy, which led to producers starting to make new forms demanded by these ›new‹ consumers. The adaptability of the Tarraconensis producers can also be seen in the production of flat-bottom Oberaden 74 amphorae, but in this case, it seems to be related to the transport system. The production of this type had no previous precedents in the region, but the shape has a close resemblance to and parallels with other flat-bottom amphorae of the period, such as the Gauloise 2 produced in southern Gaul and the *urceii* from Baetica. Currently, just three workshops of the central Catalan coast have revealed the production of Oberaden 74, which is more concentrated in southern Catalonia and the Ebro Valley. The production of Oberaden 74 and other flat-bottom amphorae in the western Mediterranean is probably linked to the beginning of an intensive colonization process in the Rhône, Ebro, and Guadalquivir Valleys from the Caesarian age, and the resulting transport of commodities in flat-bottomed ships adapted to river transport (especially on the Rhône–Rhine axis)[26]. However, the question is not easy to resolve because other Tarraconensis amphorae, above all the Pascual 1, maintained a pointed shape but followed the river routes, mainly the Aude–Garonne axis, in even larger quantities than the flat-bottom Oberaden 74.

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22 García – Gurri 1996/1997; Olesti 1996/1997, 431; Olesti 1998; Martín – Garcia 2002.
23 Berni – Miró 2013.
24 Molina 2020, 97–104; Álvarez 2017.
25 Berni – Miró 2013.
26 Carreras – González 2012.

Be that as it may, one important question that arises from the transformations of amphorae in our region is whether these formal developments went hand-in-hand with substantial technological changes. The archaeological evidence indicates that normally only small changes in production technologies took place. The most important of them seems to have occurred during the very early production phase, when the previous Iberian fabrics (see below) were replaced by the clays typical of the region in Roman times. This change required the use of different, larger, and more efficient kilns, and demanded more temper for the clay, creating sturdier and more resistant vessels that once again were better adapted to ships of greater size and capacity that could sail over longer distances. These changes opened up the possibility of increased production of amphorae that were better adapted to a ›new‹ Roman Mediterranean trade.

Lastly, in the Tarraconensis production, we can also see a close connection between typological changes and changes in the epigraphic habits, especially in the procedure for stamping. These changes were progressive, and generally we perceive a trend towards more complexity, with more associations between slaves and producers or between different slaves[27].

PHASES OF STANDARDIZATION

It would be reasonable to connect the development of amphora production and the levels of standardization the vessels achieved with the frenetic political, social, cultural, and economic changes that happened in northeast Spain during the 1st century B.C. and 1st century A.D. Even if the preconditions can already be seen in the geography and environment of the region, the installation of new social groups, new urban and rural settlements, and a new orientation and scale of economic exploitation from the beginning of the 1st century B.C. – especially from the Augustan period – brought about a major transformation of society and economy in the region that is clearly reflected in the amphora production.

Early Amphora Production Stages: the Productions of Northeast Hispania Citerior

Amphora production on the Catalan coast has been documented since pre-Roman times[28] and seems to have increased with the early presence of Roman troops in northeast Spain from the Second Punic War onwards. This early production is clearly linked to the pre-Roman populations, but seems to have continued during the 2nd and early 1st century B.C. when Roman troops settled in the Catalan area and the first Roman settlements were established. Fabric characteristics and epigraphic evidence on amphorae reveal the role of the local indigenous community in this early production, which includes some types of Iberian amphorae of Phoenician-Punic tradition. These amphorae are widely documented in coastal Iberian settlements in Valencia and Catalonia between the 6th and 1st century B.C., and several regional groups can be distinguished according to their typology[29]. Their manufacturing process is similar to that of other Iberian wares, producing thin and fragile walls and small rounded handles. Their poor manipulability suggests that they could have been used for transport over small distances or even for storage, and this type has only occasionally been documented in areas throughout present-day Catalonia and the Balearic Islands[30].

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27 The best example is the workshop of Malgrat: Járrega – Berni 2014.

28 Tsantini 2007; Ribera – Tsantini 2008.

29 Group study in Ribera – Tsantini 2008. For the northeast of Tarraconensis: Miró 1983/1984; Sanmartí et al. 1998; Sanmartí et al. 2004; Tsantini 2007.

30 Ribera – Tsantini 2008, 617. The best-known wreck is that of Binisafuller in Menorca (Guerrero et al. 1989; Guerrero et al. 1991; Aguelo et al. 2014), with a main cargo consisting of Iberian amphorae, most likely from the area south of the Ebro, which sunk towards 375–350 B.C. The content of these amphorae would have been wine (Aguelo et al. 2014, 70), although the analysis of residues in some pieces found in Catalan Iberian villages indicates that it could have been beer (Juan 2000).

From the 2nd century B.C., Graeco-Italic amphorae started to be produced, but always within an Iberian technological tradition. They were the first amphorae following a typological Roman tradition produced in the region, which can be explained by the presence of many Roman troops in Catalonia throughout the Republican period, and the pottery production supplying them necessarily went beyond containers for agricultural products to include fine and coarse wares. The imitation of amphorae and other pottery wares from the central and eastern Mediterranean by local pre-Roman populations was not a unique feature of the Roman Republican period in Spain; it has also been documented more or less continuously since the 5th century B.C. in different parts of the Iberian Peninsula[31]. Nevertheless, production here seems to have gained importance with the presence of the Roman army and other Roman/Italian population groups, especially from the late 2nd century B.C.

From around that time or during the first years of the 1st century B.C., the production of Dressel 1 began in the Catalan regions. This process is documented also in other areas of the Iberian Peninsula, especially in the Guadalquivir Valley and on the Strait of Gibraltar. However, the central Catalan coast seems to have played a special role in the imitation of Italian amphorae and fine wares during the 1st century B.C.[32]. The arrival of the Italian Dressel 1 is attested in large quantities in Republican Hispania Citerior, and thus their imitation seems logical if we take into consideration the wine production tradition in the region. Currently, their local production seems to have followed two clear paths. The first is related by both fabric composition and epigraphic features to indigenous potters and became part of their local pottery tradition; for example, in the area of Iluro[33], the same ceramic kilns that produced Iberian amphorae from at least the 3rd century B.C. manufactured Dressel 1 but still with the typical Iberian technology, using the same clay as the Iberian ceramics and the local thin-walled and Campanian black-gloss imitations[34]. The situation seems similar in the hinterland of Tarraco, but following the fabric description of Adserias and Ramon, we cannot yet confirm it[35]. For this production, even if the number of examples is quite few, there is an absence of uniformity in most of its formal features, and a lack of standardization seems to have existed that probably was also reflected in un-standardized capacities.

Nevertheless, from early on and in the same geographical area, the production of Dressel 1 followed a different pattern, separate from that of Iberian potters. The adoption of new kiln sites (generally of Cuomo di Caprio's type II) and new fabrics, which would continue into the later production of the region, represented a major transformation linked to a new organization of the territory and the beginning of more intensive agricultural exploitation. Thus, this production was more abundant than that following Iberian patterns but was still scarce[36]. However, it seems to have kept some formal uniformity, and a certain level of standardization can be proposed, especially in the workshops around Iluro/Mataró. Most of the documented examples were directly related to the Italian Dressel 1B, but Dressel 1A and 1C have been documented as well.

An extraordinary case involves the complete examples of Dressel 1B published from Can Pau Ferrer (Cabrera de Mar), just some kilometers from Iluro, that maintain a standard in measurements, formal features, and probably also in capacities. These amphorae followed quite similar standards as the Italian production, and only the fabric marks the difference between them. In this case, it may be possible to speak about ›copies‹ and not ›imitations‹ or amphorae ›based on‹ the

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31 See, for example, A. M. Sáez et al. in this volume.

32 For fine wares: Principal 2008. For the Graeco Italic amphorae: Principal – Sanmartí 1998.

33 This small central Catalan region had the name ›Maresme‹ and was highly adapted to Roman habits and cultural practices from the late 2nd cent. onwards.

34 In the Iberian *oppidum* of Burriac, the most important of the Maresme and perhaps of Layetania, the Dressel 1 was documented for the first time, being manufactured with an Iberian excellent quality ›sandwich-type‹ clay. They were dated around 90–70 B.C.: Miró et al. 1988, 69. For a synthesis of these amphorae: López – Martín 2008, 33–43.

35 Adserias – Ramon 2004.

36 The Dressel 1 amphorae are always a minor part of the production of the documented workshops that also produced later amphora types.

Italian Dressel 1. The production of these Dressel 1B in Cabrera de Mar can also be connected to the sporadic production of Lamboglia 2 (fig. 3). At present, Lamboglia 2 produced on the Catalan coast have only been documented by some examples found in the context of the mid-1st century B.C. in Iluro. They seem to follow the same patterns as the Dressel 1B of the Cabrera workshops, where they were probably produced together. Contrary to the Dressel 1, the Italian Lamboglia 2, even if always present in contexts of the 1st century B.C., was never imported in the same huge quantities into central Catalonia, and its main import area in the Iberian Peninsula seems to be in the region of Carthago Nova[37].

An important question surrounding this production ›à l'italienne‹ concerns the potters who participated in it. Were they Italian potters? Were they slaves working previously in Italian workshops and transferred to this corner of the Iberian Peninsula in order to open new workshops that could start to package and export the local (and probably already ›Roman‹) wines? The next obvious question would be: Who were the consumers of these wines? Were they the new Roman/Italian population who were arriving from this time? These questions are not easy to answer with our current state of knowledge, but epigraphy and consumer markets can provide some clues for their systematic investigation[38].

We know of some stamps on the Dressel 1 from workshops in the Layetanian area: M·COS, Q·FABI, and Q·E. These probably represent three Roman citizens referenced with their *duo nomina*. However, in the *ager* of Tarraco, the other Catalan area with high Roman populations and influence, a stamp found on a Dressel 1 handle bears Iberian letters[39]. This might confirm the involvement of the indigenous population in the early phases of this production process. This has also been suggested in the case of the very common *nomina*, *Q. Fabius*, which appears among the Tarraconensis amphora stamps. In this sense, Olesti has suggested that for the Fabii stamps, we are not dealing with freedmen but with a certain population of Iberian origin, probably part of the indigenous oligarchy, which took Roman names and was already involved in the production of wine[40].

Regarding the consumption of Tarraconensis Dressel 1, its production near Tarraco and Iluro suggests that, at least in the earliest phases, the main consumers were Roman troops and members of the administration settled near the two most important foci of the Roman population during the first part of the 1st century B.C. This may have been the initial boost for production, but the presence of these amphorae at indigenous settlements, like El Vilar (Valls) and Burriac (Cabrera de Mar), introduces the possibility that at least some of the Iberian elites also consumed their contents. The next phases in the growing production of these vessels would soon be linked to their external diffusion, as they have been found in different places in Gaul. However, the precise extent of the diffusion of early amphorae produced in Hispania Citerior is still an open question, and much more work must be done, with special attention to the fabrics of Dressel 1 at import sites in the western Mediterranean. Nonetheless, during the last few years, these amphorae have been documented at more and more sites in Gaul, where they seem to have followed the routes of the Italian Dressel 1 and to have profited from the diffusion and success of Italian wines. In our opinion, they were embedded in the same circuits and dynamics and, as in case of the Italian Dressel 1, they were consumed by the Gaulish indigenous population. In this sense, it would be logical to assume that the producers of wine and amphorae in Tarraconensis knew about the benefits they could obtain from this important trade under the control of Roman merchants.

In searching for an answer to the question of the diversity of fabrics and stamps in these early phases of Citerior/Tarraconensis production, some scholars have suggested a geographical differentiation between the two productions. In our opinion, it is probable that their production took

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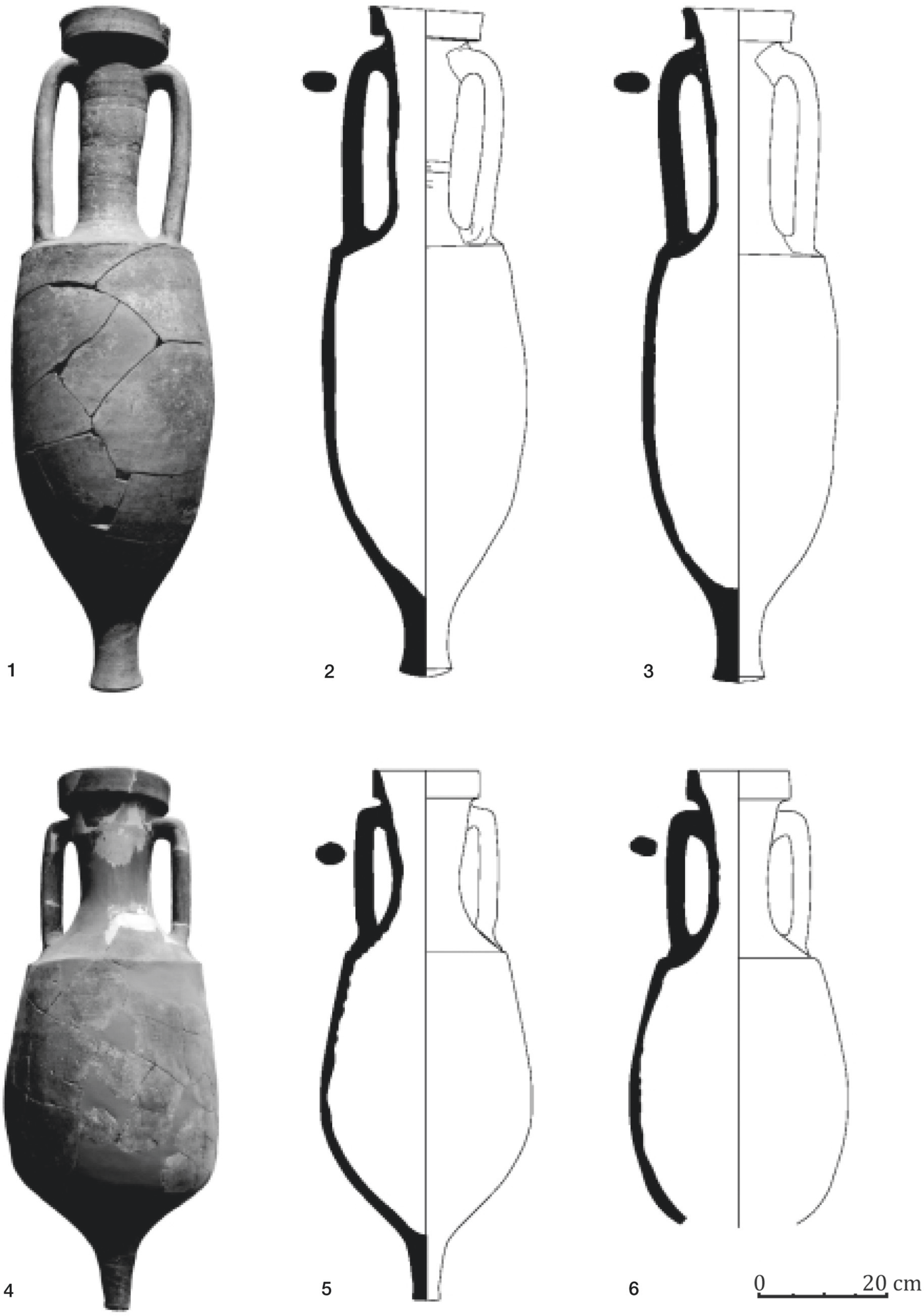
[37] Molina 1997; Mateo 2016, 44.
[38] Miró 1988a; Miró 1988b, 209–247; Pascual 1991; Pena 1999; Etienne – Mayet 2000, 139–195; Revilla 2004; Revilla 2007; Berni – Revilla 2008.
[39] Berni – Miró 2013, 65.
[40] Olesti 1996/1997, 438 f.



3 Dressel 1B (nos. 1–3) and Lamboglia 2 (nos. 4–6) produced in Layetania (from: López – Martín 2008, fig. 3)

place in different workshops and using different technologies, but we do not know if the distance between them was enough to ascribe each to a different geographical region. A chronological difference between the two productions has also been suggested. It is reasonable to link the Dressel 1 with Iberian fabrics but only in the early stages of this production, as the formal features seem to suggest a proximity to the Dressel 1A, as does the early chronology of the contexts in which they have been found. However, the typical Layetanian fabric seems to appear also from early on. One possible answer to this diversity of fabrics may be that both variants were produced by different populations in order to take advantage of the rise in potential consumers and to meet the demands of different social groups (i.e., indigenous elites versus Roman settlers). Another option, which does not preclude the previous one, is that we are dealing with two different products or qualities of products. Whatever the explanation, it is clear that the potters behind the production of the two variants were not the same. Thus, the standardized copies of Italian Dressel 1 could be directly connected to the arrival of Italian potters, probably from Campania or Etruria, who produced them in Italy in huge quantities and followed the same precise production system and labor division as in most industrial installations in Italy. The precision in the production of these Dressel 1B was not accidental, and even if the Italian model was well known by the local population, the close formal similarity to the original types and the ›new fabric‹ used seem to exclude their manufacture by indigenous potters.

In sum, it must be emphasized that this production, even if small and at present limited to merely a handful of workshops, was the first with enough capacity to export regional surpluses. Its presence in Gaul, even if rare compared to the Italian Dressel 1, must be regarded as the first step or introduction of the Tarraconensis wines in what would become their main import area from the second part of the 1st century B.C.

The production of Dressel 1 in our region continued throughout the 1st century B.C., and was produced together with later amphorae, such as those of the ovoid group and the Pascual 1. Nevertheless, it always represented a minor component of the products in their workshops from the mid-1st century B.C., when the development of new forms marked the beginning of a new phase in the production and export of amphorae and the agricultural commodities they carried.

The First Provincial Repertoires: the Middle Decades of the 1st Century B.C.

The production and distribution of Dressel 1 paved the way for later amphora forms, but the Dressel 1 were produced in only a limited number of workshops and were never exported in large quantities. Furthermore, even if they seem to have achieved a certain degree of formal and volumetric standardization, this does not appear directly linked to internal factors but rather to the previous import of the Italian Dressel 1 at the most suitable agricultural areas of northeast Spain, where they were copied and imitated, following indigenous but above all Italian craft methods, Italian forms of workshop organization, and probably Italian potters as well. We can say without hesitation that this early production was still being developed following foreign models, and it does not represent local Roman provincial production even if it was an important step in that direction. It belongs to the first phases of the process of implementation of a Roman productive and administrative system in northeast Spain, still marked by a military presence and with only some areas starting to produce in a Roman way (Cabrera, Tarraco [?]). The establishment of the Roman cities of Baetulo/Badalona and Iluro/Mataró at the beginning of the 1st century B.C. can be seen as a crucial moment. From then on, and especially from the middle decades of the 1st century B.C., the situation developed with a stronger Roman presence and control over the territory and means of production. This development is reflected in the amphora production, with new types that can be linked to the emergence of a Roman provincial society and to the implementation of Roman administrative and economic control. These amphorae, included in the large family of ›Ovoid Republican amphorae‹[41], were produced in larger quantities and achieved broader success in Mediterranean consumer markets. Yet they were still in a process of transition, as can clearly be seen in the continuous development and formal changes that occurred within a few decades (or an even shorter period).

The amphora production of the middle decades of the 1st century B.C. in Layetania is characterized by the continuous creation of new types, some of which were still related to external types (not necessarily from Italy, as was the case of the ovoid forms produced from 60/50 B.C.[42]), but which nonetheless were already far from being mere copies. Around 40–30 B.C., a new type, the Pascual 1, started to be produced extensively, becoming the most important Tarraconensis amphora of the last third of the 1st century B.C. and early years of the 1st century A.D. They seem to have developed primarily from the local Dressel 1 but also incorporated some formal features of the heterogeneous ovoid group.

Within this process, a crucial point appears to have been the foundation of Barcino/Barcelona (15–9 B.C.), a Roman colony with a rich hinterland and good connections by sea and land[43]. The creation of a new colony in the core of the most important wine production area of the Iberian Peninsula must be seen as a step forward in the consolidation of Roman control of the region and of social and economic aspects linked to a new provincial society. In previous work, we have connected the production of Dressel 3-2 to changes that accompanied the foundation of Barcino[44]. The Dressel 3-2 marked the high point of wine production and trade in all of Hispania Tarraconensis. This type was produced throughout the province from near the end of the 1st century B.C. to the late 2nd or first half of the 3rd century A.D. However, its peak was between the late Augustan and Flavian periods, when it was produced in numerous workshops that reflected a high level of standardization in the two main provincial production areas: the central Catalan coast and the territory around Tarraco. Its production involved a substantial change in the formal development of the Tarraconensis amphorae, which was directly connected to changes evident in the deep involvement of imperial elites in the wine business and in its main markets, which shifted from Gaul to Italy.

Prior to analyzing the extensive production of Dressel 3-2 in our region, however, and in order to understand better how the wine boom of Tarraconensis developed and was reflected in or connected to the standardization of clay containers, we must focus our attention on the transformations that occurred from the second part of the 1st century B.C.

The Ovoid Amphorae of Tarraconensis

During the last 15 years, several publications have dealt with the production and distribution of the broad group of ovoid amphorae produced in many different areas of the Mediterranean from the late 2nd century B.C.[45]. The economic and social development of the central Catalan coastal area, along with the immigration of Roman citizens, was favorable for the adoption of their own ovoid amphora forms, roughly at the same time as other regions in the Iberian Peninsula[46].

Once again, our region was not the only one in the territory of Hispania Citerior where the production of ovoid types has been documented. They are also attested in some workshops around the city of Tarraco, the provincial capital, and probably in the Roman *villa* of Mas d'Aragó, south of the Ebro[47]. However, the central Catalan coastal region was undoubtedly the most important

41 García et al. 2019.
42 Miró – Járrega 2019.
43 Miró 2020.
44 Berni – Miró 2013; Berni 2015; Miró 2020.
45 García et al. 2019.
46 García et al. 2011.
47 For all these regions see Nolla – Solias 1984/1985; Járrega 2016; Miró – Járrega 2017/2018; Miró – Járrega 2019.

area of production, and from a chronological point of view, it seems to have also been the initial focal point of this production, especially the workshops around the Roman town of Iluro[48].

This situation is reflected in the literature on this group of amphorae as well as in the name it has received over the last half century. It was first recognized as a distinct type by M. Comas Solà in 1985, who called it ›Layetania 1‹. Around the same time, the type was found in the excavations of Emporion/Ampurias, and three years later, J. M. Nolla and J. M. Solías called it ›Tarraconense 1‹, thinking it was a different type; later on, new finds and further research revealed that it was the same amphora or rather that it belonged to the same group. Nevertheless, the use of both terms, Layetania 1 and Tarraconense 1, was common in local and foreign scholarship until A. López Mullor and A. Martín Menéndez in 2008 divided them into seven subtypes (fig. 4). This division is not free from problems – as, for example, use of the name Tarraconense 3 for what seem to have been sporadic copies of the Baetican Ovoid 1 – but it was a valiant attempt at presenting a large number of morphological features and giving some order to the amphora production of a period that underwent deep and rapid changes and never reached an effective standardization level.

One common feature that enables the study of Tarraconensis production is the existence of many shipwrecks with cargos from different regions, but especially from Layetania. This is quite important in the case of Tarraconense 1, the different variants of which have been recorded on some shipwrecks in Catalonia and the south of France, especially the Cala Bona 1 and Illes Formigues 1 wrecks[49]. In both assemblages, the different variants described by A. López Mullor and A. Martín Menéndez appear together but also alongside Baetican ovoid types. This fact has been essential to the recognition of most variants, since their quantities in consumption and production contexts were never large and, in the absence of complete examples, they could not be clearly recognized as distinct from other Tarraconensis productions (especially Pascual 1 but also Dressel 1 and Dressel 7–11).

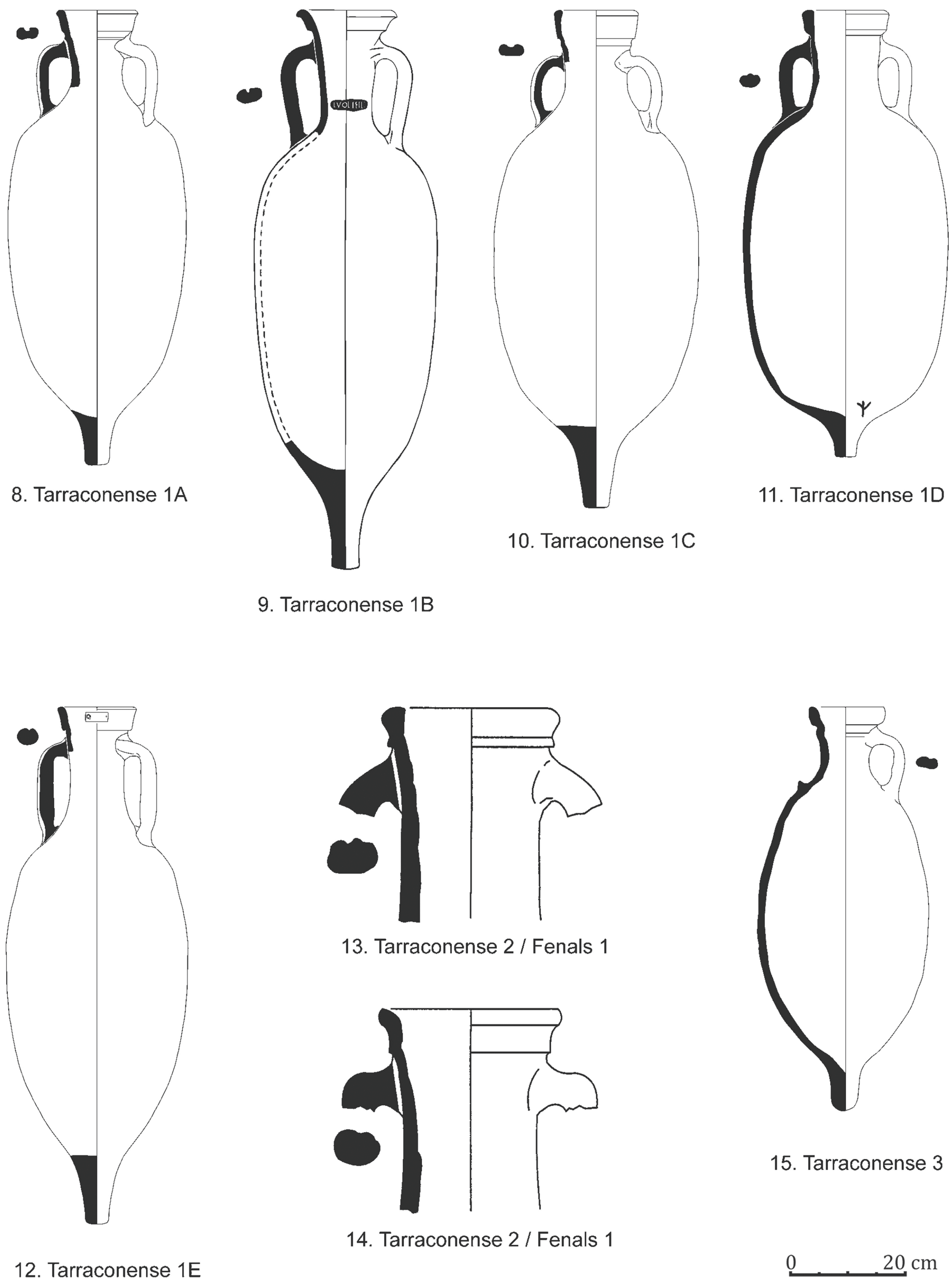
These observations have drawn attention to the extensive formal heterogeneity of the group. As A. López Mullor and A. Martín Menéndez have already suggested, the amphorae can be clearly subdivided into two main groups and may be less tightly connected to each other than normally assumed. The first group includes the ovoid-shaped amphorae, mainly Tarraconense 1C and 1D, and some variants of Tarraconense 1A; they can be included in the larger family of Mediterranean ovoid amphorae. The second group includes the spindle-shaped forms, mainly Tarraconense 1B and 1E. These forms, especially Tarraconense 1E, are close to the early Pascual 1 and seem, at least partially, to have developed from the local production of Dressel 1. Common features of all subtypes include a solid spike and small handles, normally with oval or rounded sections and one external groove; however, the size and profile of the spikes and handles can vary from one subtype to another.

The amphorae, considered by A. López Mullor and A. Martín Menéndez as Tarraconense 1A, offer probably the best examples of the extensive formal heterogeneity within this group. They can vary from 75–92 cm in height, with a maximum diameter of 31–35 cm normally at the central part of the body. This feature makes the more ovoid-shaped amphorae narrower and shorter, but more oblong in the case of the thinner and taller jars. The rim and the handle section seem to achieve a higher degree of homogeneity, exhibiting a slightly open mouth, thicker at the upper part, and with a height of 3–6 cm.

The ovoid-shaped group is completed by Tarraconense 1C and 1D. Among them, Tarraconense 1C is the best known, mainly due to the presence of some complete vessels in shipwrecks, while for 1D, only two complete examples are known at present. The two forms are not easy to distinguish, and it seems that the main difference is, once again, in the rim profile. Both forms have an ovoid body, short handles with one or two grooves on the outside, and a quite straight rim,

48 Miró – Járrega 2017/2018, 215.

49 Martín 2008.



4 Main divisions of Tarraconensis amphorae of the late Republican ovoid group (from: Miró – Járrega 2019, fig. 1; and these authors after: López – Martín 2008, figs. 5. 6)

thicker and shorter in case of Tarraconense 1D. The complete examples of Tarraconense 1C are 79.5–90 cm high, with a maximum diameter of 30–35.5 cm, and a generally straight rim that in most cases is 3–4 cm tall but can in some examples reach up to 5 cm in height[50]. Some examples of Tarraconense 1C have a slight molding below the rim, similar to that documented on Ovoide 1 and 5 of the Guadalquivir Valley. The form of Tarraconense 1D also recalls Ovoide 4 and other related types of Baetican ovoid production. At present date, there are just two examples of this type, one found at the Roman *villa* of Castellarnau (Sabadell)[51], and the other a possible Tarraconense 1D, found in the La Longarina 2 deposit (Ostia)[52]. The example of Sabadell is 77 cm high and more than 30 cm in diameter, while the Longarina 2 example is 77.8 cm high and measures again more than 30 cm in diameter. The form has a different handle section, that does not present a single dorsal groove as is the case in most of the Tarraconensis production, and seems to share this and some other typological features with the flat-bottomed amphora Oberaden 74. We have already suggested this connection in a recent paper[53], something that seems to be corroborated for the fabric characteristic of the example of La Longarina 2, similar to many Oberaden 74 produced in the area of Tarraco. Unfortunately, we do not know what kind of fabric the amphora of Sabadell has, but, even if there are kiln-sites producing ovoid forms in the area of Sabadell, it would not be surprising if this type was not a typical production of the Layetania, but from the area around Tarraco. As of yet, this type has not been found on any shipwreck.

The spindle-shaped Tarraconense 1B and 1E have marked peculiarities that make them different from the other types in some ways but similar to them in other ways. They achieved the tallest shape of all amphorae classified as Tarraconense 1, with similar diameters to the others. This ratio between height and diameter makes their bodies different from the other subtypes, even if some Tarraconense 1A appear to be similar. The rims and spikes show the biggest differences between both subtypes but also with the other group of forms. The Tarraconense 1B have a quite open mouth and a molded rim not taller than 4 cm but thicker in the upper part[54] that clearly resembles the mouth of the Baetican Dressel 7–11 of the Augustan and Tiberian periods, mainly the Dressel 9. Complete examples of Tarraconense 1B have been found on the Cala Bona 1 and Sud-Caveaux 1 shipwrecks. They vary from 94.5–98 cm in height, with a maximum diameter of 31–33 cm. Most have a large solid spike, which in some cases reaches 20 cm. On the Cala Bona 1 shipwreck, some complete Tarraconense 1E have also been found. This form is closest to Pascual 1 in its formal features, and both types appear together on the Cap Bear III shipwreck[55]. The study of complete pieces shows that they vary from 89–96 cm in height, with a maximum diameter of 30–33.5 cm. The spikes are 10–15 cm high and the rims 4–5.5 cm, with an almost vertical mouth that presents no or very minimal molding in the upper or lower part.

The chronology of this group's production extends from the mid-1st century B.C., possibly around 50–40 B.C., to some point before the change of era[56]. The presence of most variants on the same shipwrecks and their production in different areas and kiln sites prevents assigning different variants to specific localities or even workshops. However, the clay is, in most cases, similar to the productions of El Maresme area (mostly red or brown-red with large semi-rounded quartz inclusions together with golden mica), an observation that matches the main distribution of the currently known workshops, almost all of which are directly on or near the coast (fig. 14). Indeed, outside this area there are two workshops where the production of amphorae linked to the Tarraconense 1 group has been attested. The first is the Roman *villa* of La Salut (Sabadell) in the Vallès region. This was an important workshop that produced a large range of amphora types from

50 López – Martín 2008, 47.
51 López – Martín 2008, 47.
52 Contino et al. 2022.
53 Contino et al. 2022, 20.
54 López – Martín 2008, 47 fig. 5, 6–8.
55 Colls 1986.
56 López – Martín 2008, 50–54; Miró – Járrega 2019, 165 f.

the second quarter of the 1st century B.C.[57], among them Tarraconense 1A and probably 1D. The second workshop is Can Manyoses (Viladecans) in the Baix Llobregat, where only the elongated types Tarraconense 1B and 1E were produced. The production of these types, the closest to Pascual 1, at a workshop in an area closely linked to the Augustan colony of Barcino and thus dated to the last years of the 1st century B.C., seems indicative of the late chronology of production of Tarraconense 1B and 1E and their close relationship to Pascual 1.

Archaeometry has again provided important data regarding the production of this group in central and northern Catalonia[58]. Similar to the situation with Dressel 1, the Tarraconense 1 amphorae included two different production technologies that have been documented. In this case, however, they cannot be clearly linked to the existence of a pre-Roman and Roman technological tradition but rather to the experimentation of potters aiming to create new amphora types. Studies of the fabrics from two workshops, El Roser/El Mujal in Calella de Mar (Barcelona) in central Catalonia and El Collet de Sant Antoni in Calonge (Girona) in northern Catalonia, have pointed to the use of different clays within the Tarraconense 1 group and other productions, such as Pascual 1 and Oberaden 74. However, these different clays do not seem to correspond perfectly to different amphora forms or production phases, and the same clay could have been used for different forms at the same time. The use of different clays has direct consequences for the quality, the resistance, and the mechanical performance of the amphorae, as well as their adaptation to transport by sea.

The lack of homogeneity within the early provincial Tarraconensis production, along with the presence of multiple variants and also different clays and quantities of inclusions, contrasts with the predominance of production in one geographical area around Iluro/Mataró for most types and for the largest numbers of vessels. Nevertheless, this situation of regional clustering alongside formal heterogeneity is quite similar to the one observed for Baetican ovoid production and, we would add, for most of the Mediterranean ovoid amphorae[59].

Concerning capacity, L. Vila Socias has provided the only observation, placing it at ca. 25 liters[60]. Unfortunately, we are not aware of how many examples were included in this analysis or where they came from. We cannot, though, assume different volumes for the different variants since the largest variants seem to exhibit taller and massive spikes and, in some cases, narrower bodies. An accurate study of the capacities of most of the amphorae of the important shipwrecks of Cala Bona 1 and Illes Formigues 1, including the Baetican forms, will surely produce new and interesting data.

One special feature of this group, compared to other contemporary amphorae from the Iberian Peninsula, is the large amount of epigraphic evidence associated with them. We know of about 15 stamps[61], normally presented as *duo nomina* and located on the lip or sometimes on the neck[62]. These Latin names and the *duo nomina* indicate that they are free citizens; on just one occasion does the name appear to be associated with a slave. Most of these names must be originally from central and southern Italy; perhaps we are dealing with descendants of veterans or civilians who settled in Hispania and southern Gaul at the time of Caesar, who were controlling, overseeing, and organizing the territory in a new way. Some of the names appearing in the Tarraconense 1 stamps do seem to have connections with other regions, such as the *Loreii*, *Mevii*, and *Statii*, families that are also recorded in stone inscriptions at Narbo/Narbonne, a colony established in 45 B.C. with veterans of the *legio X*. This is a clear indication of the involvement of the elites of a Gallic city in the Tarraconensis wine business during the 1st century B.C., which from that point onward had its more important market on the Aude–Garonne axis.

57 Among others, Martínez 2014, 93–108; Miró – Járrega 2017/2018, 215 f.
58 Vila 2011, 587–591.
59 García et al. 2019, 408.
60 Vila 2009/2010, 171.
61 Berni – Miró 2013, 66 f.; Miró – Járrega 2019, 162–165.
62 Berni – Miró 2013, 66.

Contrary to this evidence, the *nomina* have also been interpreted as indicative of the progressive Latinization of the onomastics of the indigenous oligarchy, who would have been increasingly incorporated into the wine business as producers[63]. It has been suggested that the creation of Iluro, in addition to the organization and expansion of the culture of wine in its territory, also had the purpose of attracting an indigenous aristocracy – who were already in a process of adopting Roman cultural habits – to Roman social and economic structures; this seems to be the case, for example, with the aristocracy of the *oppidum* of Burriac (Cabrera de Mar)[64]. In this sense, the presence of a stamp in Salduie (Zaragoza) bearing an Iberian name/word (*eikebi*) written in the Iberian alphabet and dated to 50/40 B.C.[65] is indicative of the involvement of the pre-Roman population in this amphora production, at least in its earlier stages.

In a similar process of formal development as in other Hispanic areas, mainly the Guadalquivir Valley and the Atlantic coastal region of later Baetica, the Tarraconensis forms seem to have followed similar paths of distribution. As has already been mentioned, they were found together on shipwrecks with Baetican amphorae and also in some of the most important markets of the 1st century B.C.; this is the case for the amphorae from the context of La Longarina 2[66]. However, while waiting for clarification from future studies and contexts with amphorae of the 1st century B.C. in Rome and Ostia, we can observe that the distribution of the group of Tarraconensis ovoid amphorae seems to have followed more closely the paths established by Dressel 1, and these amphorae have been found in small quantities in the markets of the Gaulish provinces. Nevertheless, it is worth noting that even if their geographical distribution is similar, their consumers seem to be quite different from those of Dressel 1. The Italian wines in Dressel 1, as well as a small number of wines from northeast Hispania Citerior, were delivered during the late 2nd and first half of the 1st century B.C. to the pre-Roman population, mainly to the big *oppida* of central and eastern Gaul[67]. These populations seem to have consumed these wines in large quantities, and in many cases they were connected to ritual feasts or banquets[68]. From the Roman conquest onwards, we are faced with a new political situation and, progressively, with a new kind of consumer embedded in this provincial society. Although some Tarraconensis productions have been found in *oppida* of central and northern Gaul[69], their distribution seems to be mainly focused on the area of Narbonensis, probably due to the special connection that existed between the elites of that province – above all the elites of the Colonia Narbo Martius – and the wine producers in northeastern Spain. The new consumers would progressively demand not the huge quantities of Italian wines but new products of the Roman Mediterranean, putting the Tarraconensis wines in the best position to supply them.

Lastly, the Tarraconense 1 amphora seems generally to have been an experimental container, fashioned as though its manufacturers were experimenting and modifying it according to the function for which it was intended. They never achieved a high standardization level and were constantly developing new types that sometimes traveled together, as the amphorae on the Cala Bona wreck clearly indicate[70]. This process is quite similar to the well-studied case of Hispania Ulterior, where some types did achieve success and developed into new forms in the Imperial period, but most types seemed to have left no traces in later production[71].

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63 Olesti 1996/1997, 438 f.
64 García et al. 2000, 51.
65 Berni – Miró 2013, 66.
66 Contino et al. 2022.
67 Poux 2004; Olmer 2013.
68 Poux 2004.
69 González 2019.
70 Miró – Járrega 2019, 169.
71 García et al. 2011; García et al. 2019.

A First Commercial Success: the Pascual 1

In the third quarter of the 1st century B.C., probably around 40–30 B.C.[72], some workshops in central Catalonia started to produce a new type of amphora, Pascual 1[73]. With close formal similarities to the spindled-shape group of Tarraconensis 1, the new type was produced and distributed in massive quantities from the last quarter of the 1st century B.C., achieving its peak during the Augustan and Tiberian periods.

The production of Pascual 1 is documented at a large number of workshops all around present-day Catalonia, and it was also imitated in other areas of Hispania Tarraconensis, such as Ibiza[74]. Furthermore, Pascual 1 was copied in the Gaulish provinces already in the Augustan period, and in the central and western regions of Gaul it seems to have developed on its own during the Flavian period[75]. This latter date is important with respect to the end of Pascual 1 production. We are of the opinion that the form did not extend beyond the first third of the 1st century A.D. in the Tarraconensis workshops, at least in the workshops of Layetania where conclusive evidence for its production after this date does not exist, but we must admit that we cannot exclude a residual or simply sporadic production of Pascual 1 at that time.

Focusing on the Augustan and early Tiberian periods in the central Catalan area, this type has been documented in at least 37 workshops (fig. 14)[76]. Even if it has been found throughout the Catalan region, produced from the Ebro Valley to the area around Emporion/Ampurias, there seems to have been an important concentration of Pascual 1 production around the Roman towns of Iluro and especially Baetulo, where it seems to have been produced earlier than in other places. This is connected to the chronology of the Roman occupation of northeastern Spain and the development of the wine industry in the area, especially for these two settlements during the 1st century B.C. The type's production in the workshops near the Llobregat River, directly linked with the foundation of the Roman colony of Barcino (15–9 B.C.), seems also to have been important in the earlier phases of those workshops.

The distribution of Pascual 1 followed the established paths of Tarraconensis 1 and was directed towards the south and west of Gaul, with a secondary route to central Italy, mainly the city of Rome. However, along with its production in the Catalan regions, it achieved a much wider geographical reach than the previous types produced in the region, and from Rome it continued to be trans-shipped in very small quantities to certain sites of consumption in the eastern Mediterranean[77], as it did also from the south of France to the Rhône–Rhine axis, arriving at civilian and military consumption places[78] or jumping from western Gaul to Britain[79]. Despite this larger geographical distribution, undoubtedly the most important consumer market for Pascual 1 was the Aude–Garonne axis (from Narbonne to the mouth of the Garonne and from there to Bretagne), where its numbers and percentages in local contexts, especially in Narbonne, were never matched by another production from Tarraconensis.

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72 Other authors are of the opinion that the Pascual 1 was already produced a decade earlier: López – Martín 2008. In our opinion the stratigraphic sequences of the production workshops are unclear.

73 The name comes from the Spanish researcher Richard Pascual i Guasch, who first distinguished the type from the Dressel 1 and other productions.

74 Ramon 2008, 263–266.

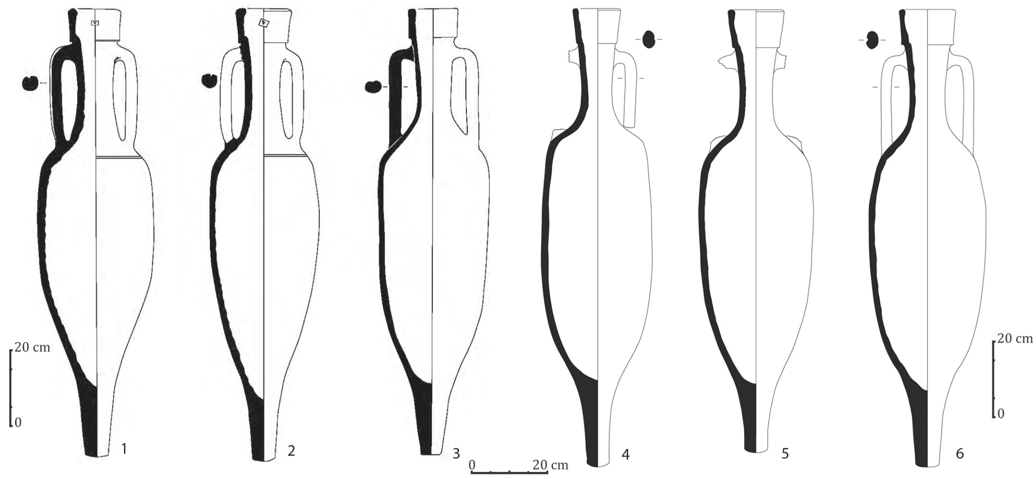
75 Barthélemy-Sylvand et al. 2005; Laubenheimer et al. 2005; Most of the Pascual 1 identified in Flavian or late 1st cent. A.D. contexts in central and western France must, in fact, correspond to local or regional productions and not be linked with the import of wines from Tarraconensis.

76 Fig. 14. See also López – Martín 2008; Martínez 2014.

77 Pascual 1 have been documented in the Aegean in places such as Ephesos, Corinth, and Kenchreai, or the Athenian Agora.

78 Lyon area: Desbat – Martin-Kilcher 1989; Laubenheimer 2015, 185 f. Military settlements in Germania: González 2015.

79 Remesal – Revilla 1991.



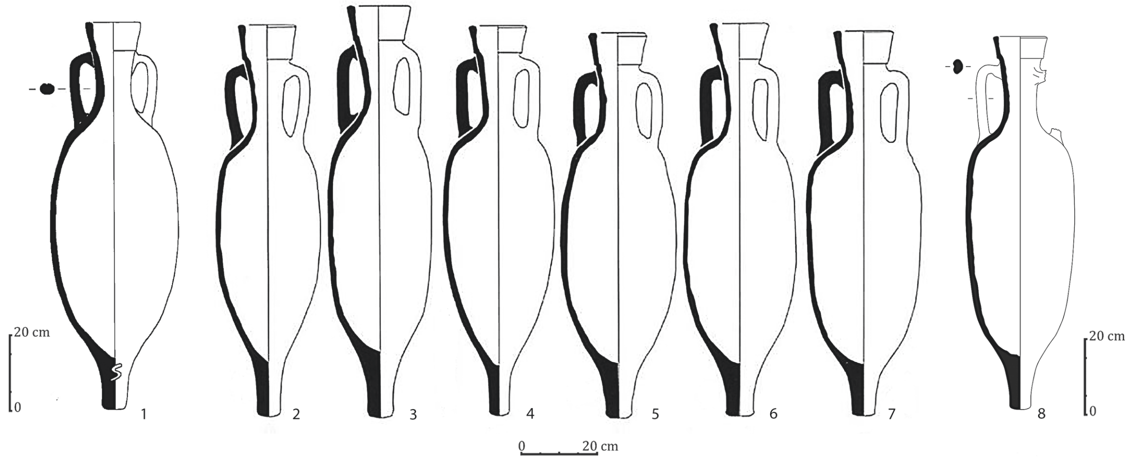
5 Pascual 1A (© by the authors): 1–2 Els Ullastres 1 shipwreck (after López – Martín 2008, fig. 8, 2–3); 3 Lyon (after López – Martín 2008, fig. 8, 4); 4–6 Aiguablava shipwreck (from: Geli 2020, fig. 7)

In Narbonne, Pascual 1 have been documented in huge quantities at both the harbor and the city[80]. In our opinion, this is significant because it highlights the importance of Narbonne as both a place of consumption and a redistribution hub, in this case mainly to the Aude–Garonne axis but also along the route of the Loire and Seine axes[81]. Furthermore, in the epigraphic record of Narbo Martius and in the stamps on Pascual 1, the link between the elites of Narbonne and the wine producers in Tarraconensis can be clearly seen, as was the case also for the Tarraconensis 1.

We will deal with this important subject in the following paragraphs, but now we should return to the topic of formal and volumetric standardization of Pascual 1. The huge quantities produced and exported are by themselves manifestation of a kind of standardization. A. López Mullor and A. Martín Menéndez divided the Pascual 1 into two variants, A and B[82]; however, they could not link either of them to a specific chronology or determine a geographical area of production[83]. In our opinion, this division is appropriate, and even if some examples seem not to belong to either of the subtypes, most of the Pascual 1 produced in Layetania can be included in either type A or B.

The data published by López Mullor and Martín Menéndez allow for the formal subdivision and the attribution of spikes and fragments of rims or semi-complete amphorae to one of these types. Despite the massive production and distribution, though, one important problem when studying the formal features of Pascual 1 remains the relatively small number of complete pieces, taking into account the large numbers of finds in the production and consumption contexts and comparing these with the numbers of complete examples of other Tarraconensis amphora types. In contrast to the Tarraconensis 1 and Dressel 3-2, the reason for the lack of large numbers of complete examples is the relatively few shipwrecks with cargos of Pascual 1[84]. However, in recent years, additional data from underwater contexts have shed new light on this issue. Currently, the best example of a homogeneous cargo of Pascual 1 is the shipwreck of Aiguablava (Begur, Girona), dated around 40–30 B.C. and with a minimum number of 78 Pascual 1[85]. The amphorae of the Aiguablava shipwreck belong to form Pascual 1A (fig. 5) except for one example that could

80 Sanchez 2009; Sanchez 2015.
81 For these routes of Tarraconensis wine, see mainly the new and accurate data of Laubenheimer 2015.
82 Form A is a larger, thinner, and vertical mouth version. Form B is a smaller, slightly ovoid-shaped, and more open-mouth version.
83 López– Martín 2008, 55–64.
84 Els Ullastres; Cap del Volt; We are not really convinced that Port-Vendres 4 is a real shipwreck nor that the heterogeneous cargo linked with it was part of a single ship. The provenance of some Pascual 1 from the Llobregat region, in our opinion, refutes the supposed chronology of the wreck, dated to 40–30 B.C.
85 Geli 2020. We would like to thank our colleague R. Geli, who is working on a doctoral study of the shipwrecks with Pascual 1, for this information.



6 Pascual 1B (© by the authors): 1 Cala Cativa 1 shipwreck (López – Martín 2008, fig. 9, 4); 2–7 Antran grave (from Laubenheimer – Martínez 2015, fig. 4); 8 Aiguablava shipwreck (from: Geli 2020, fig. 7)

be included in form 1B. This amphora has different formal characteristics and also a different shape. Furthermore, from the complete amphorae analyzed by R. Geli, it seems to have a better ratio between volume capacity and weight of the vessel itself[86]. The CV (coefficient of variation) value for the empty weights of the Pascual 1A amphorae from this shipwreck is 3.2 %, rather good for pre-industrial production; the CV related to capacities for these same jars is higher, at 9.0 %, representing a somewhat lower standardization level that seems quite normal for the Tarraconensis production[87].

Together with this shipwreck, other contexts with complete Pascual 1 present closed chronologies in Germany and especially in Gaul[88]. Among them, the rich material from the aristocratic tomb of Antran in central Gaul deserves particular attention[89]. Dated around A.D. 15, the tomb produced seven complete Pascual 1. They were analyzed in detail, with attention to their epigraphic remains, fabric composition, formal features and measurements, as well as estimated capacities. Even if the method used to obtain the capacities is not mentioned, the context reveals a lack of homogeneity, especially regarding certain measures. F. Laubenheimer and V. Martínez Ferreras saw in these features a lack of standardization and even wondered themselves whether the Catalan potters attempted to standardize this production[90]. In our opinion, although they exhibit some differences, there still exists a certain standardization in these containers – at least in the rims, handles, and general forms – that is reflected in the CV values calculated from the height and maximal diameter of the six vessels[91], such that we would put them together in group 1B of López Mullor and Martín Menéndez (fig. 6). Concerning the capacities of the Antran amphorae, it is surprising that the shortest one (ANT003) is the one with the largest capacity,

[86] Geli 2020, 66 f.

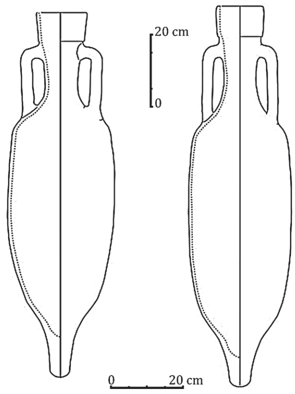
[87] This data reflect the common discrepancy between volumetric and formal standardization. Unfortunately, the heights and maximum diameters of the Aiguablava shipwreck amphorae are not published in Geli 2020. This data would have been quite interesting because it is normally in those linear dimensions where a highest standardization seems to have been achieved more generally in amphora production. We would like to thank J. Leidwanger for his help in calculating the CV values presented in this article. For CV values and their respective correlation with large, small, and very small scales of production, see Roux 2003.

[88] Germany: Tremmel 2009; Martin-Kilcher et al. 2009; Gaul: Laubenheimer – Martínez 2015; Narbonne: Sanchez 2009; Sanchez 2015; Lyon: Becker et al. 1986; Arlaud et al. 1998; Ostia: Hesnard 1980.

[89] Laubenheimer – Martínez 2015.

[90] Laubenheimer – Martínez 2015, 194: »On peut se demander si la standardisation était une préoccupation des poitiers Catalans.«

[91] The capacities of these Pascual 1B and the one from Aiguablava shipwreck give a somewhat higher CV of 11.4 %, though this contrasts with the CVs for maximum diameter (4.1 %) and especially for height (2.4 %). More research must be done, but the data already reflects the discrepancy between volumetric and formal standardization.



7 Pascual 1 from Malard (Narbonne) (after: Sanchez 2015, fig. 11)

reaching 29 liters, seemingly because it has a wider maximum diameter (30.6 cm); the tallest one (ANT004), though, is the second largest, with slightly less capacity probably because of the long spike and narrower diameter (28 cm). The archaeometric analysis of these amphorae, together with the epigraphic evidence on three of them, point to an origin in the region of Baetulo/Badalona, probably in different workshops; those with known stamps – and maybe also others – must have been produced in the workshop of Illa Pradera[92].

One important context with a large quantity of complete or almost complete Pascual 1 is the site of Malard in Narbonne. The drawings of two examples presented by C. Sanchez seem to show different sizes and different formal features in the rim, spike, and body, and they could be assigned to the subtypes 1B and 1A[93] (fig. 7). However, the spike and body do not correspond exactly to the proposed association of large spindle-shaped bodies/large spikes and short oval bodies/short spikes, and we may be dealing with examples exhibiting mixed features from both types A and B. This context has been dated, based on the amphora evidence, to the very end of the 1st century B.C. or the beginning of the 1st century A.D.[94]. The amphorae were used for elevation of the area for drainage and thus were selected with this goal in mind, as most of them presented an elongated shape. Furthermore, the different amphorae need not be exactly contemporaneous; they could have been chosen from among those stocked in the harbor as presenting a better shape/form with the aim of creating this drainage. The archaeometric analysis of several Pascual 1 from Malard point to the existence of a large variety of workshops, most of them in the central Catalan area but some not yet identified[95]. The epigraphy on those Pascual 1 is quite rare, but some of the stamps point to the Maresme region.

From a formal point of view, we suggest a development of Pascual 1 from Tarraconense 1, even if the influence of Dressel 1 must also be considered. This connection has already been pointed out by many scholars, such as R. Geli, when analyzing the amphorae of the Aiguablava shipwreck. In this case, Geli highlights the formal link of Pascual 1A with Tarraconensis 1 and suggests that it could be the earlier of the two variants, even if both were produced contemporaneously over a large time span and were found together in the Aiguablava shipwreck[96]. This hypothesis is not to be disregarded, and the Pascual 1 from the Antran grave, dated around a half-century later than the shipwreck, must be included in the 1B group. Nevertheless, in our opinion, we are dealing with two linear evolutions that are, most of the time, interlocked. Pascual 1A comes from the spindle-shaped group of Tarraconense 1, particularly Tarraconense 1E, while Pascual 1B comes from the ovoid-shaped group, especially Tarraconensis 1C.

As with Tarraconensis 1, the largest variant of Pascual 1 (1A) normally bears a larger spike, while the shortest variant has a much smaller spike. This suggests that both variants should have carried a similar volume of wine, something that seems to be more or less confirmed from the comparison of the Pascual 1A of the shipwreck of Aiguablava with the Pascual 1B from the grave of Antran, the latter being slightly larger. In case of Aiguablava, the volume of the Pascual 1A varies from 19.4 to 25.4 liters, with most of them around 21 to less than 24 liters[97], while the seven amphorae from Antran vary from 21.6 to 29 liters[98]. Curiously, the 1B, with a shorter body but

92 Laubenheimer – Martínez 2015, 201.
93 Fig. 7. Sanchez 2015, fig. 11, 1. 2.
94 Sanchez 2009, 306.
95 Martínez 2011/2012.
96 Geli 2020, 67.
97 Geli 2020, 58.
98 Laubenheimer – Martínez 2015, 196.

larger diameter and shorter spike, is the one that seems to have a slightly bigger capacity. This might imply a better ratio between weight of the vessel and weight of the contents, as seems to be the case for the only Pascual 1B found in the Aiguablava shipwreck, but more analysis must be done in order to test this idea.

Concerning the production locations, unfortunately there is still a lack of complete or almost complete published pieces, even though we know of some examples in the area of Baetulo and the Llobregat River. We hope to count on future drawings of complete pieces from more kiln sites in order to link specific formal characteristics with fabric characteristics. In this sense, the archaeometric work developed in the last decade by V. Martínez Ferreras has supported an important compilation that enables the attribution to specific geographical areas or even workshops, even in the absence of epigraphic evidence.

Concerning epigraphy, Pascual 1 is again rich in stamps. Some of the earliest are also documented on Tarraconense 1 and highlight the continuity of production processes under the same families[99]. However, with Pascual 1, we see a real boom in the habit of stamping, the result of a more specialized industry supported by a well-established market in south Gaul. Together with the continuity of some epigraphic series, some new owners appear, belonging to the upper classes of Roman society, as for instance *Cn. Cornelius Lentulus Augur*, consul in 14 B.C. Nevertheless, the most suggestive case is that of the *Caii Iulii* of the Augustan period. We have interpreted this group of stamps as belonging to freedmen of Augustus who were acting as managers of his estates in Hispania and probably also in south Gaul. In the Layetanian area, they were closely connected with the foundation of Barcino/Barcelona[100]. The large number of *Iulii* appearing on Pascual 1 stamps in Catalonia and Narbonensis[101] seems to support this possibility.

On Pascual 1 are recorded Roman citizens, freedmen, and slaves – that is, the three economic and social strata of Roman society – which are represented in many different ways in the amphora epigraphy (*duo nomina, tria nomina*, and *cognomina*). A large number of free persons appear in *duo nomina* and, to a lesser extent, just with the demonym. However, more freedmen gradually appear, mainly through *duo* but also through *tria nomina*, and in the last phases, the number of slaves increases significantly, represented just by a *cognomen* that can be referred to by a complete or almost complete name, by three or four letters, or just by one or two letters. One important feature of the late Pascual 1 production is the association of two stamps on a vessel. They represent different hierarchies within the workshops or general production, with pairs of individuals of the same or different social strata[102]. The complexity achieved by the stamp habit on the Pascual 1 is clear evidence of the growth of the wine economy, based on the exportation and the involvement of powerful families in this important business.

CONSOLIDATION OF PRODUCTION = CONSOLIDATION OF MARKETS?

The data from Gaul indicate the arrival, from the first part of the 1st century B.C., of commodities of the central Catalan coastal region packed in Dressel 1. These amphorae seem to have entered into the commercial flow of Italian wine in Gaul and probably arrived with greater abundance during the period immediately prior to the Roman conquest of Gaul, when they were consumed by the Celtic population. The amphorae of the ovoid group, especially Tarraconensis 1, seem to have already been produced in larger quantities in the central Catalan workshops and entered the Roman consumer markets of south and western Gaul in larger (if still limited) quantities. They are the first provincial repertoire, but their lack of standardization can be seen in their many different formal variants. A step further was the production of Pascual 1 from around 40–30 B.C.;

99 Berni – Miró 2013, 68.
100 For this hypothesis see, Berni – Miró 2020, 154.
101 *C. Iulius Anicetus*, *Iulius Papus*, *C. Iulius Theophilus*, *Iulius Ruf[us (?)]*, *C. Iulius Anteros.*
102 Berni – Miró 2013, 70 f.

this form reached its production peak during the Augustan and Tiberian periods, when it is found in large quantities in south and west Gaul and achieved a certain degree of formal and volumetric standardization.

Even if Pascual 1 was distributed in great numbers in the last decades B.C. and first decades A.D., a new type of amphora started to be produced in massive quantities in our region in the last years prior to the B.C.–A.D. divide: Dressel 3-2. The production of this form would change the commercial paths followed by Tarraconensian wines for almost a century. The new amphora production was based on emulating external models, namely Italian Dressel 3. Nevertheless, for some decades, Dressel 3 and Pascual 1 were produced together in the region, and even in the same workshops[103], but rarely shared the same primary consumer markets. This interesting observation suggests a junction between old and new economic and commercial interests. It shows an opportunistic vision for the possibilities of expanding economic activity while ›conquering‹ the demand of other markets, but also an extensive knowledge of the gradual drop in demand that was starting to take place in southern Gaul, linked to the progressive growth of the wine economy in Narbonensis.

It is quite possible that the elites of Narbonne continued to be involved in the production and commerce of Tarraconensis wine but started to share this economic activity with new groups that came probably from central Italy and played an important role in the creation of the colony of Barcino. As we will see in the next section, the epigraphic record is revealing in this respect.

Changing the Paradigm: the Dressel 3-2

With Dressel 3-2 we reach the zenith of the commerce in Tarraconensis wine. In the last few years, P. Berni has called into question the traditional nomenclature of ›Dressel 2–4 Tarraconensis‹ and proposed ›Dressel 3-2 Tarraconensis‹ instead. This is not the place to explain the reasoning that led to this change in a well-established yet often criticized classification, but it is important to note that it arose from a detailed study of the formal, epigraphic, and chronological features of examples from a large variety of contexts of very different natures, which included production workshops, consumption sites, and shipwrecks along the main trade routes[104].

The beginning of this production seems to start around 15–5 B.C. and is closely connected to the foundation of Barcino (15–9 B.C.), a new colony that would immediately become the most important settlement of the central Catalan area and ancient Layetania[105]. The foundation of a new colony implied an in-depth reorganization and administration of the territory that seems to have been divided into lots, following the well-known system of centuriation[106]. The territory of the new colony was organized for massive-scale wine production and its various subsidiary industries. Under this scheme, certain suburban areas played an essential role, especially the area around the ancient Rubricatus River (now Llobregat) some kilometers south of Barcino (fig. 8), which seems to have been navigable for the last 10–15 km before its mouth. In the lower valley of the Llobregat, an impressive industrial area with several workshops was established in the final years before the turn of the century, producing initially Pascual 1 together with minor quantities of Dressel 3. This situation changed from the late Augustan period or early years of Tiberius' reign, when Dressel 3 was now the main product of the Llobregat workshops[107].

The Llobregat and other suburban areas around Barcino are the most important industries so far documented from late Augustan and Julio-Claudian times, but they were not the only ones that produced amphorae in central Catalonia. The important industries of ovoid and Pascual 1

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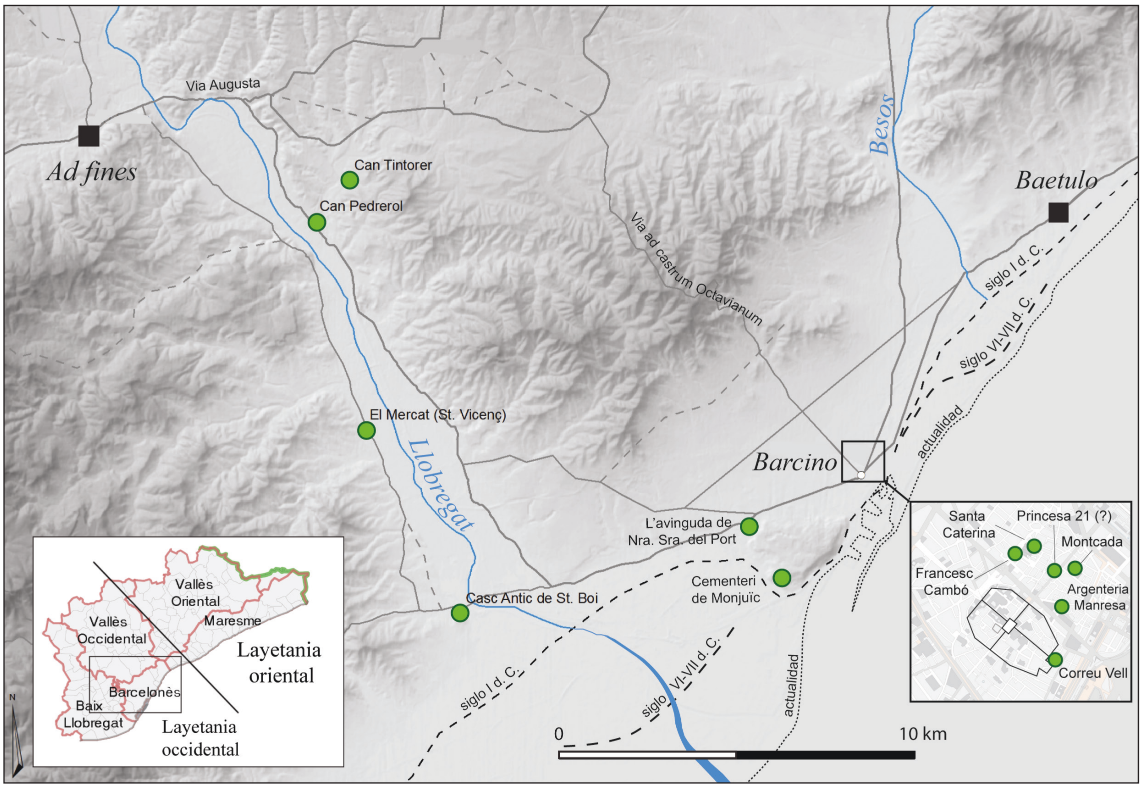
[103] Among others: López – Martín 2008, 73.
[104] For all these questions: Berni 2015; Berni 2019.
[105] Miró 2020.
[106] Palet 1997, 185.
[107] Berni 2015; Berni 2019. This is evidenced by large quantities of these amphorae in the shipwrecks analyzed by Corsi-Scialliano – Liou 1985.



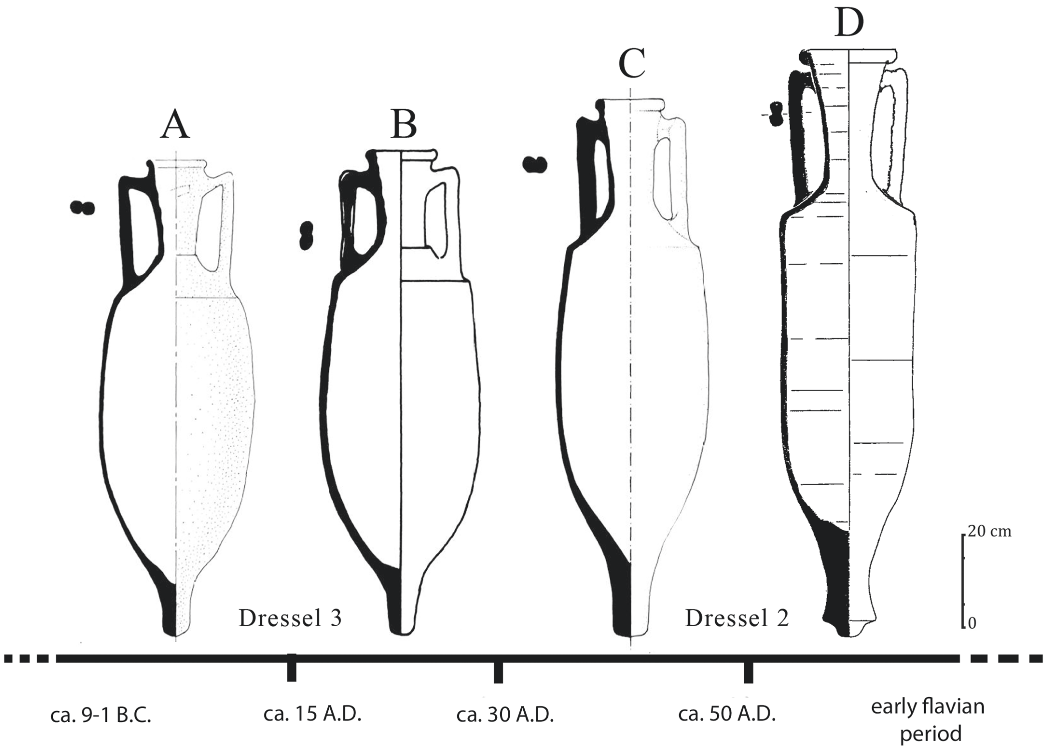
8 Map of western Layetania (© I. Tobar and authors)

amphorae around Baetulo/Badalona, and especially in the area of Iluro/Mataró, continued producing vessels, even if not to the same extent as they did before. The dynamics of production were transformed significantly due to the foundation of Barcino, and from then on, the former Layetania can be divided into two main productive areas, western and eastern Layetania[108], with significant typological and chronological differentiations between them. To explain this complex economic trajectory, it is essential to look again at the amphorae, their formal characteristics, and their level of standardization.

As has already been mentioned, the first Dressel 3-2 from Catalonia were produced in the last years of the penultimate or the final decade before the B.C.–A.D. divide. These first vessels were ›imitating‹ Dressel 3 produced in central Italy at that time, but in the earliest documented examples, it seems that they also borrow some formal features of Pascual 1, which was at its peak during the final years of the 1st century B.C.[109]. The seemingly earliest finds of Dressel 3-2 in consumer markets coincide still with the commercial paths followed by Pascual 1[110]. Nevertheless, this situation changed quite quickly, and soon after its initial production, Dressel 3-2 acquired unique and distinctive formal features and started to follow different export paths.

Before continuing our inquiry into this continuously evolving dynamic, it must be clarified that when referring to Dressel 3-2, we are not dealing with a single amphora but rather two different chronological variants. This implies that one developed from the other. The Dressel 3 is the earliest variant, but in a process spanning around 30–40 years, it developed into Dressel 2. According to this theory, it would be most convenient to divide the type not using different numbers but rather using the more logical letter designation, distinguishing between variants A and B. However, this would have created confusion and would not have taken into consideration that

108 Berni 2019; Berni – Miró 2020.
109 Berni 2015, 198 f.
110 López – Martín 2008, 72 f.



A Early Dressel 3	B Classic Dressel 3	C Classic Dressel 2	D Late Dressel 2
Height: 70 - 97,5 cm. Maximal diameter: 29-36 cm. Capacity: 22,9 - 33,5 Lt. Weight of empty vessel: 13 - 19,6 Kg. Ratio Cap/Weigh: 1,53 - 2,19		Height: 97,5 - 107,5 cm. Maximal diameter: 28-33 cm. Capacity: 23 - 30 Lt. Weight of empty vessel: 15 - 20 Kg. Ratio Cap/Weigh: 1,35 - 2	

9 Dressel 3–2. Proposal of evolution from early Dressel 3 to late Dressel 2 (© authors, after: Berni 2015, fig. 8)

already in the 19th century, H. Dressel presented both forms in his amphora chart. For this reason we chose to call the type Dressel 3-2 but consider it a single form with two chronological variants: Dressel 3 of the Augustan and Tiberian periods, and Dressel 2 of the late Tiberian and Flavian periods (fig. 9). Furthermore, this chronological division seems also to have carried geographical and possibly also qualitative distinctions. In recent years, the evolution of the form has been studied from the Augustan era to the Flavian period[111]. The existence of many well-dated shipwrecks with cargos of Dressel 3-2 has enabled a deeper analysis of this form, leading to a further subdivision. Even if more studies must be undertaken in order to support this subdivision, which is at present well defined by the form and size of the spikes[112], it seems useful to facilitate a better understanding of the chronological development of the form. Hence, subvariants A and B are included within Dressel 3, while C and D belong to Dressel 2.

The Tarraconensis Dressel 3 (fig. 10) rapidly acquired its own formal characteristics that differentiated it from the Italian Dressel 3. The division between A and B is chronological, with the latest variant acquiring a longer spike, a more cylindrical neck, a broader mouth, and a bigger and rounder rim. The production of Dressel 3 in a large number of workshops before the turn of the century suggests that a high standardization level was achieved almost from the beginning, even if some small differences can be observed. In general, Dressel 3 has a height that varies between 70 and 97 cm, with the earlier versions being generally smaller. Their maximum diameter ranges

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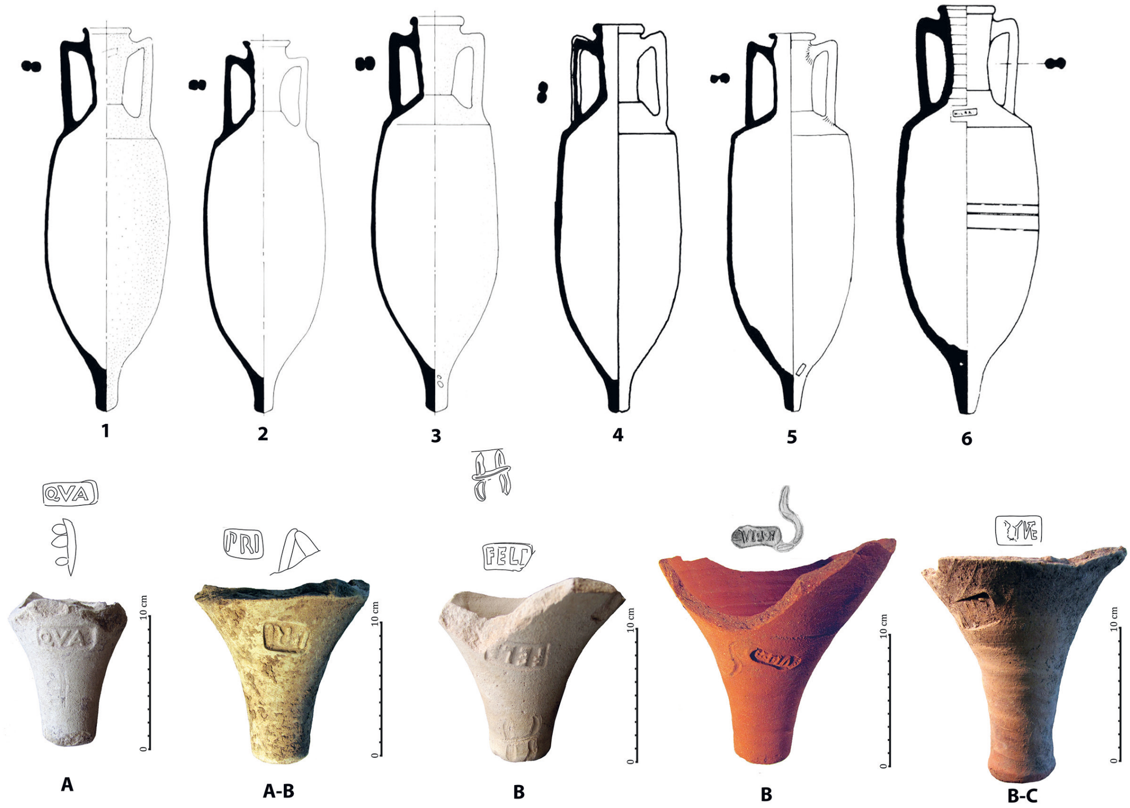
111 Berni 2015; Berni 2019; Berni – Miró 2020.
112 Cf. fig. 10 with fig. 11; see Berni 2019.



10 Complete Dressel 3 from different shipwrecks. 1: Planier 1; 2: Sud-Lavezzi 3; 3: Dramont B; 4: Chrétienne H; 5: Perduto 1; 6: Diano Marina; Dressel 3 toes from different kiln-sites in central Catalonia (Sant Boi; Sant Vicent; Malgrat) (© authors, after: Berni 2015, figs. 5. 6)

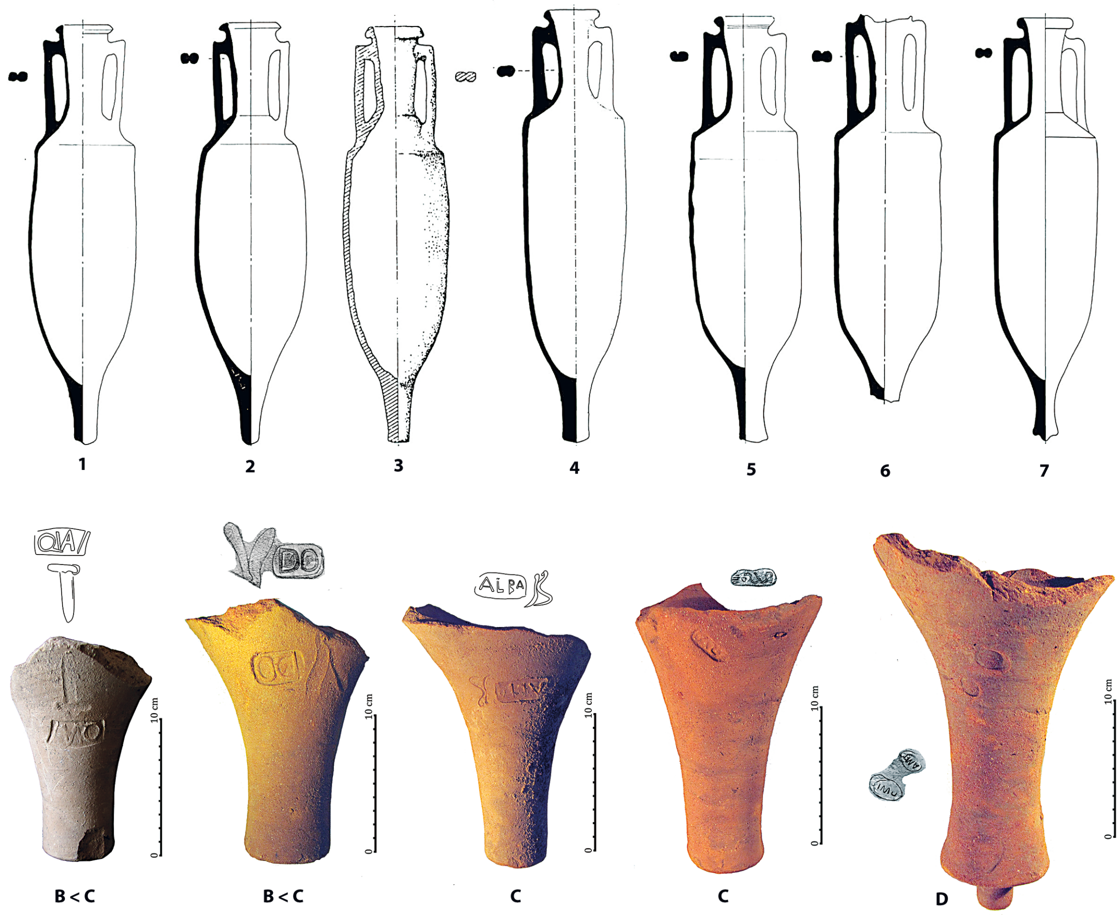
from 28 to 36 cm, among which the earlier production is generally wider. Their weight seems to vary between 13 and 19.6 kg and their capacity between 22.9 and 33.5 liters. This gives us a ratio between the weight of the vessel and its capacity that ranges from 1.53 up to 2.19. A large number of Dressel 3 from different shipwrecks give CV values of 4.9 % for height and 4.4 % for maximum diameter, but these increase to 13.4 % for the weight of the empty amphora and 9.2 % for the capacity[113].

Dressel 2 developed from the latest versions of Dressel 3 around 30 A.D. In general, it is taller and slenderer, with an almost cylindrical body in the latest variants (D), and with a broader rim and much longer spike (fig. 11). Its weight seems to vary between 15 and 20 kg, the height between 97 and 107 cm, the maximum diameter between 28 and 33 cm, and the capacity between 23 and 30 liters. The ratio between the weight of the vessel and its capacity ranges from 1.35 up to 2. Some Dressel 2 from different shipwrecks published give CV values of 2.5 % for height, 4.2 % for maximum diameter, 7.9 % for the empty weight and 6.9 % for the capacity[114].

From these general measurements, two observations can be made. The first is that the metrological and volumetric variation is narrower in the Dressel 2 than in the Dressel 3. This may indicate that production of the form achieved an increased level of standardization during the

[113] Corsi-Sciallano – Liou 1985. These shipwrecks include: Planier 1, Sud-Lavezzi 3, Dramont B, Chrétienne H, Perduto 1 and Diano Marina.

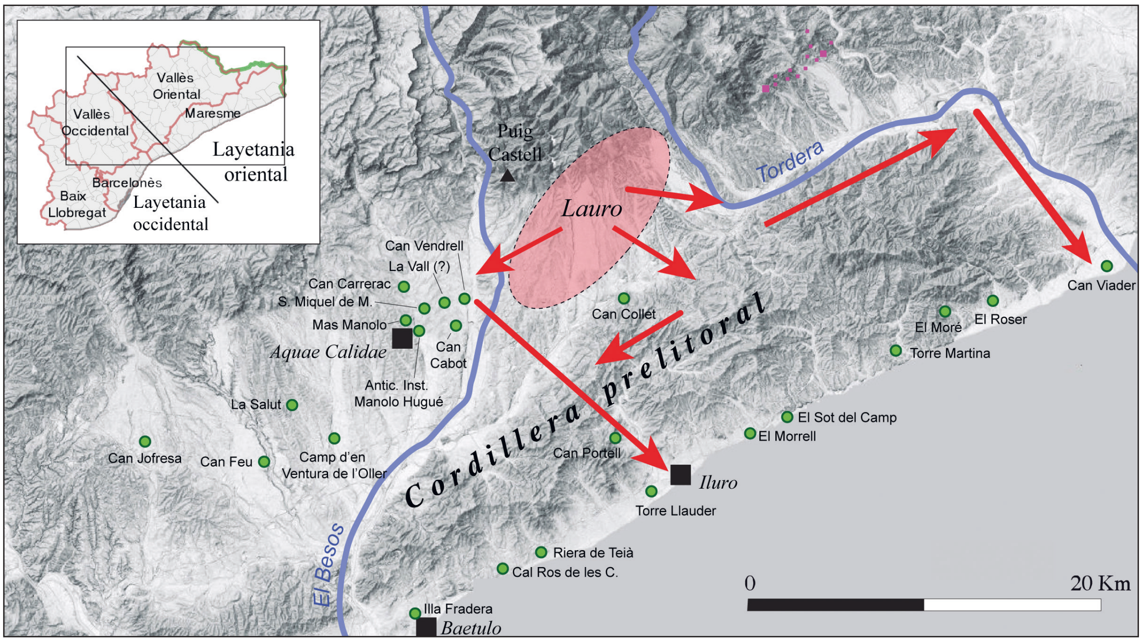
[114] Corsi-Sciallano – Liou 1985. These shipwrecks include, among others: Grand-Rouveau, Les Fourmigues, Cavallo 1, Petit Conglué, and Est-Perdutto. The CVs for weight and capacity have been calculated with a smaller number of amphorae than for the height and maximum diameter figures, but the contrast between a lower volumetric and height standardization and a higher formal and linear standardization is quite clear. See also infra, chap. 1.



11 Complete Dressel 2 from different shipwrecks. 1: Petit-Conglué; 2: Formigue; 3: Barà; 4: Grand-Rouveau; 5: Cavallo 1; 6: Est-Perduto; 7: Cala Vellana; Dressel 2 toes from different kiln-sites in central Catalonia (Sant Boi; Sant Vicent; Malgrat) (© authors, after: Berni 2019, fig. 7)

Julio-Claudian and early Flavian periods. However, this higher degree of standardization does not imply a better ratio between the weight of the empty vessel and the transport capacity in liters. In other words, it does not mean an increase in the economic ›efficiency‹ of the individual vessel; on the contrary, the Dressel 2 carried a similar quantity of wine, but the containers themselves were heavier. To explain this apparent process of standardization toward a less obviously economically ›efficient‹ vessel, we should pose other questions related to the geography of production and the quality of the transported product.

While the area immediately around Barcino, especially on the Llobregat River, was the most important production area for the variant Dressel 3, Dressel 2 was particularly intensively produced in eastern Layetania, chiefly in the workshops documented between the Besos and Tordera Rivers (fig. 12). This area includes the current Catalan county of Maresme and also the inland areas of Vallès Oriental and Vallès Occidental. The inclusion of inland areas in this production in eastern Layetania, even if attached or proximal to the main river valleys, represents an important change from the previous production of Pascual 1, which was mainly concentrated around the coastal settlements of Baetulo and Iluro. In our opinion, this shift is closely connected to the emergence or increase in production of a special wine variety, the so-called *Lauronensis* wine. This name seems to have been used as a kind of designation of origin by ancient authors, who refer to it as a high-quality wine. The production region must have been in the central area of the Vallès Oriental county, where the ancient Iberian city of Lauro was located, probably around present-day



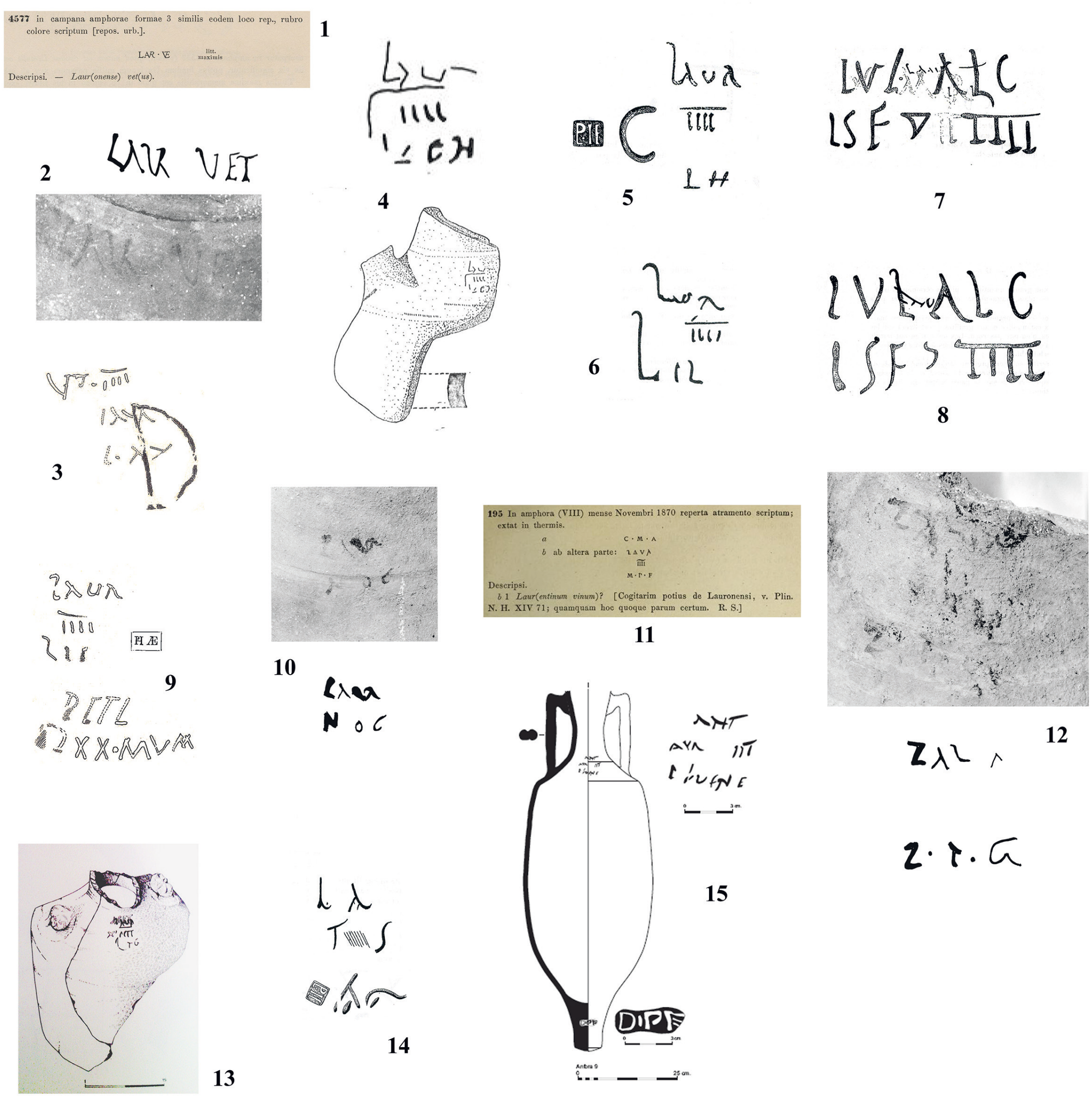
12 Map of eastern Layetania, with the Lauro area and the export routes of this prized wine (© Iván Tobar and authors)

Llerona (Les Franqueses del Vallès, Barcelona). According to Pliny (nat. 14, 71), the wine from Lauro was of high quality, and it is quite possible that its production started to spread to other neighboring areas, especially on the western side of the Besos River around Aqua Calidae/Caldes de Montbui, where a large number of *villae* with pottery workshops have been found. The Lauro wine was distributed from the main harbors of the region, probably from Iluro, but it is also possible that other minor ports at the mouth of El Besos and even the Tordera Rivers also participated in this distribution. The role played by Baetulo and especially Barcino, just some 30 km south of Iluro, is not known, but it seems likely that they were also used for transferring this wine.

The epigraphy has played an essential role in our knowledge about the *Lauronensis* wine and its association with the production of Dressel 2 in eastern Layetania. In a recent article, we have listed a large number of ink inscriptions mentioning this wine and generally the years aged (fig. 13). Most of these have been found in central Italy (Rome, Ostia, and Pompeii), in Carthage, and on some shipwrecks in Narbonne and Bonifacio. Visual analysis of the fabric of the containers bearing ink inscriptions, and especially the combination of the latter with stamps known from kiln sites of the region, has identified the role played by eastern Layetania in the production of high-quality wine and its distribution to central Mediterranean markets during the second and third quarters of the 1st century A.D. Furthermore, the ink inscriptions on Dressel 2 of eastern Layetania have revealed the delivery of other wines from the region, like the *Aminneum*, a high-quality vintage originally from Italy and also mentioned in inscriptions on amphorae produced in south Gaul[115].

Despite this evidence, we cannot assume that all Dressel 2 produced in Layetania were used for the transport of high-quality wines, not even all those produced in eastern Layetania. In this sense, Martial (Mart. 1, 26; 7, 53, 6; 13, 118) also refers to the low quality and disgusting taste of the wines from Layetania consumed in Rome during the Neronian or early Flavian period. These wines surely traveled in Dressel 3-2 amphorae, but it is possible that other containers were also used, especially the large *dolia* documented together with Italian and Layetanian Dressel 3-2 on

[115] Laubenheimer 1985, 447–450; Desbat et al. 1987, 142–146; Liou 1987, 71–74.



13 Inscriptions on amphorae mentioning *Lauronensis* wine (© by the authors)

several shipwrecks of the period[116]. A possible option is that these ships were transporting a low-quality bulk product in the *dolia*, of which some reached volumes of more than 1,000 liters, while the more expensive wine travelled in the amphorae.

Based on this combination of literary and epigraphic sources with archaeological evidence, the indications clearly suggest that during most of the 1st century A.D., the region was a massive producer of wines. There likely existed different qualities for different consumers and different markets, from the cheapest ones probably transported to local markets in wine skins, possibly barrels and similar containers, or to Italy in large *dolia* and eventually in amphorae, to the most appreciated *Lauronensis* and *Aminneum*, whose clearest archaeological evidence is the production of Dressel 3-2, a highly standardized vessel adapted to the new commercial situation and rooted in an extensive knowledge of the consumer markets and economic dynamics of the wine. Surprisingly, this substantial knowledge and mastery of the economic situation did not coincide with the development of a container with a more advantageous ratio between the weight of the vessel and its capacity. The reason behind this could be related to a preference for more robust and

[116] Marlier 2008.

resistant containers that would decrease the likelihood of breakage and loss of the high-ranking wines. This assertion leads one to think that even if not only the finest wines were transported in the Dressel 2, vintages of higher quality should have been the driving force behind production in the eastern Layetanian region.

The epigraphic system behind the stamps of Dressel 3-2 was constantly evolving and presents traces of a unique structure. It represents the peak of Layetanian wine production and reflects an economic model focused on large interprovincial trade, much more ambitious than before in competing head-to-head with other Mediterranean wines in the large consumer markets of Italy (Rome) and Africa (Carthage). The high specialization and intensive activity of the Layetanian workshops can clearly be seen in the epigraphic repertoire.

One important formal aspect of this epigraphy is that the stamps gradually became larger and more developed, with new formal traits and shared characteristics in the elaboration of matrices and text design. The groups of stamps attributable to one individual are also more abundant in variants, showing a highly heterogeneous and elaborate set of sealing matrices, with variable dimensions and texts exhibiting diverse techniques of writing. At earlier times, free persons commonly expressed themselves with *tria nomina*, either partially developed or with three initials (LCM, MCN, SLL, M·S·PVP, T·VAL·RVF, etc.). We know of three variants of the family of *L. Cor(nelius) Pr()* with different shapes and developments due to the widespread use of this practice in sealing. The archaic expression of *duo nomina* with *praenomen* and *nomen*, widespread on Pascual 1, continues although it is much less representative (T·LIC, C·PAV, QTE, L·VOLTEIL, etc.), and *duo nomina* with *nomen* and *cognomen* are unusual (IVLI THEOPHIL, MIN·CEL). Interpunct dots are common and separate the parts of the name in the text of the inscription. The position of the stamps on the rim or neck is less frequent than it was on Pascual 1; on the contrary, they are usually on the spikes.

However, the most prominent aspect of the stamp epigraphy on Dressel 3-2 is the emergence or almost absolute predominance of the simple names, normally referring to slaves, that appear on a large number of amphorae. We can gain an approximate idea of the magnitude of the social phenomenon by taking into account the epigraphic production of Baix Llobregat. The list of names is practically monopolized by Greek and Latin *cognomina* of servile nature: *Aemu(lus)*, *Alba(nus)*, *Calam(us, -anus)*, *Fav(entinus)*, *Felix, Hele(nus)*, *Opt(atus)*, *Ploc(amus)*, *Primul(us)*, *Sec(undus)*, *Sosibia, Stab(ilio)*, *Theop(hilus)*, etc.

Another important facet is the association between two names, mostly in two different stamps on the same amphorae. These associations between *cognomina* seem related to the manufacturing process of the amphorae and reflect control of the production or of the accounting of vessels. The names appear on the spikes almost always with another seal of the same class. If we analyze the pairs of seals from the workshop of Sant Vicenç dels Horts (Baix Llobregat), we see how the names combine with each other in many different ways, through reciprocal relationships and without a clear functional subordination (for instance: SYNE + MVR; MVR + SEC; SEC + SYNE; SYNE + PRIMVL, etc.). This dynamic is repeated in the seals of the other centers of production in the Baix Llobregat and, more interestingly, with other stamps from other regions, for instance, the Maresme around 50 km to the north. We can suggest that the mobility of potters throughout the Baix Llobregat productions and the constant interaction of workers are the main aspects that define the dynamics of the productive system put into operation in this territory. The current perception is that the implementation of a new productive system, which affected wine and amphora production, and the uniqueness of its management should be closely related to a new strategic plan from the colony of Barcino to benefit the newly founded city. Furthermore, the abundance of servile *cognomina* involved in the wine industry reflects the social dynamism and integration typical of the colony of Barcino at this time, offering to dependent groups linked to industrial and commercial activities the possibility of social and economic effective advancement.

In conclusion, the production of Dressel 3-2 reflects a major shift in the trend in wine and amphora production in central Catalonia. In our opinion, this morphological shift is probably one of the most detailed examples of a change in the economic direction of agricultural production during the Roman period. The change was not solely due to the demise of wine production or demand in consumer markets, nor was it due to a new economic situation in the region or to the copying of the best-known and most widely consumed vessel in central Catalonia, as was the case of the Republican Dressel 1. The reasons for the change are multiple, but the main actors behind it were the economic elites of the western Mediterranean. The change meant the gradual abandonment of a well-established and standardized amphora production, caused not by any crisis in local wine production; nor did it develop from a previous to a new type, even if some formal features are shared between Pascual 1 and Tarraconesis Dressel 3-2. The latter are not technologically more advanced than the former but rather an adaptation to new consumer markets using the vessel most accepted by those markets. The change was due simply to the commercial opportunities available in the central Mediterranean for the new elites who arrived with the foundation of the colony of Barcino and the ›industrial‹ exploitation of its territory, the best examples of which are the large quantities of new workshops established in the lower Llobregat Valley. The multiplication of workshops and the growth of amphora production can also be seen in the large number of stamps documented in the whole of Layetania[117]. Nevertheless, in our opinion, the link with already established elites can be seen in the epigraphic record, as well as in the shift of the main import markets and the progressive abandonment of the south Gaulish markets. This could not have been a matter of coincidence, as the close connection that existed between the elites of Narbonne and those of Layetania should have been behind the productive change. The rise of the Gaulish production from the Augustan period onwards seems to have closed off the Gaulish markets for low-quality Tarraconensis wines[118]. The same or similar low-quality wines were thus sent to central Italy, maybe first in Pascual 1 but soon in different containers, namely Tarraconensis Dressel 3. Nevertheless, probably already at the same time or just a few years later, producers in Tarraconensis profited from increased production of high-quality wines exported alone or together with low-quality wines to Italy and North Africa. This carefully planned economic process went hand in hand with a scaling up of amphora production and was naturally reflected in standardization of the clay containers, which achieved at that juncture a greater standardization in measures and volumes, even if they did not increase their ratio between weight of the vessel and weight of the contents.

The End of Production of Tarraconensis Amphorae

Little can be said about the last and still incompletely studied phase, following the Flavian recession, of wine amphora production in the central area of what is today Catalonia. Competition with other Tarraconensis regions, such as the Tarraco area (very active in the 1st cent. A.D. and also renowned according to ancient writers for the quality of its wine[119]), the northern Catalan area[120], or south of the Ebro in the area around the city of Saguntum[121], could have led to a reduction in wine and amphora production in central Catalonia. Some authors have suggested a crisis in the Flavian period and the consequent cessation of imports of Tarraconensis wines at Rome, Carthage or southern France, from that time[122]. Nevertheless, the production of Dressel 2 continued in Tarraconensis probably until the late 2nd or early 3rd century[123] but in very diminished numbers compared to previous times. Given the current state of research, little can be said about the homogeneity and standardization level of this late production, as future discoveries and more research are needed.

117 For the Llobregat: Berni – Carreras 2013. For a general overview of Tarraconesis: Berni – Miró 2013, 75–81.

118 We have already mentioned that the low quality of the Tarraconensis wines, with the exception of the wines from Lauro and Tarraco, is the reason behind the low presence of these wines in the military camps of the Rhine (González 2015; González – Berni 2018, 34–38), where the cheap and bad-quality wines from Gaul had arrived already in barrels in the earlier era of the Roman military presence.

119 Miró 1987.

120 Tremoleda 2000.

121 Mateo et al. 2004.

122 Berni – Miró 2020, 28.

123 Járrega – Otiña 2008.

Other Minor Productions: Flat-Bottom and Fish-Production Amphorae

In the preceding pages, we have focused our attention on the main amphorae produced in the central Catalan area. Linked to the wine boom of the region, these amphorae were produced in many different workshops and exported to many different places, with special emphasis on Gaul and Italy. Even if they represent the large majority of Layetanian production and the best examples of the regional standardization process, the same chronological period also saw other vessels produced: for example, the flat-bottom form Oberaden 74, a wine container with origins in the lower Ebro Valley; some different forms of amphorae for fish products that are linked to extra-provincial types, such as the Dressel 21–22, the origins of which must be sought in south Italy and Sicily; and the group Dressel 7–11, a typical Baetican production.

Some crucial questions about standardization can be raised with respect to the vessels that were produced, certainly in smaller numbers, together with the main amphorae of the central Catalan area in the 1st century B.C. and 1st century A.D. The most obvious question concerns whether they were also standardized, despite being produced in smaller quantities, since they potentially benefitted from the same potters and were produced in the same workshops as the major forms. This question is not easy to answer at the present state of research in Tarraconensis, but some suggestions can be proposed.

The production of flat-bottom amphorae in the northeastern Iberian Peninsula seems to have started in the early Augustan period in the lower Ebro Valley[124] and represents a similar economic process as documented in the important flat-bottom amphora production of southern Gaul[125], and the *urceus* and Dressel 28[126] of inland Baetica, a process related to the production and export of wine along the main river routes. In the case of Oberaden 74, the main markets seem to have been in the colonies and important settlements developed in the inner Ebro Valley from the early Augustan period onwards, but they were also directed toward other markets, especially the Rhône and the Rhine[127]. Its production at present seems to be documented in three workshops in Layetania[128], but just a small number of pieces in a fragmentary state of preservation have been preserved, which hinders any detailed hypothesis concerning their standardization. The situation is slightly better in other Catalan areas, and it seems that a certain standardization level was achieved in southern Catalonia, including the lower Ebro Valley and the territory directly south of the city of Tarraco. The best example here is found in the group of Oberaden 74 stamped SEX·DOMITI, which at present we know to have been produced in two different workshops: L'Aumedina in the lower Ebro and La Canaleta in the Camp de Tarragona. They exhibit some differences in the form of the rim and the profile of the handles, but in our opinion they do not create a clear differentiation, and the similar formal attributes and measurements of this production suggest an elevated degree of standardization that, however, should be compared with the concurrent production of other workshops.

Amphorae for fish products played a very small role, if any, in the total production of our region. However, they could be an important indicator that these commodities were produced in the area at a level that surpassed local consumption[129]. Even if they were produced here in limited quantities, the production was more important in other areas of Tarraconensis, especially in the northern coastal area, in the current province of Girona, with a center at the city of Emporion/Am-

124 Carreras – González 2012.
125 Laubenheimer 1985; Bigot 2020; F. Laubenheimer in this volume.
126 García et al. 2011, 248–252; Almeida – González 2017.
127 Carreras – González 2012; González 2015.
128 Carreras – González 2012, 209.
129 Some authors have hesitated about the use of these amphorae as fish or fish related vessels: López – Martín 2008, 76–78. In our opinion, there is no reason to doubt the function of these amphorae as containers for fish and fish-related products, even if their production is documented in some inland workshops as in Tivissa, near the Ebro, where it can be connected with the production of riverine fish commodities.

purias and its distinctive so-called Dressel 8 Ampuritana[130], or in the southern coastal area of the current province of Barcelona and in the workshops of the Tarragona area[131], with their Dressel 7–11. In both areas, production seems to have started in the last years of the 1st century B.C.[132] and achieved its peak probably during the first half of the 1st century A.D. In Layetania, just a small number of workshops have been proposed as production centers for this type[133], always found in sporadic quantities and in a fragmentary state of preservation, with no complete amphora yet documented. Due to the lack of complete examples, the current state of research on this production does not allow us to explore questions regarding the standardization of Dressel 7–11 produced in Layetania or to even confirm that it was produced there.

If the production of Dressel 7–11 and possibly other amphorae for fish whose forms are originally based on Baetican types like Dressel 12[134] took place, it represents an opportunistic strategy of introducing local products similar to the Baetican or based on the Baetican originals into the most important consumer markets for Baetican fish products. In this case, Tarraconensis products from the Tarraco area and from the Emporion/Ampurias region would have followed the route to central Italy, where they seem to have been found in the La Longarina 1 depot[135] and probably in the Castro Praetorio[136]. Their distribution to Gaul and the northern European markets also seems possible and has been confirmed for the products of Emporion/Ampurias[137].

Contrary to the generally fragmentary state of preservation of the supposed Layetanian Dressel 7–11, a complete amphora for fish products was found in the large *vide sanitaire* documented in Caesaraugusta/Zaragoza at the mouth of the Huerva River in the Ebro[138]. The context is dated to the last third of the 1st century B.C., which matches well with the amphora's form, a Layetanian imitation (not a copy) of the Italian Dressel 21–22 form 3 of E. Botte[139], with some formal characteristics, mainly the handles and the spike, that remain consistent with Pascual 1 and other wine amphorae of the region. The presence of a completely preserved stamp of IVLI·THEOPHIL, with the PH forming a ligature, on the rim also suggests a similar chronology as that proposed for the context. It has been suggested that this amphora was produced in the Llobregat area[140], but it seems to us more probable that its production was in northern Layetania, where stamps of this series have been found on Pascual 1 and early Dressel 3 produced in the workshops of Calella de Mar and Canet de Mar. In addition to the stamp, an inscription in red ink is preserved on the rim. It is easy to read *T(esta)·XLV (librae)*, an indication of the weight of the vessel (tare weight), around 14.715 kg, a weight similar to that of Pascual 1 produced at that time (fig. 14).

This exceptional discovery reinforces our notion about the organization of the productive economy of central Catalonia being similar to the organization during the 1st century B.C. of the most significant productive regions of Italy. The production in the same workshop of different forms of amphorae used for different commodities has been documented in Campania and other regions of Italy linked to the Italian senatorial class, who possessed large agricultural domains where different commodities were produced alongside the necessary subsidiary industries. If the stamps *Cai Iulii* documented on different types of Tarraconensis amphorae are a good example of the mass production and export of different agricultural goods by the provincial elites, a similar

130 Tremoleda 2000, 128 f.; López – Martín 2008, 78 f.; Tremoleda 2016.
131 López – Martín 2008, 78 f.
132 López – Martín 2008, 79.
133 López – Martín 2008, 78.
134 Járrega 2016.
135 López – Martín 2008, 79.
136 Personal observation, H. González Cesteros.
137 van den Berg 2013.
138 Beltrán 2014, 144 f.
139 Botte 2009.
140 Beltrán 2014.

case can be found with the amphorae produced in the Campania area and marked with POST· CVRT, stamps that are found on Campanian Dressel 1B, Dressel 2–4, and Dressel 21–22[141].

In our opinion, the important aspects of this versatile amphora production are that it represented a very organized and articulated agricultural production, and that this would obviously have had an impact on the standardization of the vessels, even of those produced in low numbers or over a short period.

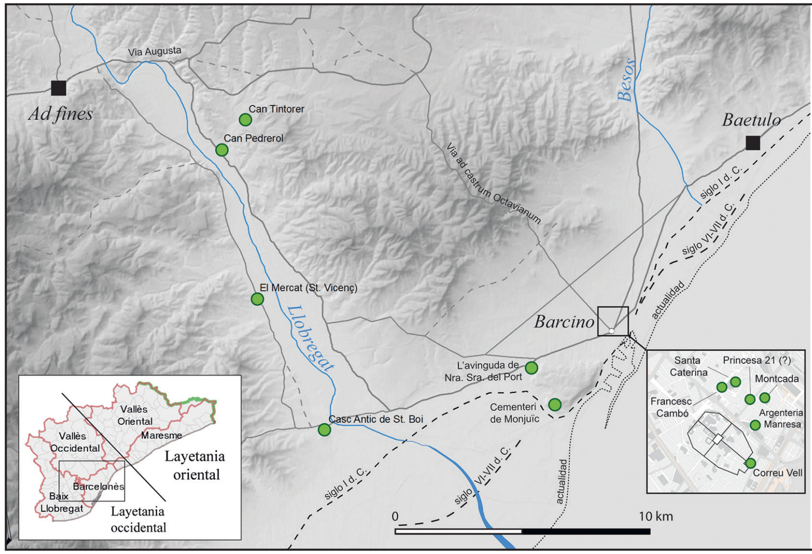
SOME CONCLUSIONS

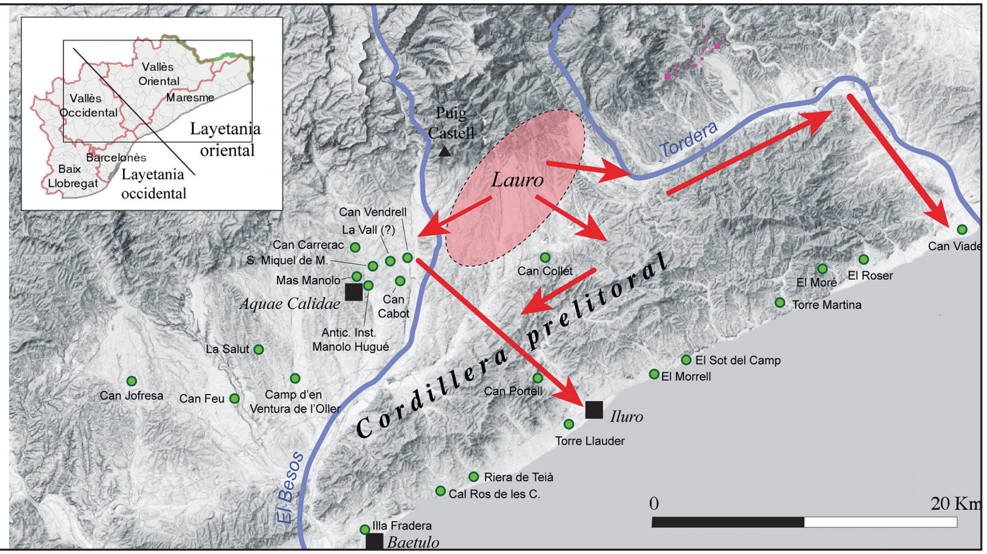
The main trends in the social, political, and economic development of the central Catalan area during the 1st century B.C. and 1st century A.D. can be traced through local amphora production and related processes of standardization. Studies of wine and amphora production here have revealed close connections with other regions of the western Mediterranean, which not only acted as major consumer markets but also influenced wine production in both direct and indirect ways. If the early Roman settlers together with the local indigenous elites played an important role in the earliest phases of the wine export economy of ancient Layetania, the epigraphy has revealed the involvement of the elites of southern Gaul and Italy also in the wine business of the region.

Further, this broad economic process is clearly linked to and reflected in the standardization of the vessels and their development over two important centuries in the history of the western Mediterranean, spanning the entire transition from the establishment of the first Roman population and later settlements of the Republican period to the complete integration into the economy of the larger Roman Empire. However, this was far from being a linear process. As we have attempted to show in these pages through analysis of the standardization processes of our vessels, the evolution of agricultural production in the region, based on an almost monoculture around wine, had constant breaks and sharp transformations that were closely related to the continuous economic and social changes which broadly characterized the period in most regions of the western Mediterranean. The Catalan area was central to these developments due to its fertility and good connections, thus making it a significant case study. The production of different wines, their arrival at different markets, and the involvement of different social groups in their production and trade can be analyzed from different perspectives, but all of them left traces in the production of amphorae and the search for suitable transport containers to meet the needs of their specific consumer markets and elite tastes.

Lastly, the vast amount of diverse evidence related to the development of Layetanian wine and amphora production is advantageous for studying economic trends in production in ancient times, and the analysis of the vessels' standardization is particularly important for a better understanding of the different nuances of a process that seems to confirm A. Schiavone's analysis of the economic and social history of Rome as a nonlinear process[142], a continuous back and forth, independent but at the same time connected with the political transformation of the Roman Mediterranean.

141 Bezeczky 2013, 213–219; González et al. 2020, 196 f.
142 Schiavone 1996.





Production Center/Municipality	Dressel 1	Tarraconense 1	Pascual 1	Dressel 3–2	Other Amphorae
Can Manyoses (Viladecans)		•	•	•	
Can Tintorer (El Papiol)			•	•	Dressel 7/11 (?)
Can Pedrerol (Castellbisbal)			•	•	
Can Reverter (St Vicenç dels Horts)			•	•	
El Mercat (St Vicenç dels Horts)			•	•	Dressel 20
Vila Vella (St Boi de Llobregat)			•	•	Dressel 7/11 (?)
Argenteria Manresa (BCN)			•		
Correu Vell (BCN)			•		
Nostra Senyora del Port (BCN)			•	•	
Cementerio de Montjuic (BCN)			•	•	Dressel 20 (?)
Avinguda Francesc Cambó (BCN)			•	•	
Carrer Princesa (BCN)			•	•	
Mercat Santa Caterina (BCN)			•	•	
Carrer Montcada (BCN)			?	?	
Can Viader (Malgrat)			•	•	
El Roser/El Mujal (Calella)		•	•	•	
El Morè (Sant Pol de Mar)			•	•	
Torre Martina (Sant Pol)			•	•	

El Sot del Camp (St Vicenç Montalt)		●	●	●	Oberaden 74
Horta Nova (Arenys de Mar)		●	●		
El Morrell (St Andreu Llavaneres)			●	●	
Les Casetes (Mataró)		●			
Santa Cecilia (Mataró)	●				Iberica B3
Torre Llauder (Mataró)			●	●	
Can Portell (Argentona)	●	●	●	●	
Can Notxa (Argentona)		?			
San Sebastià (Argentona)			?	?	
Ca l'Arnau/Can Pau Ferrer (Cabrera de Mar)	●	●	●		Grecoitalic
Veinat de St Crist (Cabrils)			●		
La Fornaca (Vilassar de Dalt)		?			
Gran Via/Can Ferrerons (Premià de Mar)	?	●	●	●	
Club Tennis Barcelona (Teia)			●		
Riera de Teia (El Masnou)			●	●	
Cal Ros de les Cabres (El Masnou)		?	●	●	
Alella Autopista (Alella)			●		
Can Peixau (Badalona)			●		
Illa Fradera (Badalona)			●	●	
Can Collet (Llinars del Valles)			●	?	
Can Cabot (Sta Eulàlia de Ronçana)			●	●	
Can Vendrell (Sta Eulàlia de Ronçana)	●		●	●	
St Miquel dels Martres (Caldes Montbui)			●	●	
Can Carerac (Caldes Montbui)				?	
Carrer Balmes (Caldes Montbui)			●	●	
Mas Manolo (Caldes Montbui)			●	●	
Antic Institut Manolo Hugué (Caldes Montbui)			●	●	
Camp d'en Ventura de l'Oller (Sta Perpètua de Mogoda)			●	●	
Sta Maria de les Feixes (St Quirze del Valles)					Gauloise 4 (?)
Can Feu (St Quirze del Valles)			●	●	
La Salut (Sabadell)	●	●	●	●	
Can Jofresa (Terrassa)				●	

14 List of some the most important kiln-sites in eastern and western Layetania and the amphora types produced (© Iván Tobar and authors)

BIBLIOGRAPHY

Adserias – Ramon 2004 M. Adserias Sans – E. Ramon Sariñena, La Villa romana del Vilar (Valls, Alt Camp), Quaderns de Vilaniu 45, 2004, 5–18.

Aguelo et al. 2014 X. Aguelo – O. Pons Machado – C. De Juan Fuertes – J. Ramon Torres – C. Mata Parreño – L. Soria Combadiera – R. Piqué i Huerta – F. Antolín i Tutusaus, El pecio de Binisafuller. Estado de las investigaciones, in: X. Nieto Prieto – M. Bethencourt Núñez (eds.), I Congreso de Arqueología Náutica y Subacuática Española, Cartagena, marzo de 2013 (Madrid 2014) 67–85.

Almeida – González 2017 R. R. De Almeida – H. González Cesteros, Las excepciones sudhispánicas: las ánforas de tipo *urceus* y las Dressel 28, in: C. Carreras – J. Van den Berg (eds.), Amphorae from the Kops Plateau (Nijmegen): trade and supply to the Lower-Rhineland from the Augustan period to AD 69/70, Archaeopress Roman Archaeology 20 (Oxford 2017) 105–110.

Álvarez 2017 J. F. Álvarez Torrosa, Modelos de producción en la agricultura comercial del noroeste de la provincia Hispania Citerior (PhD thesis Universitat d'Alacant Alicante 2017).

Aranegui 2008 C. Aranegui Gascó, La producción y el comercio de ánforas tarraconenses en el País Valenciano, in: López – Aquilué 2008, 227–240.

Arlaud et al. 1998 C. Arlaud – E. Bertrand – L. Laubenheimer – J.-M. Lurol, Un vide sanitaire, rue Childebert à Lyon, in: F. Laubenheimer (ed.), Les amphores en Gaule, production et circulation (Besançon 1998) 193–204.

Barthélémy-Sylvand et al. 2005 C. Barthélémy-Sylvand – M.-P. Chambon – F. Couvin, Les amphores ligériennes en Région Centre (Carnute, Turon, Biturgie), de la période augustéenne à la fin du Haut-Empire, SFECAG. Actes du Congrès de Blois (Marseille 2005) 159–176.

Becker et al. 1986 C. Becker – C. Constantin – A. Desbat – L. Jacquin – J.-P. Lascoux, Le dépôt d´amphores augustéen de la rue de la Favorite à Lyon, Figlina, 7, 1986, 65–89.

Beltrán 2014 M. Beltrán Lloris, Iulius Teophilus. Un nuevo fabricante de salazones tarraconenses en época de Augusto, in: A. Duplá Ansuátegui – M. V. Escribano Paño – L. Sancho Rocher – M. A. Villacampa Rubio (eds.), Miscelánea de estudios en homenaje a Guillermo Fatás Cabeza (Zaragoza 2014) 143–153.

Berni 2015 P. Berni Millet, Novedades sobre la tipología de las ánforas Dressel 2–4 tarraconenses, AEspA 88, 2015, 187–201.

Berni 2019 P. Berni Millet, Dynamiques économiques de la production et du commerce des amphores Dressel 3-2 léétaniennnes, RANarb 50/51, 2019, 223–236.

Berni et al. 2005 P. Berni Millet – C. Carreras – O. Olesti, La gens licinia y el Nordeste peninsular. Una aproximación al estudio de las formas de propiedad y de gestión de un rico patrimonio familiar, AEspA 78, 2005, 167–187.

Berni – Carreras 2013 P. Berni Millet – C. Carreras Monfort, Corpus epigràfic de segells en àmfores, dolia, tegulae i gerres de ceràmica comuna oxidada del Baix Llobregat, Barcino 2. Marques i terrisseries d'àmfores al Baix Llobregat, Institut d'Estudis Catalans (Barcelona 2013) 127–285.

Berni – Miró 2013 P. Berni Millet – J. Miró Canals, Dinámica socioeconómica en la Tarraconense Oriental a finales de la República y comienzos del Imperio. El comercio del vino a través de la epigrafía anfórica, Tarraco Biennal. Actes del primer congrès internacional d'arqueologia i món antic (Tarragona 2013) 63–83.

Berni – Miró 2020 P. Berni Millet – J. Miró Canals, Le vin Léétanien et de Tarraco à Carthage. Contribution de l'épigraphie amphorique à la connaissance du développement économique de la Léétanie à l'époque julio-claudienne, AntAfr 56, 2020, 129–159.

Berni – Miró (forthcoming) P. Berni Millet – J. Miró Canals, Los vinos de la Layetania, Aportación de los tituli picti en ánforas Dressel 3-2 (forthcoming).

Berni – Revilla 2008 P. Berni Millet – V. Revilla Calvo, Los sellos de las ánforas de producción tarraconense: representaciones y significado, in: López – Aquilué 2008, 95–111.

Bezeczky 2013 T. Bezeczky, The Amphorae of Roman Ephesus, FiE 15, 1 (Vienna 2013).

Bigot 2020	F. Bigot, Production et commerce des amphores gauloises sur le littoral et dans les ports de Narbonnaise, Archéologie et Histoire Romaine 44 (Montagnac 2020).
Botte 2009	E. Botte, Salaisons et saices de poissons en Italie du sud et en Sicilie durant l'Antiquité (Naples 2009).
Cabrelles 2013	I. Cabrelles, Elits ciutadanes i propietat rural durant l'Alt Imperi. El cas dels *Clodii* de *Tarraco*, Pyrenae 44, 2, 2013, 7–32.
Carandini 1989	A. Carandini, La villa romana e la piantagione schiavistica, in: A. Schiavone (dir.), Storia di Roma IV. Caratteri e morfologie (Turin 1989) 101–200.
Carreras – Berni 1998	C. Carreras Monfort – P. Berni Millet, Producció de vi i àmfores tardanes del NE de la Tarraconense, in: El vi a l'antiguitat 1998, 270–276.
Carreras – Berni 2002	C. Carreras Monfort – P. Berni Millet, Microspatial relationships in the Laietanian wine trade: shipwrecks, amphora stamps and workshops, in: L. Rivet – M. Schiallano (eds.), Vivre, produire et échanger. Reflets méditérranéens. Mélanges offerts à Bernard Liou (Montagnac 2002) 359–369.
Carreras – González 2012	C. Carreras Monfort – H. González Cesteros, Ánforas tarraconenses para el limes germano: una nueva visión de las Oberaden 74, in: D. Bernal-Casasola – A. Ribera i Lacomba (eds.), Cerámicas hispanorromanas II. Producciones regionales (Cádiz 2012) 207–230.
Castanyer et al. 2009	P. Castanyer i Masoliver – J. M. Nolla Brufau – J. Tremoleda i Trilla, La producció vinícola en època romana a les comarques gironines. Inversió, propietat, treball de la terra i artesanat, in: Prevosti – Martín 2009, 43–59.
Colls 1986	D. Colls, Les amphores léétaniennes de l'épave Cap Béar III, REA 88, 1986, 1–4, Hommage à Robert Etienne, 201–213.
Comas – Carreras 2008	M. Comas i Solà – C. Carreras Monfort, Les àmfores de la Laietània: estat de la questió, in: López – Aquilué 2008, 177–188.
Contino et al. 2013	A. Contino – L. D'Alessandro – F. Luccerini –V. Mastrodonato – R. Tanganelli, Anfore Dressel 2–4 »Tarraconensi« a Roma. Richerche epigrafiche dal sito del Nuovo Mercato Testaccio. Dati preliminari, in: D. Bernal-Casasola – L. C. Juan Tovar – M. Bustamante Álvarez – J. J. Díaz Rodríguez – A. M. Sáez Romero (eds.), Hornos, talleres y focos de producción alfarera en Hispania, I Congreso Internacional de SECAH (Madrid 2013) 333–350.
Contino et al. 2019	A. Contino – L. D'Alessandro – G. L. Pascual – A. Ribera, Distribution of African and Hispanic ovoid amphorae in Italy: the cases of Pompei and Rome, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. Sáez Romero, The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 237–273.
Contino et al. 2022	A. Contino – L. D'Alessandro – A. D'Alessio – H. González Cesteros – S. Pannuzi, La Longarina 2 (Ostia). Revisione dei dati provenienti dai contenitori da trasporto. Rapporto Preliminare, The Journal of Fasti Online 2022, 1–29 <http://www.aiac.org; http://www.fastionline.org> (11. 04. 2023).
Corsi-Sciallano – Liou 1985	M. Corsi-Sciallano – B. Liou, Les épaves de Tarraconaise à chargement d'amphores Dressel 2–4, Archaeonautica 5 (Paris 1985).
Dell'Amico – Pallarés 2007	P. Dell'Amico – F. Pallarés, Le anfore della Laietania. Appunti e riflessioni, Archeologia Marittima Mediterranea 4, 2007, 53–133.
Dell'Amico – Pallarés 2011	P. Dell'Amico – F. Pallarés, Appunti sui relitti a dolia, Archaeologia Maritima Mediterranea 8, 2011, 47–135.
Desbat – Martin-Kilcher 1989	A. Desbat – S. Martin-Kilcher, Les amphores sur l'axe Rhône-Rhin à l'époque d'Auguste, in: Amphores romaines et histoire économique. Dix ans de recherche, CEFR 114 (Rome 1989) 339–365.
Desbat et al. 1987	A. Desbat – R. Lequément – B. Liou, Inscriptions peintes sur amphores: Lyon et Saint-Romain-en-Gal, Archaeonautica 7, 1987, 141–166.

El vi a l'antiguitat 1987 El Vi a l'antiguitat I (Badalona 1987).

El vi a l'antiguitat 1998 El Vi a l'antiguitat. Economia, producció i comerç al Mediterrani occidental. II Col loqui Internacional d'Arqueologia Romana (Barcelona 6–9 maig de 1998), Monografies Badalonines 14 (Badalona 1998).

Etienne – Mayet 2000 F. Etienne – F. Mayet, Trois clés pour l´économie de l'Hispanie Romaine I: Le vin hispanique (Paris 2000).

Freed 1998 J. Freed, Stamped Tarraconensian Dressel 2–4 Amphoras at Carthage, in: El vi a l'antiguitat 1998, 350–356.

García – Gurri 1996/1997 J. García Roselló – E. Gurri Costa, Les imitacions laietanes d'àmfores itàliques a la zona central de la comarca del Maresme en època tardo-republicana, Annals de l'Institut d'Estudis Gironins 36, 1996/1997, 397–424.

García et al. 2000 J. Garcia Roselló – J. Pujol del Horno – X. Cela Espin – D. Zamora Moreno, Burriac, un centre d'intercanvi i de comerç a la Laietània ibèrica, III Reunió sobre Economia en el Món Ibèric, Saguntum – PLAV, extra 3 (Valencia 2000) 357–367.

García et al. 2011 E. García Vargas – R. R. De Almeida – H. González Cesteros, Los tipos anfóricos del Guadalquivir en el marco de los envases hispanos del siglo I a.C. Un universo heterogéneo entre la imitación y la estandarización, Spal 20, 2011, 185–283.

García et al. 2019 E. García Vargas – R. R. De Almeida – H. González Cesteros – A. M. Sáez (eds.), A Family Business: Ovoid Amphorae in the Central and Western Mediterranean, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019).

Geli 2020 E. Geli Mauri, El derelicte Aiguablava I: un exemple de comerç de vi de la tarraconense en època d'August, Empúries 58, 2020, 51–79.

Gisbert 2009 J. A. Gisbert Santonja, Vi tarraconense al País Valencià. Una mirada des dels forns d'àmfores, arqueologia de les villes i derelictesde la costa de »Dianium« (Dénia), in: Prevosti – Martín 2009, 125–150.

González 2014 H. González Cesteros, Ánforas hispanas en la Germania Inferior antes de la formación de la provincia (20 a.C. – 69 d.C.) (Tesis Doctoral inédita, URV-ICAC Tarragona 2014).

González 2015 H. González Cesteros, Hallazgos de productos tarraconenses en la frontera germana. Un mercado secundario, in: Martínez 2015, 205–220.

González 2019 H. González Cesteros, Eastern Mediterranean Amphorae, in: T. Bezeczky (ed.), Amphora research in the Castrum Villa on Brijuni Island, DenkschrWien = AForsch 29 (Vienna 2019) 67–90.

González – Berni 2018 H. González Cesteros – P. Berni Millet, Roman Amphorae in Neuss. Augustan to Julio-Claudian contexts, Roman and Late Antique Mediterranean Pottery 12 (Oxford 2018).

González et al. 2020 H. González Cesteros – V. Scheibelreiter-Gail – A. Galik, From the Atlantic to the Cayster: the consumption of fish and sea products in Ephesos, Herom 9, 2020, 135–231.

Gorgues 2010 A. Gorgues, Économie et société dans le nord-est du domaine ibérique (IIIe–Ier s. av. J.-C.), Anejos de Archivo Espa-ñol de Arqueología (Madrid 2010).

Guerrero et al. 1989 V. Guerrero – J. Miró Canals – J. Ramon, L'Épave de Binisafuller (Minorque). Un bateau de commerce punique du III^{e} siècle av. J.-C., in: H. Devijver – E. Lipinski (eds.), Punic Wars, Studia Phoenicia 10, 1989, 115–125.

Guerrero et al. 1991 V. Guerrero – J. Miró Canals – J. Ramon, El pecio de Binisafuller (Menorca), un mercante púnico del siglo III a.C., Meloussa 2, 1991, 9–30.

Hesnard 1980 A. Hesnard Un dépôt augustéen d'amphores à la Longarina, Ostie, MemAmAc 36, 1980, 141–163.

Járrega 2009 R. Járrega Domínguez, La producción vinícola i els tallers d'àmfores a l'ager Tarraconensis i l'ager Dertosanus, in: Prevosti – Martín 2009, 99–123.

Járrega 2016 R. Járrega Domínguez, La Tarraconense 1, una ánfora ovoide de época altoimperial, in: R. Járrega – P. Berni (eds.), Amphorae ex Hispania: paisajes de producción y consumo. III Congreso internacional de la SECAH, Ex Officina Hispana (Tarragona 2016) 55–65.

Járrega 2018 R. Járrega Domínguez, Los nomina en la epigrafia anfórica de las ánforas Dressel 2–4 del NE de la Hispania Citerior. Cambios estructurales e implicación de las élites urbanas, Saguntum 50, 2018, 175–202.

Járrega – Berni 2014 R. Járrega Domínguez – P. Berni Millet, El taller de ánforas de Malgrat de Mar (Barcelona): arqueometría y epigrafía, R. Morais – A. Fernandez – M. J. Sousa (eds.), As produçoes cerâmicas de imitaçao na Hispania, Monografias Ex Officina Hispana 2 (Tarragona 2014) 393–403.

Járrega – Berni 2015 R. Járrega Domínguez – P. Berni Millet, Exportación e importación de ánforas en el ager Tarraconensis entre finales de la República y el Alto Imperio, in: Martínez 2015, 79–90.

Járrega – Colom 2020 R. Járrega Domínguez – E. Colom Mendoza, Nuevas hipótesis en torno a la presencia de élites locales de *Barcino* en la producción del vino layetano: el caso de *Lucius Minicius Natalis*, Zephyrus 85, 2020, 229–242.

Járrega – Otiña 2008 R. Járrega Domínguez – P. Otiña, Un tipo de ánfora tarraconense de época medio-imperial (siglos II–III): la Dressel 2–4 evolucionada, SFECAG. Actes du Congrès de l'Escala-Empúries (Marseille 2008) 281–286.

Járrega et al. 2020 R. Járrega Domínguez – P. Berni Millet – J. Miró Canals, Anfore dalla *Hispania Citerior (Tarraconensis)* a Pompei: un approccio all'epigrafia delle anfore, in: Festi Cretaria. Dal frammento al contesto. Studi sul vasellame ceramico del territorio vesuviano, Studi e ricerche del parco archeologico di Pompei 40 (Rome 2020) 131–134.

Jongman 2007 W. N. Jongman, The Early Roman Empire: Consumption, in: W. Scheidel – I. Morris – R. Saller (eds.), The Cambridge Economic History of the Greco-Roman World (Cambridge 2007) 592–618.

Juan 2000 J. Juan Tresserras, La cerveza: un producto de consumo básico entre las comunidades ibéricas del N.E. peninsular, Saguntum extra 3, 2000, 139–145.

Laubenheimer 1985 F. Laubenheimer, La production des amphores en Gaule Narbonnaise sous le Haut-Empire, Annales littéraires de l'Université de Besançon 327 (Paris 1985).

Laubenheimer 2015 F. Laubenheimer, Les circuits des vins de Tarraconaise en Gaule, in: Martínez 2015, 181–192.

Laubenheimer – Martínez 2015 F. Laubenheimer – V. Martínez Ferreras, L'origine des amphores de l'ensemble aristocratique d'Antran (Vienne, France), in: Martínez 2015, 193–204.

Laubenheimer et al. 2005 F. Laubenheimer – N. Cantin – A.Schmitt, Vin et vignoble du centre-ouest de la Gaule au I[er] s. Le témoignage des amphores Pascual 1 et Dressel 2/4 blanches à pâte orangée à coeur gris, SFECAG. Actes du Congrès de Blois (Marseille 2005) 377–382.

Liou 1987 B. Liou, L'exportation du vin de Tarraconaise d'après les épaves, in: El vi a l'antiguitat 1987, 271–284.

López – Martín 2008 A. López Mullor – A. Martín Menéndez, Tipologia i datación de les àmfores tarraconenses produïdes a Catalunya, in: López – Aquilué 2008, 33–94.

López – Aquilué 2008 A. López Mullor – X. Aquilué i Abadías (eds.), La producció i el comerç de les àmfores de la Provincia Hispania Tarraconensis. Homenatge a Ricard Pascual i Guasch (Barcelona, 17–18 novembre 2005), Museu d'Arqueologia de Cataluny Monografies 8 (Barcelona 2008).

Marlier 2008 S. Marlier, Architecture et espace de navigation des navires à dolia, Archaeonautica 15, 2008, 153–173.

Martin-Kilcher 1994 S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels und Kulturgeschichte: Die Amphoren für Wein, Fischsaucen, Südfrüchte (Gruppen 2–24) und Gesamtauswertung, FiA 7, 2 (August 1994).

Martin-Kilcher 2005 S. Martin-Kilcher, Carthage: Imported Eastern Amphorae in the Roman Colonia Iulia, in: M. Berg Briese – L.-E. Vaag (eds.), Trade Relations in the Eastern Mediterranean from the Late Hellenistic Period to Late Antiquity: The Ceramic Evidence, Halicarnassian Studies 3 (Odense 2005) 202–220.

Martin-Kilcher et al. 2009 S. Martin-Kilcher – D.C. Tretola Martínez – R. Vogt, Die Amphoren aus dem Grabbezirk von Goeblingen-Nospelt, in: J. Metzler – C. Gaeng – I. Le Goff (eds.), Goeblange-Nospelt. Une nécropole aristocratique trévire (Luxembourg 2009) 333–394.

Martín 2008 — A. Martín Menéndez, Àmfores tarraconenses i bètiques en els derelictes de mitjan segle I a.C. a la costa catalana, SFECAG. Actes du Congrès de l'Escala-Empúries (Marseille 2008) 103–127.

Martín – Revilla 2019 — A. Martín Oliveras – V. Revilla Calvo, The Economy of Laetanian Wine: A Conceptual Framework to Analyse an Instensive/Specialized Winegrowing Production System and Trade (First Century BC to Third Century AD), in: P. Verhagen et al. (eds.), Finding the Limits of the Limes. Modelling Demography, Economy and Transport on the Edge of the Roman Empire (Computational Social Sciences) (Berlin 2019) 129–164.

Martín – García 2002 — A. Martín Manéndez – J. García Roselló, La romanización en el territorio de los layetanos y la fundación de la ciudad romana de *Iluro (Hispania Tarraconensis)*, in: A. Ribera i Lacomba – J. L. Jiménez Salvador (eds.), Valencia y las primeras ciudades romanas de Hispania (Valencia 2002) 195–204.

Martínez 2011/2012 — V. Martínez Ferreras, El estudio arqueométrico de las ánforas vinícolas. Una nueva forma de aproximarnos al conocimiento de la producción y exportación del vino de la *Tarraconensis*, in: J. M. Noguera Celdrán – J. A. Antolinos Marín (eds.), De vino et oleo Hispaniae. Áreas de producción y procesos tecnológicos del vino y el aceite en la Hispania romana, Anales de Prehistoria y Arqueología de la Universidad de Murcia 27/28, 2011/2012, 513–525.

Martínez 2014 — V. Martínez Ferreras, Ánforas vinarias de Hispania Citerior-Tarraconensis (s. I a.C. – I d.C.). Caracterización arqueométrica, Roman and Late Antique Mediterranean Pottery 4 (Oxford 2014).

Martínez 2015 — V. Martínez Ferreras (ed.), La difusión comercial de las ánforas vinarias de *Hispania Citerior-Tarraconensis* (s. I a.C. – I d.C.), Archaeopress Roman Archaeology 4 (Oxford 2015).

Mateo 2016 — D. Mateo Corredor, Comercio anfórico y relaciones mercantiles en Hispania Ulterior (ss. II a.C. – II d.C.), Instrumenta 52 (Barcelona 2016).

Mateo 2018 — D. Mateo Corredor, La producción de ánforas en el área costera central de la Tarraconense durante el Alto Imperio, in: R. Járrega (ed.), Estudios sobre las ánforas hispanas, Cuadernos de la SECAH 3 (Madrid 2018) 133–151.

Mateo et al. 2021 — D. Mateo Corredor – R. Járrega Domínguez – E. Colom Mendoza – V. Martínez Ferreras, Figlinae y producción anfórica en el territorium de Saguntum, Lvcentvm 40, 2021, 173–195.

Miró 1983/1984 — J. Miró Canals, Algunas consideraciones sobre las ánforas ibéricas Mañá B-3, Pyrenae 19/20, 1983/1984, 157–189.

Miró 1985 — J. Miró Canals, Les fonts escrites i el vi del Conventus Tarraconensis, Pyrenae 21, 1985, 105–112.

Miró 1987 — J. Miró Canals, Vi català a França: una síntesi preliminar, in: El vi a l'Antiguitat. Economia, producció i comerç al Mediterrani occidental. Badalona. 28, 29, 30 de novembre i de 1 desembre de 1985. Actes, Monografies Badalonines 9 (Badalona 1987) 249–268.

Miró 1988a — J. Miró Canals, La producción de ánforas romanas en Catalunya. Un estudio sobre el comercio del vino de la Tarraconense (siglos I a.C.–I d.C.), BARIntSer 473 (Oxford 1988).

Miró 1988b — J. Miró Canals, Les estampilles sobre àmfores catalanes. Una aportació al coneixement del comerç del vi del »Conventus Tarraconensis« a finals de la República i principis de l'Imperi, Fonaments 7 1988, 243–265.

Miró 2020 — J. Miró Canals, Barcino augustea y julio-claudia. Dinámica socio-económica de la producción y el comercio del vino layetano, Spal 29, 2, 2020, 205–234.

Miró – Járrega 2017/2018 — J. Miró Canals – R. Járrega Domínguez, Les ateliers de production d'amphores ovoïdes du Nord-Est d'Hispania Citerior (Tarraconensis) aux époques tardo-républicaines et augustéenne précoce, RANarb 50/51, 2017/2018, 209–221.

Miró – Járrega 2019 — J. Miró Canals – R. Járrega Domínguez, Ánforas ovoides del noreste de la Hispania Citerior Tarraconensis en época tardorepublicana. Ensayo de síntesis, The Ovoid Amphorae in the Central and Western Mediterranean (Oxford 2019) 148–174.

Miró et al. 1988	J. Miró Canals – J. Pujol del Horno– J. García Roselló, El dipòsit del sector occidental del poblat ibèric de Burriac (Cabrera de Mar). Una aportació al coneixement de l'època ibèrica tardna al Maresme (s. I a.C.), Laietania 4, 1988, 7–182.
Molina 1997	J. Molina Vidal, La dinámica comercial romana entre Italia e Hispania Citerior (Alicante 1997).
Molina 2020	J. Molina Vidal, El sistema económico policéntrico romano (siglos I–II D.C) (Alicante 2020).
Morley 2007	N. Morley, The Early Roman Empire: Distribution, in: W. Scheidel – I. Morris – R. Saller (eds.), The Cambridge Economic History of the Greco-Roman World (Cambridge 2007) 570–591.
Nieto – Raurich1998	X. Nieto Prieto – X. Raurich Santaló, El transport naval de vi de la Tarraconense, in: El vi a l'antiguitat 1998, 113–137.
Nolla 2008	J. M. Nolla, La producció de les àmfores tarraconenses a la Catalunya Septentrional, in: López – Aquilué 2008, 163–176.
Nolla – Solias 1984/1985	J. M. Nolla – J. M. Solías, L'àmfora Tarraconense 1. Característiques, procedència, àrees de producció, cronologia, Butlletí Arqueològic de Tarragona 1984/1985, 107–144.
Olcese et al. 2017	G. Olcese – M. A. Cau Ontiveros – L. Fantuzzi – A. Razza, Le anfore del contesto della ruota idraulica di Ostia antica: archeologia e archeometria, ArchCl 68, 2017, 197–224.
Olesti 1996/1997	O. Olesti Vila, Els primers productors d'àmfores vinícoles al Maresme (s. I a.C.), Annals de l'Institut d'Estudis Gironins 36, 1996/1997, 425–448.
Olesti 1998	O. Olesti Vila, Els inicis de la producció vinícola a Catalunya: el paper del món indígena, in: El vi a l'antiguitat 1998, 246–257.
Olesti 2020	O. Olesti Vila, Propietats i propietaris vinícoles a la Laietània romana. Un context històric local, provincial i imperial, in: X. Aquilué – J.Beltrán de Heredia – A. Caixal – J. Fierro – H. Kirchner (eds.), Estudis sobre ceràmica i arqueologia de l'arquitectura. Homenage al Dr. Alberto López Mullor (Barcelona 2020) 203–213.
Olesti – Carreras 2008	O. Olesti Vila – C. Carreras Monfort, Tierra y libertad: libertos e institores en el Ager Barcinonensis (Barcelona), in: P. P. A. Funari – G. J. Da Silva – D. Pérez-Sanches (eds.), Arqueología e Historia del mundo antiguo: contribuciones brasileñas y españolas, BARIntSer 1791 (Oxford 2008) 93–103.
Olmer 2013	F. Olmer (ed.), Itinéraires des vins romains en Gaule III^{e}–I^{er} siècles avant J.-C. Confrontation de faciès, Monographies d'Archéologie Méditerranéenne, Hors-série n° 5 (Lattes 2013).
Palet 1997	J. M. Palet, Estudi territorial del Pla de Barcelona, Estudis i Memòries d'Arqueologia de Barcelona. Ajuntament de Barcelona (Barcelona 1997).
Pascual 1977	R. Pascual Guasch, Las ánforas de la Layetania, in Méthodes classiques et méthodes formelles dans l'étude typologique des amphores, Publications de l'École française de Rome 32 (Rome 1977) 47–96.
Pascual 1991	R. Pascual Guasch, Index d'estampilles sobre àmfores catalanes (Barcelona 1991).
Pena 1999	M. J. Pena Gimeno, Las marcas de M. Porcius sobre ánforas Pascual 1, Faventia 21, 2, 1999, 75–83.
Peña 2010	Y. Peña Cervantes, La producción de vino y aceite en Hispania, Documenta 14 (Tarragona 2010).
Poux 2004	M. Poux, L'Age du vin. Rites de boisson, festins et libations en Gaule indépendante, Protohistoire Européenne 8 (Montagnac 2004).
Prevosti – Martín 2009	M. Prevosti – A. Martín i Oliveras (eds.), El vi tarraconense i laietà: ahir i avui, Actes del simpòsium, Documenta 7 (Tarragona 2009).
Principal 2008	J. Principal Ponce, El Mediterráneo Occidental como espacio periférico de imitaciones, in: D. Bernal-Casasola – A. Ribera i Lacomba, Cerámicas Hispanorromanas. Un estado de la cuestión (Cádiz 2008) 127–145.

Principal – Sanmarti 1998 J. Principal Ponce – E. Sanmartí Greco, Vi per a Hispania, Consideracións entorn del comerç romanoitàlic a les darreries del segle III–començ del II a.C., in: El vi a l'antiguitat 1998, 175–182.

Ramon 2008 J. Ramon Torres, Les àmfores altimperials d'Ebusus, in: López – Aquilué 2008, 241–270.

Ramon 2012 J. Ramon Torres, La cerámica púnico-ebusitana en época tardía (siglos III–I a.C.), in: D. Bernal-Casasola – A. Ribera i Lacomba (eds.), Cerámicas hispanorromanas II. Producciones regionales (Cádiz 2012) 583–617.

Remesal – Revilla 1991 J. Remesal Rodríguez – V. Revilla Calvo, Weinamphoren aus Hispania Citerior und Gallia Narbonensis in Deutschland und Holland, FuBerBadWürt 16, 1991, 389–439.

Revilla 1993 V. Revilla Calvo, Producción cerámica y economía rural en el Bajo Ebro en época romana. El alfar de l'Aumedina, Tivissa (Tarragona), Instrumenta 1 (Barcelona 1993).

Revilla 1995 V. Revilla Calvo, Producción cerámica, viticultura y propiedad rural en Hispania Tarraconensis (siglos I a.C. – III d.C.), Cuadernos de Arqueología 8 (Barcelona 1995).

Revilla 2004 V. Revilla Calvo, Ánforas y epigrafía en *Hispania Tarraconensis*, in: J. Remesal Rodríguez (ed.), Epigrafía anfórica, Instrumenta 17 (Barcelona 2004) 159–196.

Revilla 2007 V. Revilla Calvo, Las ánforas tunecinas y tripolitanas de mediados del siglo III d. C., in: J. M. Blázquez Martínez – J. Remesal Rodríguez (eds.), Estudios sobre el Monte Testaccio (Roma) 4, Instrumenta 24 (Barcellona 2007) 317–344.

Revilla 2008 V. Revilla Calvo, La producción anfórica en el sector meridional de Cataluña: Prácticas artesanales, viticultura y representaciones culturales, in: López – Aquilué 2008, 189–226.

Revilla 2011/2012 V. Revilla Calvo, Viticultura, territorio y hábitat en el litoral nororiental de Hispania Citerior durante el Alto imperio, in: J. M. Noguera Celdrán – J. A. Antolinos Marín (eds.), De vino et oleo Hispaniae. Áreas de producción y procesos tecnológicos del vino y el aceite en la Hispania romana, AnMurcia 27/28, 2011/2012, 79–95.

Revilla 2015 V. Revilla Calvo, Agricultura, artesanado rural y territorio en el noreste de Hispania Citerior: estructuras y dinámicas, in: Martínez 2015, 1–17.

Revilla 2020 V. Revilla Calvo, Elites y viticultura en Hispania Citerior: representación epigráfica y patrimonio, in: V. Revilla Calvo – A. Aguilera Martín – L. Pons Pujol – M. García Sánchez (eds.), Ex Baetica Romam. Homenaje a José Remesal Rodríguez (Barcelona 2020) 737–750.

Ribera – Tsantini 2008 A. Ribera i Lacomba – E. Tsantini, Las ánforas del mundo ibérico, in: D. Bernal-Casasola – A. Ribera i Lacomba (eds.), Cerámicas Hispanorromanas. Un estado de la cuestión (Cádiz 2008) 617–634.

Rizzo 2014 G. Rizzo, Ostia 6. Le Terme del Nuotatore. Le anfore, Ostia e i commerci mediterranei. Studi Miscellanei 38 (Rome 2014) 67–481.

Rizzo 2018 G. Rizzo, Ostia, le anfore e i commerci mediterranei. Un bilancio preliminare, ArchCl 69, 2018, 223–266.

Rodà 2010 I. Rodà de Llanza, La promoción de las élites en las ciudades del *Conventus Tarraconensis*, in: F. J. Navarro Santana (eds.), Pluralidad e integración en el mundo romano, Colección Mundo Antiguo 13 (Pamplona 2010) 177–188.

Roux 2003 V. Roux, Ceramic Standardization and Intensity of Production: Quantifying Degrees of Specialization, American Antiquity 68, 4, 2003, 768–782.

Sanchez 2009 C. Sanchez, Narbonne à l'époque tardorépublicaine: chronologie, commerce et artisanat céramique, RANarb Suppl. 38 (Montpellier 2009).

Sanchez 2015 C. Sanchez, Les amphores de Tarraconaise dans les contextes narbonnais, in: Martínez 2015, 165–180.

Sanmartí et al. 1998 J. Sanmartí Greco – J. Morer de Llorens – R. Bruguera, Les àmfores ibèriques de la Catalunya meridional, Quaderns de prehistòria i arqueologia de Castelló (Castellón 1998) 267–290.

Sanmartí et al. 2004 — J. Sanmartí – R. Bruguera – M. Miñarro, Las ánforas ibéricas de la costa de Cataluña, Documents d'archéologie méridionale, 2004, 379–403; DOI: 10.4000/dam.746

Scheidel 2009 — W. Scheidel, In search of Roman economic growth, JRA 22, 46–70.

Schiavone 1996 — A. Schiavone, La storia spezzata. Roma antica e Occidente moderno (Rome 1996).

Tchernia 2011 — A. Tchernia, Les Romains et le commerce (Naples 2011).

Tchernia – Zevi 1972 — A. Tchernia – F. Zevi, Amphores vinaires de Campanie et de Tarraconaise à Ostie. Recherches sur les amphores romaines. Actes du Colloque de Rome, Publications de l'École française de Rome 10 (Rome 1972).

Tremmel 2009 — B. Tremmel, Die römische Keramik aus Holsterhausen, Augusteische Marschlager und Siedlungen des 1. bis 9. Jahrhunderts in Dorsten-Holsterhausen. Die Ausgrabungen 1999–2002 (Mainz 2009) 100–126.

Tremoleda 2000 — J. Tremoleda Trilla, Industria y artesanado cerámico de época romana en el nordeste de Cataluña, BARIntSer 835 (Oxford 2000).

Tremoleda 2008 — J. Tremoleda Trilla, Les instal·lacions productives d´àmfores tarraconenses, in: López – Aquilué 2008, 113–150.

Tremoleda 2016 — J. Tremoleda Trilla, Dressel 8 ampuritana (Tarraconensis northern coastal area), Amphora ex Hispania. Landscapes of production and consumption <http://amphorae-icac.cat/amphora/dressel-8-ampuritana-tarraconensis-northern-coastal-area> (14. 04. 2023).

Tsantini 2007 — E. Tsantini, Estudi de la producció i la distribució d'àmfores ibériques en el nord-est peninsular a través de la seva caracterització arqueomètrica (PhD thesis University of Barcelona 2007).

van den Berg 2013 — J. van den Berg, La primera evidencia de un producto ampuritano en el interior de la frontera germana. Hallazgo de un sello anfórico ANTH en Coriovallum (Heerlen, Holanda), Boletín Ex Officina Hispana 4, 2013, 11–13.

Vila 2009/2010 — L. Vila Socias, Canvi tecnològic, disseny ceràmic i simulació virtual: el cas de les àmfores romanes, o la mida és realment tan important?, Mayurqa 33, 2009/2010, 161–174.

Vila 2011 — L. Vila Socias, Una Arqueometria del Canvi Tecnològic: Producció I consum d'àmfores durant el canvi d'Era en la zona nord de la costa catalana (PhD thesis University of Barcelona 2011).

Wilson 2011 — A. Wilson, Developments in Mediterranean shipping and maritime trade from the Hellenistic period to AD 1000, in: D. Robinson – A. Wilson (eds.), Maritime Archaeology and Ancient Trade in the Mediterranean, Oxford Centre for Maritime Archaeology Monograph 6 (Oxford 2011) 33–59.

Fanette Laubenheimer

STANDARDIZATION OF AMPHORAE IN GALLIA NARBONNENSIS

THE EXCEPTIONAL CASE OF THE GAULOISE 4 TYPE

Abstract
Vineyards and amphora production are two essential facets of the Roman colonization of Gallia Narbonnensis. The first Roman amphorae produced in the province seem to have lacked standardization in both volumetric and formal aspects. As was the case with foreign amphora types, like Italic Dressel 1 and Dressel 2/4 or Tarraconensis Pascual 1, this lack of standardization is evident in the first provincial types, mainly in the Gauloise 2, a new type produced around Marseille, a city that had been producing transport amphorae for wine export since before the Roman conquest. The Gauloise 2 form also represented the initiation of production of the large group of flat bottom amphorae of south Gaul. This ›family‹ of typical Gauloise amphorae included many different types, most of them with a short trajectory and limited level of standardization, the result of the relatively few workshops engaged in their production and also their limited distribution. However, already in the first part of the 1st century A.D., the general standardization of one amphora type becomes evident, the Gauloise 4, produced in massive quantities in many workshops throughout Gallia Narbonnensis. The Narbonnensis Gauloise 4 is a special case study since it represents an amphora type that was created in many workshops and attained a large distribution in external markets, mainly in the large military import centers in the northern frontiers, as well as in Rome and other areas of the western Empire. But we must also question what we mean by amphora standardization. This is not an easy question to answer, but this chapter offers one detailed comparative example of standardized production of pottery vessels in a traditional workshop in Spain that was in operation at the end of the 20th century. This case study clearly illustrates how the skills of potters and the organization of production were essential to achieving a certain standardization level.

The Roman colonization of Gallia Narbonnensis began at the end of the 2nd century B.C. with the foundation of Narbonne in 118 B.C., and later the foundation of several colonies. But we must wait until the last decades B.C., and particularly the beginning of the 1st century A.D., to see the development of vineyards and the production of the first wine amphorae.

At first, various types of amphorae were produced, but in small quantities. Some were imitations of imported models, like the Italian Greco-Roman types, the Dressel 2/4, or the Spanish Pascual 1 types, among others. They were produced mainly, but not exclusively, in the Marseilles area. Marseilles also started to produce a new flat-bottomed type, Gauloise 2, the first typically Gaulish amphora that was imitated elsewhere in Gallia Narbonnensis. These early productions were small and not standardized. For example, we find several types of Gaulish Dressel 2/4 in the same workshop. These productions also differ from one workshop to another. Exports were mostly over short distances and are not well known.

There was a great change during the second half of the 1st century and the 2nd century A.D., with the large increase in vineyards, *villae*, and wineries throughout the country. At that time, a new type of amphora appeared, Gauloise 4, which seems to have been standardized in many places of production throughout Gallia Narbonnensis.

But before we go any further, I would like to ask the following question: what do we mean by standardization of amphorae? This is an old question that I asked myself in the 1980s, and I would like to share here my experience on the subject.

CERAMIC STANDARDIZATION

Standards reflect a modern notion or concept. In Roman times, an amphora was a liquid measure estimated today at 25.89 liters, almost 26 liters. This kind of indication is never found in the *tituli picti* of amphorae. On the Gauloise 4 amphorae from Gaul, we sometimes find the term *modius*, a smaller unit measurement of 8.63 liters. If it was necessary to write information concerning volume on an amphora, it implies that the amphora itself was not a sufficient indicator of a precise and standardized volume of wine. The same applies to Dressel 20 oil amphorae from Baetica, for which we have many examples.

Why were such amphorae not standardized for their volume? Years ago, in 1982, I asked myself this question. My colleague and friend Charlette Arcelin-Pradelle had the same question concerning the gray clay proto-historic ceramics of Provence she was studying. Consequently, we wondered if the way we were working in archaeology, the way we measured ceramics, was correct when applied to potters' mass productions.

So we decided to go to Spain, near Valencia and Castellón, where we knew that traditional potters were working. At that time, it was still possible to find productions very similar to ancient ones: no mechanization, no touristic production, just an ordinary production for everyday life. We found eight locations where traditional potters were working. We were able to work there as archaeologists, to study production, and to test real products of the same shape from one or several potters, in the same place or in several workshops. We needed to understand whether our archaeological methods of characterization were correct or not, and there we would find the answer to all our questions[1].

We found a place in Alcora where two brothers were producing traditional small amphorae of an 11-liter capacity – an Arabic unit of measure – used to carry water to the fields for workers (fig. 1). These potters had a warehouse in which they stored their finished products to be sold. There we found 24 of the brothers' amphorae, which were mixed together such that we did not know the products of one from those of the other.

1 Amphorae from Alcora workshop (Spain) by two different potters (photo © F. Laubenheimer)

Working as usual with our measurements, we did not notice any difference for 11 variables apart from the diameter of the foot. Thus, two different groups were clearly identified: three amphorae on one side and 21 on the other. The difference lay in the diameter of the base, which for one group was larger than for the other.

Then we mixed up the two groups and asked the first potter to identify which amphorae belonged to him. He answered without hesitation, showing the three in our first group. We mixed up the amphorae again and asked the same question of the second potter. He replied very easily as well, indicating the second group with 21 amphorae. So we asked the two brothers how they recognized one of their own production. The answer was very simple: »Because I made it myself!« Elsewhere, another potter said: »Pottery is like writing, each potter has his own way!« So, it was easy for one potter to identify his own production in the middle of several amphorae, even if he could not explain why. This also confirms that our way of characterizing different groups was correct.

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1 Arcelin-Pradelle – Laubenheimer 1985.

We also studied other types of large pottery productions in different workshops, observing how the potters worked with the clay and in particular how they positioned their bodies. We noticed that to make the diameters of the foot, the body, the neck, and the rim of a ceramic container, the potter turned slowly and very carefully and reached a stable position. He could even check the diameter if needed. But when the potter turned the clay very fast to obtain the height of the belly of the amphora, for instance, his body was unbalanced. Thus, it was very difficult for him to obtain a standard size for the maximum diameter.

We checked this observation by measuring several parameters for groups of pottery in different workshops where variable diameters were the most precise but not the position of the maximum diameter. This is significant to establish the capacity of amphorae.

Let us come back to the two potters of Alcora and their amphorae. They produced amphorae supposedly of 11 liters. But in the end, the variation in the capacities was ±10 % of this 11-liter goal: we measured the volume of several amphorae from the two brothers' productions[2]. They sought to make an amphora of 11 liters and did their best, but it was impossible for potters who make large pots like amphorae to obtain such a precise and standard capacity. There was a limit to standardization for the hand-made production of amphorae.

PRODUCTION OF GAULOISE 4 IN GALLIA NARBONNENSIS

During the Augustan period and the first half of the 1st century, many different types of amphorae were produced in Gallia Narbonnensis: imitations of foreign models like Dressel 1, Pascual 1, and Dressel 2/4, as well as flat-based creations like Gauloise 2, Gauloise 3, and Gauloise 7. These types were not standardized and show many variations. Distribution remained limited, and the jars were used for local wine trade and consumption. After the first half of the 1st century, fewer amphora types were produced. Three new types appeared: Gauloise 1, Gauloise 5, and Gauloise 4. They were standardized from one workshop to another.

Gauloise 1 was a special production from the right bank of the Rhône River, in Languedoc, mainly in the department of the Gard (fig. 2). The distribution was directed to the local population, mostly to the north of the Massif Central and sometimes up the Rhône Valley to Lyon but not farther north. They were never exported to the ports of the south coast, nor were they present in maritime trade. With very wide and solid flat bottoms, these amphorae seem to have been conceived for land transport[3]. They were produced from the 1st century to the 3rd or beginning of the 4th century.

The production of Gauloise 5 was specific to Provence, on the left side of the Rhône River (fig. 3). They were also standardized and exported to the coast, and from there to Rome during the second half of the 1st century but not later. Trade of Gauloise 5 to the north or to the German border through the Rhône Valley was exceptional.

The case of standardized Gauloise 4 is completely different. From the second half of the 1st century to the beginning of the 4th century, they were produced throughout Gallia Narbonnensis (fig. 4). The workshops were very numerous. More than fifty are known today, and we presume there were many more, in particular throughout the Rhône Valley, according to the analysis of clay and stamps. Most of these workshops produced only Gauloise 4. If they made other types of amphorae as well, the Gauloise 4 type could be ten times as numerous as the others produced. Gauloise 4 was therefore mass-produced. During the 1st and 2nd century, this production was so standardized that one cannot distinguish the Gauloise 4 of one workshop from that of another, even when they come from distant parts of the *provincia*. Workshops were located in the country *villae* and close to large ports like Arles.

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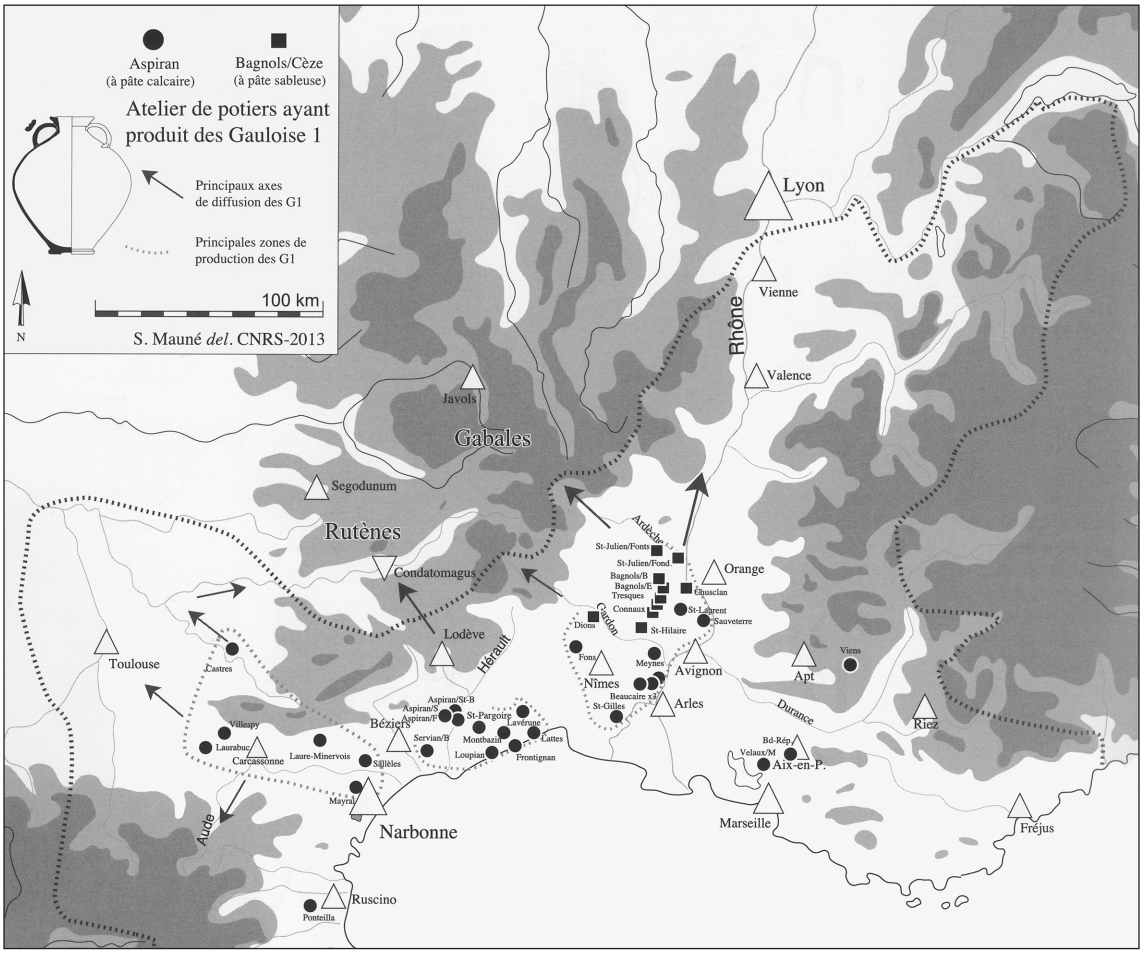
2 Laubenheimer 1985, 238.

3 Bigot 2017.



2 Gauloise 1 workshops on the right bank of the Rhône River and especially in the Gard department (from: Mauné 2013, fig. 9)

The Gauloise 4 amphora was made for large-scale and distant trade. Great quantities of exports reached northern countries through Arles and the Rhône Valley to northern Gaul, the German border, and Great Britain. To the south, great quantities were also exported to Italy and Rome. Furthermore, Gauloise 4 amphorae are found along the entire Mediterranean coast, both west and east, and as far as the deserts of Syria at Palmyra, Egypt, and beyond the Empire[4].

Were the contents of Gaulish wine amphorae a reason for the different standardized types? The few *tituli picti* on the amphorae we know show that there was no special quality of wine connected to one particular type of amphora[5]. For instance, *Aminneum*, a good wine, was transported in Gauloise 1, Gauloise 3, and Gauloise 4. *Picatum*, another wine tasting of resin, was carried in Gauloise 4 as well as in Gauloise 5. Gauloise 4 amphorae carried different kinds of wine. Thus, there is no relationship between the type of an amphora and the particular wine it contained.

DIFFICULTIES OF MANUFACTURE

Many Gauloise 4 amphorae were found in the excavation of the workshop of Sallèles d'Aude, near Narbonne. They were broken and piled up in huge rubbish dumps in the 2nd and 3rd centuries.

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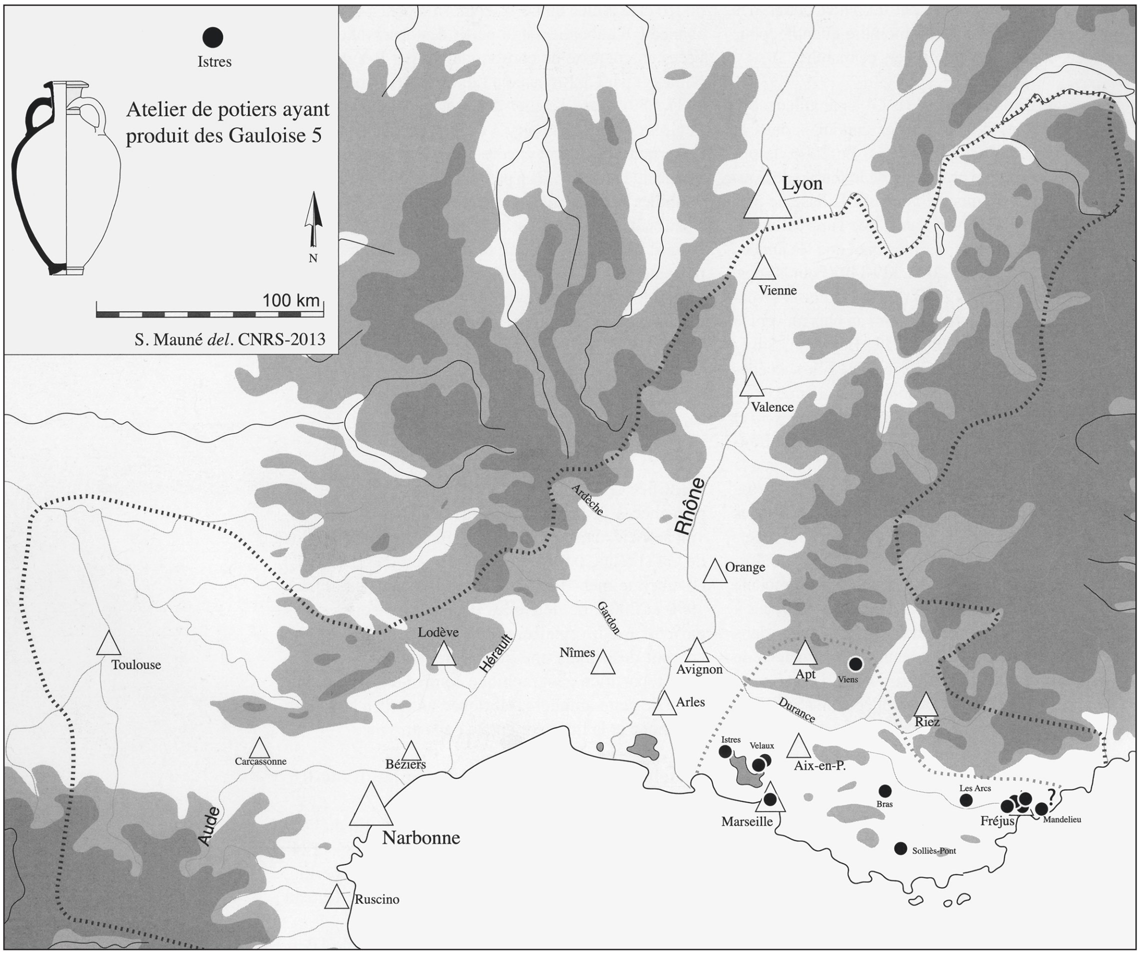
4 Laubenheimer 2017/2018.
5 Laubenheimer 2004.



3 Gauloise 5 workshops on the left bank of the Rhône River (from: Mauné 2013, fig. 12)

We have been able to completely restore 15 of them (fig. 5). It was the first time that we had a series of complete amphorae of the same type from one workshop[6]. Apparently, the amphorae looked similar and yet at the same time different, but why?

Necks, rims, and bases were nearly the same; the main differences were in the total height (61.5–67.2 cm), the maximum diameter (38.4–42.4 cm), and most of all in the volume (29.9–37.7 liters, a variation of nearly 8 l) (fig. 6; tab. 1). When we arrange the amphorae in order of increasing volume, we see that neither the height nor the diameter follow a similar ascending order. Increasing volume has a regular progression. No different moduli appear (fig. 7).

The difficulty for the potters working on such large pieces explains this wide variation in volume. For a Gauloise 4 amphora, the potter had to turn 15 kg of clay. To obtain a diameter of 40 cm at 40 cm from the bottom is a ›tour de force.‹ Additional measurements made on complete amphorae found in various marketplaces show the same results[7]. Thus, we see that the standardization of Gauloise 4 had its effective limit due to the manufacturing technique by hand. Potters did their best to make an amphora as close as possible to a consistent volume, and this seems to have been enough for them.

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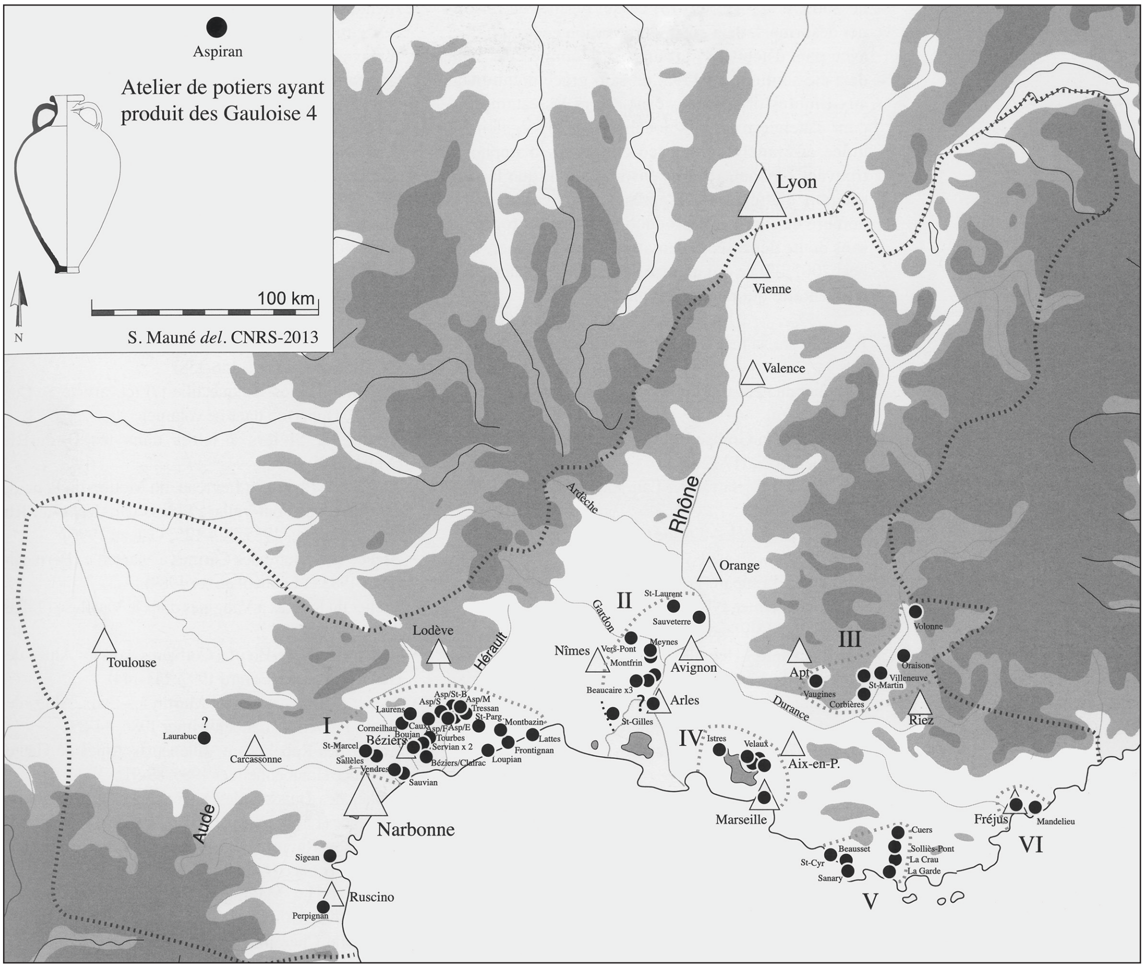
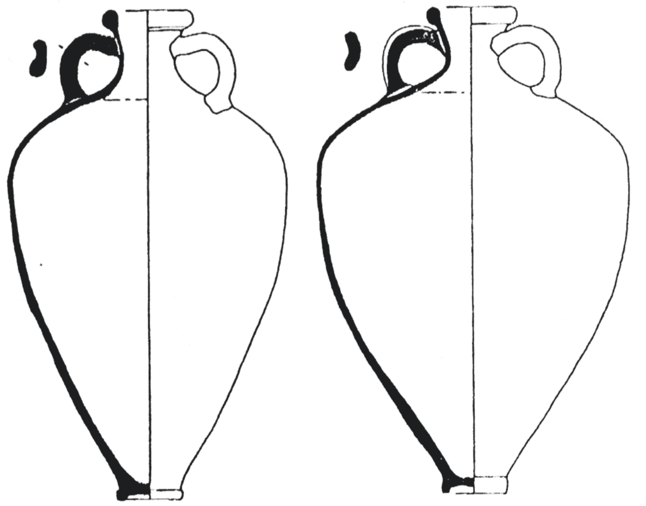
6 Laubenheimer – Gisbert 2001.
7 Laubenheimer 1985, tab. 15; 331.



4 Gauloise 4 workshops in Gallia Narbonnensis (from: Mauné 2013, fig. 13)

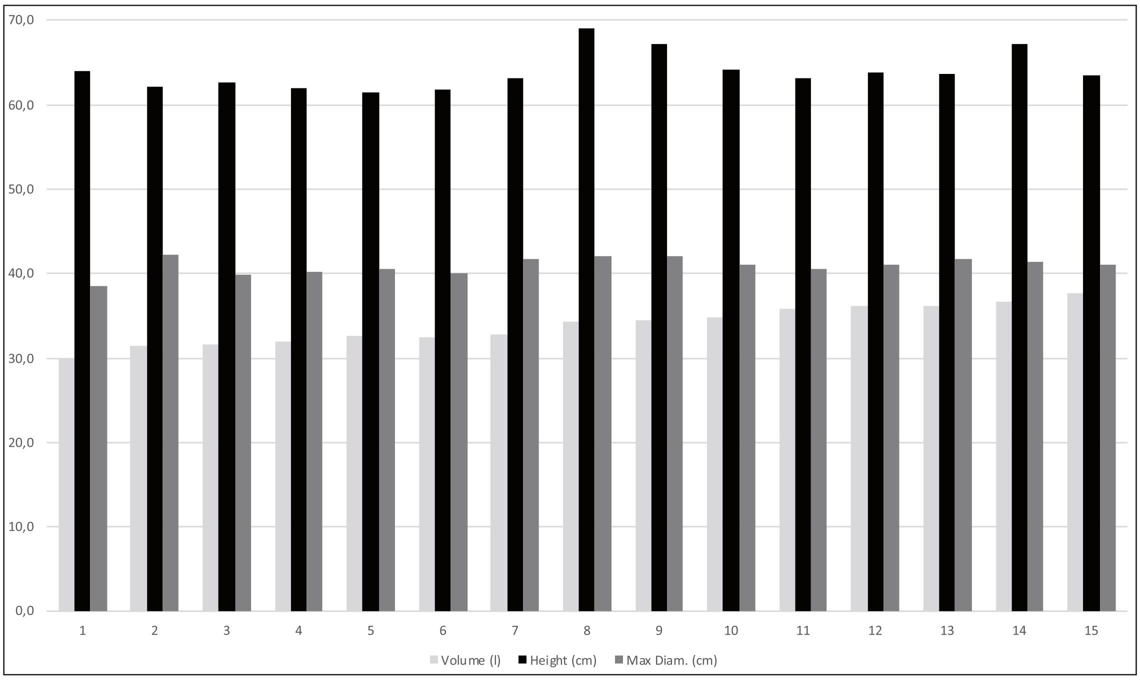
5 Gauloise 4 amphorae from Sallèles d'Aude workshop (photo © F. Laubenheimer)



6 Gauloise 4 amphorae from Sallèles d'Aude workshop, left 29.9 liters, right 37.7 liters (drawing © F. Laubenheimer)

Inventory ID	Number	Volume (l)	Height (cm)	Max. Diam. (cm)
S89 29011 1215	1	29.9	64.0	38.5
S89 29011 1275	2	31.4	62.1	42.2
S89 29003 951	3	31.6	62.6	39.8
S89 29011 1279	4	31.9	62.0	40.2
S89 29011 1282	5	32.7	61.5	40.5
S89 29003 558	6	32.4	61.8	40.0
S89 29011 1280	7	32.8	63.2	41.7
S77 HI 17-18 161	8	34.3	69.0	42.0
S78 HI 17-18 160	9	34.5	67.2	42.0
S86 L17-18 1	10	34.8	64.2	41.0
S89 29011 1267	11	35.9	63.2	40.5
S89 29011 1228	12	36.1	63.9	41.0
S89 29011 1285	13	36.2	63.6	41.8
S78 L17-18 32	14	36.7	67.2	41.4
S89 29011 1283	15	37.7	63.5	41.1

Table 1 Volume and measurements of complete Gauloise 4 amphorae from Sallèles d'Aude



7 Gauloise 4 amphorae from Sallèles d'Aude following crescent volume, which is not associated with maximum height or maximum diameter (© F. Laubenheimer)

WHY THE STANDARDIZATION OF AMPHORAE IN GALLIA NARBONNENSIS?

During the initial production of amphorae in Gallia Narbonnensis, several types coexisted and there was no standardization. Vineyard owners and even potters might have decided which type of amphora was to be produced locally, and both the market and consumption were locally focused.

With the increase of viticulture in the middle of the 1st century, amphora types changed, and there were fewer and more standardized types. For the first time, the export trade moved beyond the province. For example, Gauloise 1 amphorae were exported to the north, to the Massif Central, and to Lyon. Then trade extended abroad to Italy with Gauloise 5 from Provence. The introduction of Gauloise 4 brought a big step forward in interregional trade with the whole of the Roman world and beyond[8].

What prompted the production of the Gauloise 4 amphora type everywhere in the province? First, Gaulish potters created a new form with a large capacity, around 30 liters, but only a low weight of around 10 kg. This represents a kind of efficiency revolution. The traditional forms, like Dressel 1 or Dressel 2/4, have a capacity-to-weight ratio that is less conducive to trade: around 20 kg for 20 liters. Certainly, other key factors for the success of the Gauloise 4 type were the market and probably the international merchants who bought wine from producers. Vineyard owners seem no longer to have had a choice with respect to the shape of their amphorae. At that time, Rome needed to import wine from the provinces for both the capital itself and for the army. That rationale is how Rome approached its politics in Gallia Narbonnensis. Gaulish wine from Gallia Narbonnensis was recognizable first through the standardized shape of its regional amphorae and then by the *tituli picti* that indicated the quality. Here, the standardization of amphorae was related to the large economic scale and the political context of trade.

BIBLIOGRAPHY

Arcellin-Pradelle – Laubenheimer 1985 — C. Arcellin-Pradelle – L. Laubenheimer, La notion de série de production en céramique tournée, Cahiers du GIS 7, 1985, 129–139.

Bigot 2017 — F. Bigot, Nouvelles données, nouvelles réflexions sur la production et la diffusion des amphores gauloises à partir de l'étude de contextes portuaires et littoraux de Gaule Narbonnaise (Ier s. av. J.-C.–IVe s. ap. J.-C) (PhD thesis Université Paul Valéry Montpellier III 2017).

Laubenheimer 1985 — F. Laubenheimer, La production des amphores en Gaule Narbonnaise sous le Haut-Empire, Annales littéraires de l'Université de Besançon 327 (Paris 1985).

Laubenheimer 2004 — F. Laubenheimer, Inscriptions peintes sur les amphores gauloises, in: M. Feugères – P.-Y. Lambert (eds.), L'écriture dans la société gallo-romaine, Gallia 61 Dossier (Paris 2004) 153–171.

Laubenheimer 2016 — F. Laubenheimer, Le vin gaulois du Midi aux frontières de l'Empire et au-delà, in: Le regole del giocco. Tracce archeologici racconti. Studi in onore di Clementina Panella, LTUR Suppl. VI (2016) 569–577.

Laubenheimer 2017/2018 — F. Laubenheimer, Exporter le vin de Narbonnaise dans l'Empire et au-delà, RANarb 50/51, 2017/2018, 25–39.

Laubenheimer – Gisbert 2001 — F. Laubenheimer – J. Gisbert Santonia, La standardisation des amphores Gauloise 4 des ateliers de Narbonnaise à la production de Denia (Espagne), in: F. Laubenheimer (ed.), 20 ans de recherches à Sallèles d'Aude, Presses Universitaires Franc-Comtoise (Besançon 2001) 33–50.

Mauné 2013 — S. Mauné, La géographie des productions des ateliers d'amphores de Gaule Narbonnaise pendant le haut-Empire; nouvelles données et perspectives, RANarb 46, 2013, 335–374.

[8] Laubenheimer 2016.

Michel Bonifay – Claudio Capelli – Alessia Contino –
Elyssa Jerray – Jihen Nacef (†)

REGIONAL AMPHORA STANDARDIZATION IN ROMAN AFRICA (146 B.C.–A.D. 699+)[1]

Abstract
The present contribution aims to describe African amphora production between the late Republican age and Late Antiquity to show both how the African amphora underwent a long succession of standardization and diversification during the centuries and to reflect upon the different periods and regions where the standardized forms appear and develop. The paper is focused on three main research issues: the introduction of the Greco-Roman model in Africa and the first efforts at standardization, the development of different patterns of amphora production in different regions and its impact on the amphora shape, and the last transformations of typology, capacity, and production centers of the late Roman, Vandal, and Byzantine periods. Lastly, the paper compares the chrono-typological data of amphora production with the general chronology of Africa from the mid-2nd century B.C. to the end of the 7th century A.D.

INTRODUCTION

African amphora genealogy shows a long succession of standardization and diversification phases. The present contribution aims to give a panoramic view over African amphora production between the second half of the 2nd century B.C. and Late Antiquity, reflecting upon the following question: when, how, and why did standardized amphora forms develop in different regions of Africa?

In particular we will place special emphasis on:

1) the introduction in Africa of the Greco-Roman model of amphora during the 2nd century B.C. and the survival of the Punic amphora types until Late Antiquity;
2) the two different patterns of amphora production in Africa during the mid-Roman period and their impact on amphora typology;
3) the transformations during the late Roman, Vandal, and Byzantine periods, in terms of container typology, capacity, and production centers.

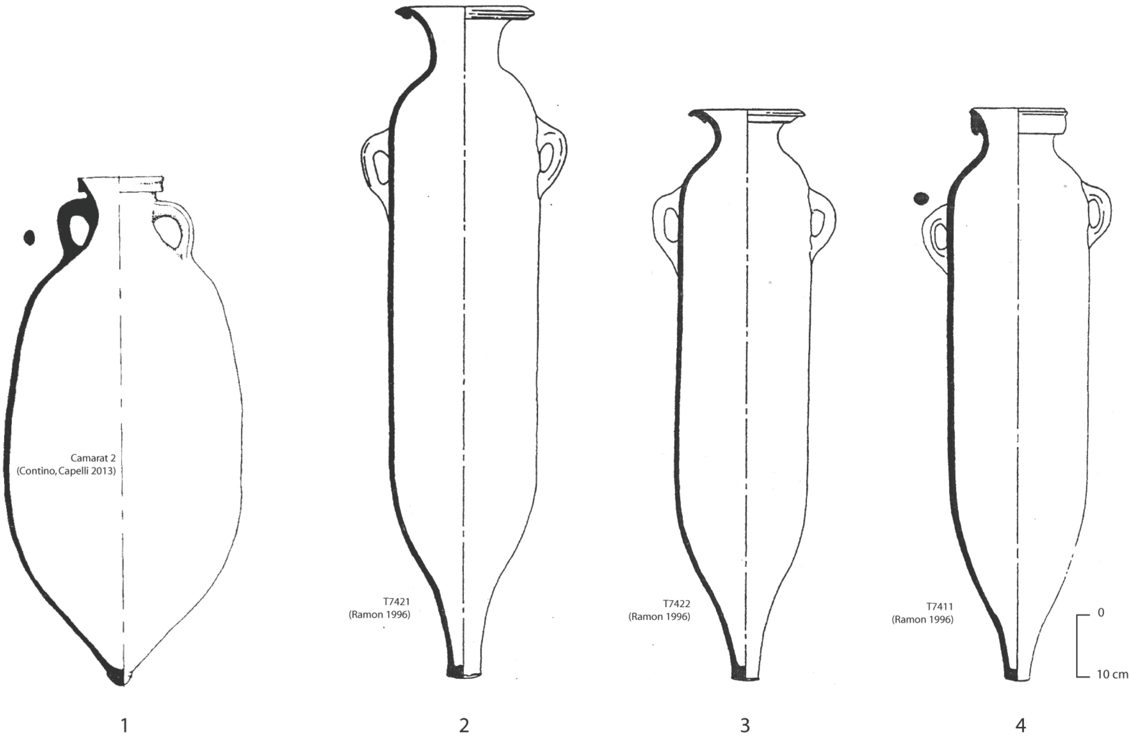
This short survey will focus on the territory of the Roman provinces of Africa Proconsularis, Numidia, and Mauretania Caesariensis, today included in the territory of Algeria, Libya and Tunisia.

THE INTRODUCTION OF THE GRECO-ROMAN MODEL OF AMPHORA AND THE SURVIVAL OF THE PUNIC AMPHORA TYPES

Introduction of the Greco-Roman Model of Amphora

The first Greco-Roman amphora known in Africa is the ovoid ancient African amphora (fig. 1, 1). Ovoid republican amphora production is attested throughout the Mediterranean. This Greco-Roman model seems to have arrived in Africa at the beginning of the second half of the 2nd cen-

[1] This paper is dedicated to our dear colleague Jihen Nacef, lecturer at the University of Monastir (ISEAHM), prematurely deceased on 1 August 2018, who devoted her too-short life to studying the Roman amphora production in the Sahel region of Tunisia.



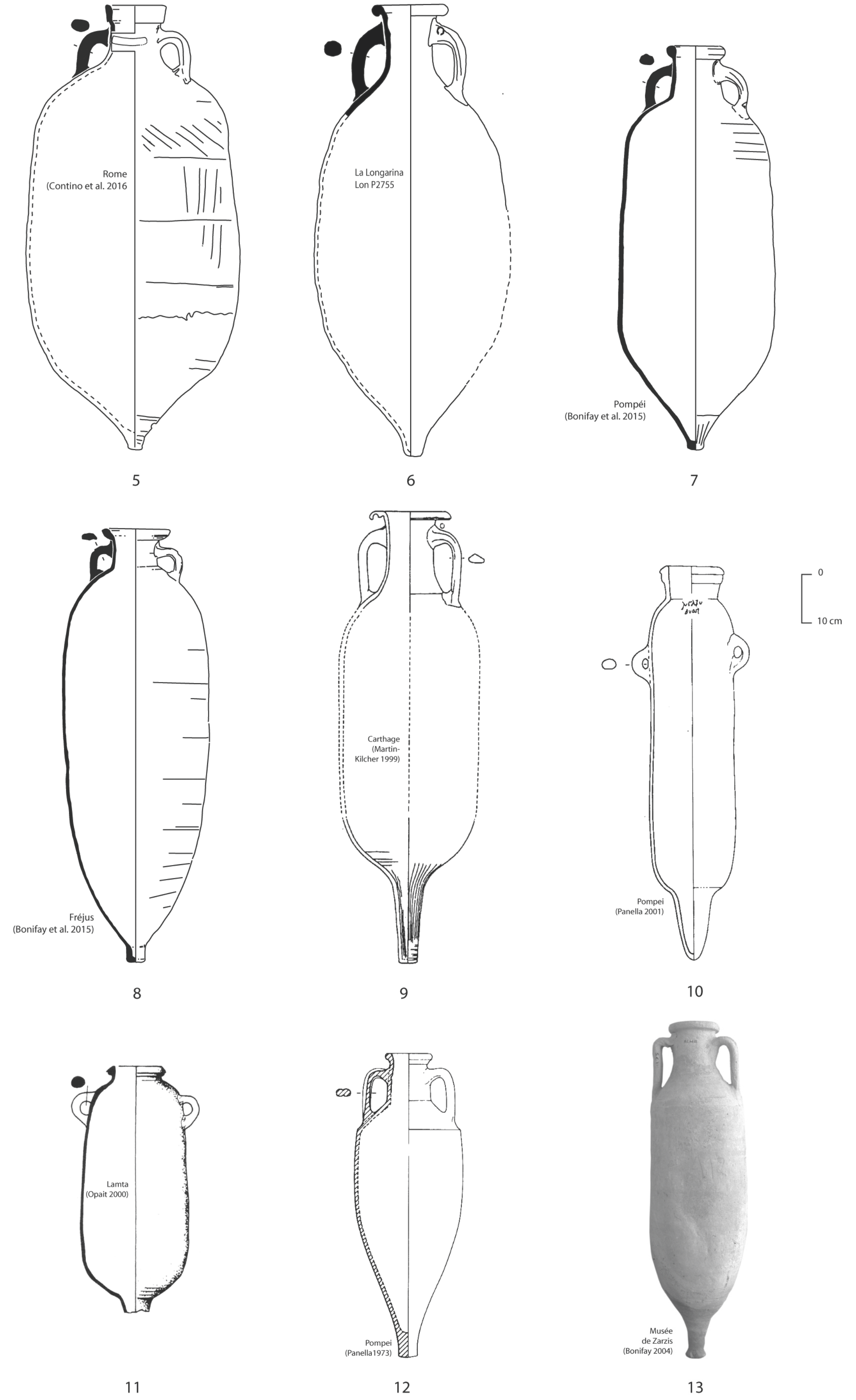
1 African amphorae. Standardization phase (Republican-Augustan period). First Greco-Roman type: Ancient African (1). 2: Classic Punic/Neo-Punic types: Van der Werff 1–3 (2–4) (© see the individual numbers)

tury B.C., and the appearance of this new shape in northern Africa could be attributed to two main causes: a) the movement of Greek populations across the Mediterranean, particularly after the fall of Corinth in 146, which diffused this model of amphora all along the Mediterranean coasts, as is suggested too for the production of ovoid amphorae on the Adriatic coast of Italy[2]; b) the birth of the Roman province of Africa in northwest Tunisia in 146 B.C., with Utica as the first capital and then Carthage. The colonization of the African coast and inland, beginning with the northwest region, caused the arrival of the *colonii italici*, who perhaps brought typical Italic traditions and forms of amphorae with them[3].

The recent systematic typo-petrographic study of those containers carried out on samples from the Nuovo Mercato Testaccio in Rome and from Pompeii, La Longarina, Ostia, Cap Camarat 2, and Valencia allows us to localize the start of the production in northwest Tunisia (so-called Zeugitana), more specifically in the Carthage-Tunis-Utica triangle[4], and not in Tripolitania as previously proposed[5]. This hypothesis has been confirmed by Imed Ben Jerbania, who recently discovered production traces in the hinterland of Carthage and Tunis, and then in Utica[6]. In fact, this new hypothesis appears quite obvious because this is the area of the first official Roman settlement.

Moreover, the analyses allow us to propose that two different types of amphorae descend from the ancient African amphora. First is the Dressel 26 type (fig. 2, 5), initially identified at Castro Pretorio by Heinrich Dressel and recently studied and republished[7]. This amphora is bigger than the ancient African one and more cylindrical with a collar rim. Its capacity can reach around 80 liters for the biggest examples. The typo-petrological study allows us to propose a production area located in the hinterland of Carthage. This amphora seems to be distributed only during the

2 Manacorda – Pallecchi 2012; Panella 2013, 192 f.
3 Contino – Capelli 2016, 541; Contino – Capelli 2019.
4 Capelli – Contino 2013; Contino 2015.
5 Empereur – Hesnard 1987, 69 fig. 42.
6 Ben Jerbania 2013; Ben Jerbania 2017.
7 Contino et al. 2016.



2 African amphorae. Diversification phase (1st cent.–mid-2nd cent. A.D.). Greco-Roman types: Dressel 26 (5), early Ostia LIX (pseudo-ovoid amphora) (6), Ostia LIX (7), Ostia XXIII (8). Romanized Punic type: Carthage Early Amphora IV (9). Punic tradition types: Schöne-Mau XL (10), Leptiminus II (11). Introduction of exogenous Mediterranean types: Schöne-Mau XXXV (12), ›pseudo-Dressel 2/4‹ (12) (© see the individual numbers)

1st century A.D. The second type is a pseudo-ovoid amphora with an annular ring (fig. 2, 6), attested in the 1st century A.D. and similar in rim and fabric to the Ostia LIX amphora, the first cylindrical Greco-Roman amphora produced in Africa, with a rounded rim, a wide cylindrical neck, short bent handles[8], and a capacity of 40 liters. The pseudo-ovoid type was probably produced in the region near the current border with Algeria, perhaps close to Tabarka, due to the similarity of the clay with one group of the ancient African and some groups of the two following types. The Ostia LIX and the Ostia XXIII (fig. 2, 7–8) types represent the latest stage of early African amphorae that started with the ancient African type. They appear between the 1st century A.D. and the early 2nd century in northern Tunisia and are the best attested outside Africa during this period.

These new Greco-Roman models of amphorae appeared in northwest Tunisia, then spread towards other, more southern production areas of Africa. For example, it is not impossible that the ancient African type might have provided a model for the production of the first examples of Tripolitana I. In the Longarina context, two pseudo-ovoid amphorae, with handles on the rim, have been identified with Tripolitanian fabrics[9]. On the other hand, the amphora Ostia LIX was imitated in Byzacena, as suggested by the identification of this type in the Salakta workshop by J. Nacef[10]. This discovery attests to the beginning of Roman amphora production in this region that led to the serial and massive production of Africana I and II starting from the mid- to late 2nd century.

It is difficult for these first centuries to propose a pattern that involves agricultural activities, amphora production, and goods distribution. Perhaps we can imagine a low level of surplus production with a low level of exportation and consequently low levels of amphora production and a low level of standardization of the types, which is particularly clear when observing the variety of rims and fabrics attested in the earliest examples. Probably the workshops could be related to the sites of agricultural activities, and there was not yet a system of pottery production, checking, and distribution of goods related to the main cities of the coast, as would happen from the 2nd century A.D. onward. Probably the Ostia LIX and perhaps also the Dressel 26 type carried oil or olives, as recently proposed in a collective article that reinterprets the epigraphy of those containers and specifically the tituli *vir* as *olivae virides*, *str* as *olivae strictae*, *mol* as *olivae mollis* and *tavr* as a place name for *Thabraca*, where olive production is attested[11]. However, recents archeometric studies attested olive oil and other products. At this moment is hard to define the possible reuse of the sampled amphorae, coming from consumption sites.

Survival of Punic Amphora Types

The production of amphorae with a Punic shape – i.e., with handles attached on the shoulder – however, did not stop with the fall of Carthage and the introduction of the Greco-Roman types that just preceded or followed this event. In fact, the standardization process implied by the introduction of the first Greco-Roman type of amphora in Africa in the mid-2nd century B.C. meets the standardization, already in place, of the local Phoenician-Punic types. At that time, three main types shared the Punic territory and markets: Van der Werff 1 (= Maña C2 = Martin-Kilcher A = Ramon T7421/7431) in the north (fig. 1, 2), Van der Werff 2 (= Martin-Kilcher B1 and B3 for the latest variants = Ramon T7311/7422 and T7511/7523) in Byzacena (fig. 1, 3), and Van der Werff 3 (= Martin-Kilcher B2 = Ramon T7211/7411) in Tripolitania (fig. 1, 4). Then, during the second half of the 2nd century and the 1st century B.C., in the region of Utica and the former Carthage, the same workshops produced both the Greco-Roman and the neo-Punic types (Ancient African and Maña C2)[12].

8 Contino – Capelli 2016, fig. 8, 1.
9 Contino et al. 2019.
10 Nacef 2007b; Nacef 2015a (type *Sullecthum* 3).
11 Bonifay et al. 2015. Chemical traces of *Moringa* oil in some exemplars could be explained by a reuse of the amphorae: Djaoui et al. 2015. See more recently Pecci et al. 2021.
12 Utica: Ben Jerbania 2017; Mnihla: Ben Jerbania 2013.

In Zeugitana and Byzacena, the Punic amphora traditions coexisted with the new Greco-Roman types until at least the first half of the 2nd century A.D. In the region of Carthage, the latest variants of the Maña C2 type (e.g., Dressel 18) gave birth, with the shift of the handles from the shoulders to the neck, to the Carthage Early Amphora IV (fig. 2, 9) in the mid-1st century A.D.[13], perhaps as an attempt (without real follow-through) at a new morphological standardization. On the contrary, in the Sahel region, we can see a broad diversification of Punic-tradition types, quite heterogeneous in the details of their shapes, during the 1st century A.D.: small amphorae with a band rim, types Schöne-Mau XL (fig. 2, 10), Vindonissa 592 and similar, as well as Leptiminus II (fig. 2, 11) were produced in Byzacena (central Tunisia) between the cities of Sullecthum, Thapsus, and Leptiminus, according to recent petrographic studies and fieldwork[14]. A workshop was recently studied by Jihen Nacef in Thapsus[15], which showed that the capacity of these containers is generally low (25/30 l).

The production of Punic-tradition amphorae continued throughout the Roman, Vandal, and Byzantine periods. In some regions, these amphorae become rather standardized, as shown by the Tripolitana II type of the 2nd and 3rd centuries A.D.[16] and its successors until the first half of the 6th century (Benghazi LRA 7)[17] or in the production of the northern Hammamet Gulf[18]. In contrast to this general trend, some other regions completely break with the production of Punic-tradition amphorae at the beginning of the 1st century A.D., for example in Jerba and Zitha[19]. For some other regions (Algeria), information is lacking. We do not exactly know the contents of these Punic-tradition amphorae; however, it is clear enough that the Tripolitana II amphora was not devoted to olive oil but rather to fish products and/or wine[20].

Introduction of Other ›Universal‹ Greco-Roman Types

As in other regions of the Empire, amphora standardization here includes the introduction of some ›universal‹ Greco-Roman types. It is not clear whether this should be understood as a phenomenon of imitation or of appropriation/interpretation of a model by local producers. Finally, the same question could have been asked about the introduction of the ovoid type and the appearance of the ancient African amphora.

Nevertheless, two examples of imitation or interpretation of non-African types by African potters are beyond doubt. The first is the African adaptation of the Eastern and then Italian Dressel 2/4 type, with its distinctive bifid handles, during the 1st and 2nd centuries A.D. in Tripolitania, mainly at Oea, Zitha, and Jerba. Even if the production in Africa of Dressel 2/4 amphorae of normal size is not completely excluded, the interpretation of this model in Tripolitania is mainly through a series of small versions that are not homogeneous in their details. Two main variants are known to date[21]: the Schöne-Mau XXXV type (fig. 2, 12), characteristic of central Tripolitania (Oea and perhaps Leptis Magna), and the so-called pseudo-Dressel 2/4 type (fig. 2, 13) in western Tripolitania (Zitha and Jerba). The first one reproduces the sharp edge of the Italian Dressel 2/4 shoulder, while the second one does not; the size and the general shape of the body and of the bottom are also different, all attesting to an incomplete standardization of this type in the same geographic area. The second example is the imitation of Gaulish 4 amphorae in Africa, where they

13 Martin-Kilcher 1999.
14 Contino et al. 2017.
15 Nacef 2015b.
16 Panella 1973.
17 Bonifay et al. 2010a.
18 Bonifay 2004, 92.
19 Jerray 2015; Jerray 2016.
20 Bonifay 2007; Bonifay 2021.
21 Jerray 2016, 162.

are given the name Dressel 30, not only in Mauretania Caesariensis but also in Africa Proconsularis during the 3rd century A.D.[22].

In both cases there is no doubt that wine was the main content, and the workshops were located not far from the ports. In these conditions, one may wonder whether the introduction of local interpretations of the Dressel 2/4 type in Tripolitania could help explain the end of production of the latest variants of the Van der Werff 3 type if this local neo-Punic form was also dedicated to the transport of the wine[23].

THE TWO DIFFERENT PATTERNS OF AMPHORA PRODUCTION IN AFRICA (MID-2ND TO BEGINNING OF THE 5TH CENTURY A.D.)

After a first attempt at amphora standardization following the introduction in Africa of the Greco-Roman ovoid type and after a period of broad typological diversification during the 1st century and the first half of the 2nd century A.D., African amphora production entered a new period of strict standardization. This phenomenon includes two patterns[24].

Pattern 1: Centralized Production Links to Port Cities (Zeugitana and Byzacena, Mid-2nd to Mid-/Late 3rd Century A.D.)

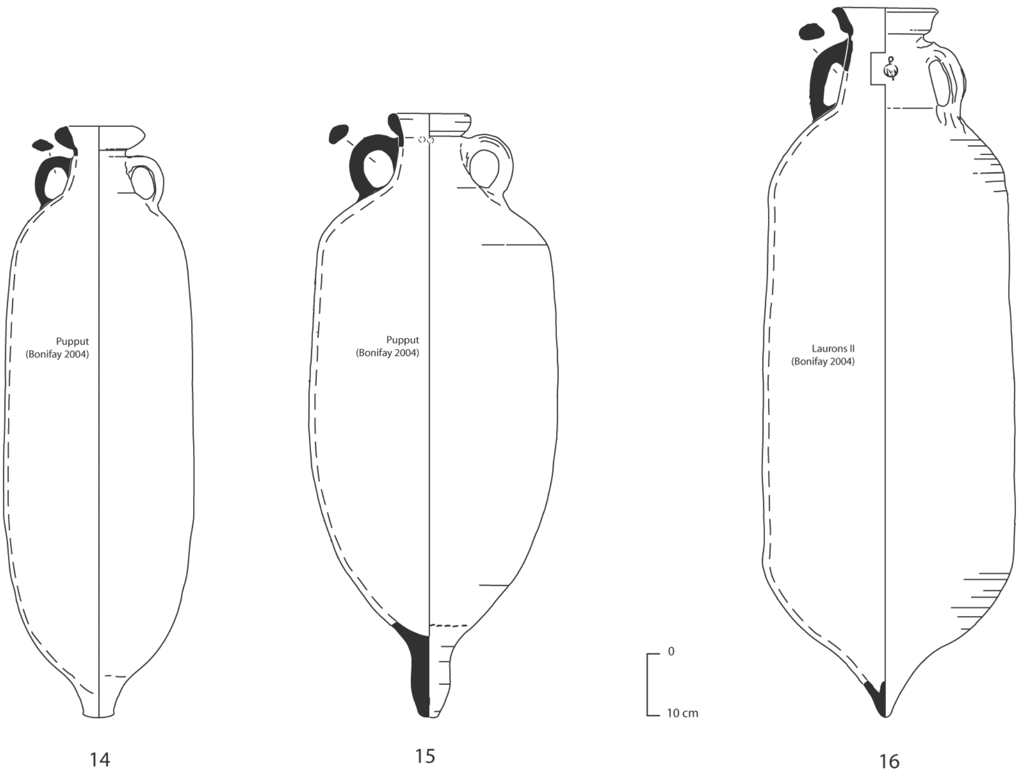
The first pattern shows a centralization of amphora production in the suburbs of the port cities. This pattern is characteristic of the Byzacena region and part of the Zeugitana region, from the mid-2nd century up to the mid- to late 3rd century A.D. Such a centralization of production led to a strict standardization of amphora typology. During this period, the production was dominated by two types[25]:

– Africana I or ›Africana piccola‹ (fig. 3, 14), with a capacity of about 40 liters.
– Africana II (variant A) or ›Africana grande‹ (fig. 3, 15), with a capacity of about 60 liters.

Both types were produced in a series of port cities along the eastern coastline of Tunisia: Thaenae, Acholla (?), Sullecthum, Leptiminus, Hadrumetum in the Byzacena region, and Neapolis/Nabeul in Zeugitana[26]. It is not clear whether Carthage and the northwest part of Tunisia were included in this pattern at this date: late variants of the Ostia LIX and XXIII types, perhaps originating from this region, are attested at Monte Testaccio[27], and information on amphora production in Hippo Regius is lacking. The typological standardization is even reinforced by the standardization of the fabrics. Twenty years of petrographic research on the workshops have made it possible to easily identify the fabrics of each port city's production, even sometimes with a simple lens[28].

Two types mean two different contents. The content of Africana I was olive oil, as evidenced by chemical analyses[29]. Africana I is the African counterpart of the Spanish Dressel 20. The centralization of the production of these amphorae implies the preliminary mobilization in the port cities of olive oil coming in leather skins from the inland regions of Africa. This pattern, demonstrated by J. T. Peña through the Carthage ostraca[30], is probably applicable to all the port cities with a centralized amphora production[31]. The content of Africana II was different: locally produced salted fish or wine from the near or distant hinterland[32]. In this case, standardization clearly

[22] Laporte 2010.
[23] Fentress 2001.
[24] For a general discussion on this point, see more recently: Hobson 2015, 140–142.
[25] Panella 1973.
[26] Bonifay 2004, with bibliography.
[27] Revilla 2007, fig. 70, 14–18.
[28] See most recently Capelli et al. 2016.
[29] See most recently Garnier et al. 2011.
[30] Peña 1998.
[31] Marlière – Torres Costa 2007.
[32] Bonifay 2007; Bonifay 2021.



3 African amphorae. Standardization phase (late 2nd cent.–mid-3rd cent.). Eastern Zeugitana and Byzacena types: Africana I and II (14–15). Tripolitania: type I–III transitional (16) (© see the individual numbers)

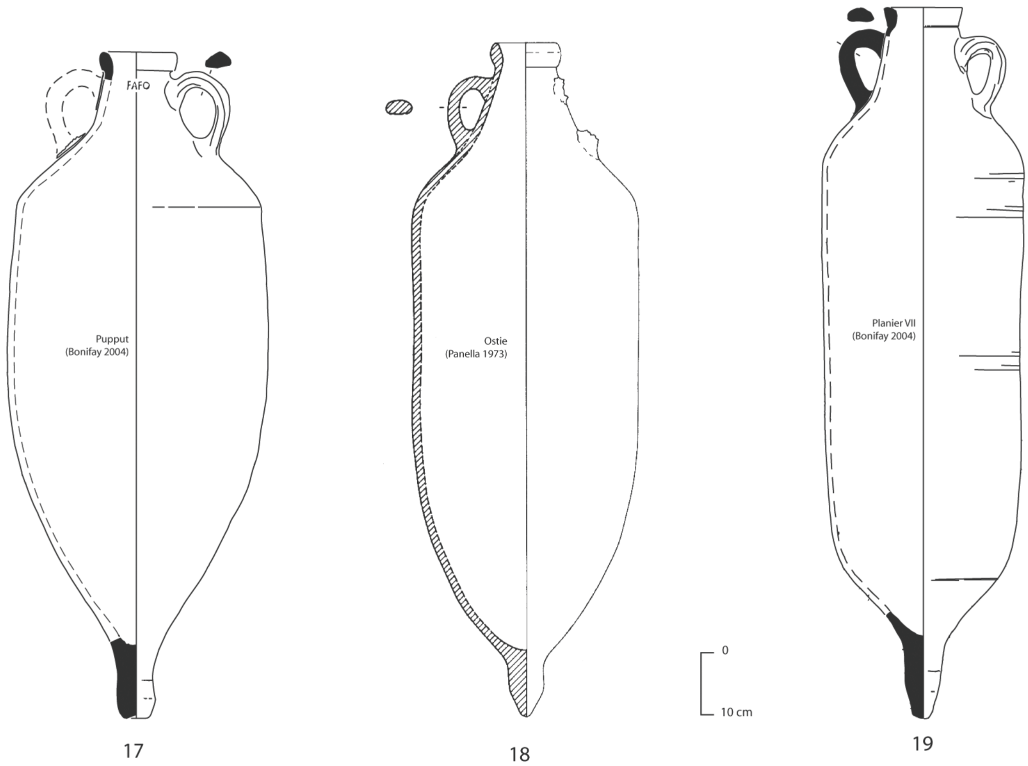
means a controlled general capacity and content (about 42 l for type Africana I, and 62 l for type Africana II A). The traceability implied by the standardized shape is even reinforced by a series of stamps, the first ones indicating the name of the *figlinator* (?) through initials of two or three letters and the second ones specifying in addition or alone the name of the city: *C(oloni I(ulia) N(eapolis)*, *COL(onia) HADR(umetum)*, *LEP(timinus)*, *A SVLL(ecthum)*[33].

This typological uniformity, generated by the mass production of two single types of amphorae across a huge geographical area that covered most of the very large province of Africa Proconsularis, tends to disappear in the mid-3rd century. At that time, we observe the beginnings of diversification internally within the Africana II type with the appearance of types Africana II B (fig. 4, 17) in Hadrumetum, II C (fig. 4, 18) in Nabeul, and II D (fig. 4,19) in the Sahel region. This typological diversification goes together with the development of stamps indicating the name of the port cities. These last stamps could be intended to balance this diversification by reinforcing confidence among purchasers in the traceability of the products[34].

Pattern 2: Production Linked to the Estates (Tripolitania, 1st–4th Century A.D.)

The second pattern shows a rural production linked to estates, which is characteristic of the Tripolitania region from the 1st century into the mid- to late 3rd century A.D. This amphora production includes two types: Tripolitana I and III (fig. 3, 16), both of them devoted to the transport of olive oil[35]. These amphorae are less standardized than the Byzacena amphorae, with great variability in rim profiles as well as fabrics. The size and capacity of the Tripolitana I type seem to vary through

[33] Bonifay 2004, 9–15, with bibliography.
[34] Bonifay 2018, 344.
[35] Jerray 2016.



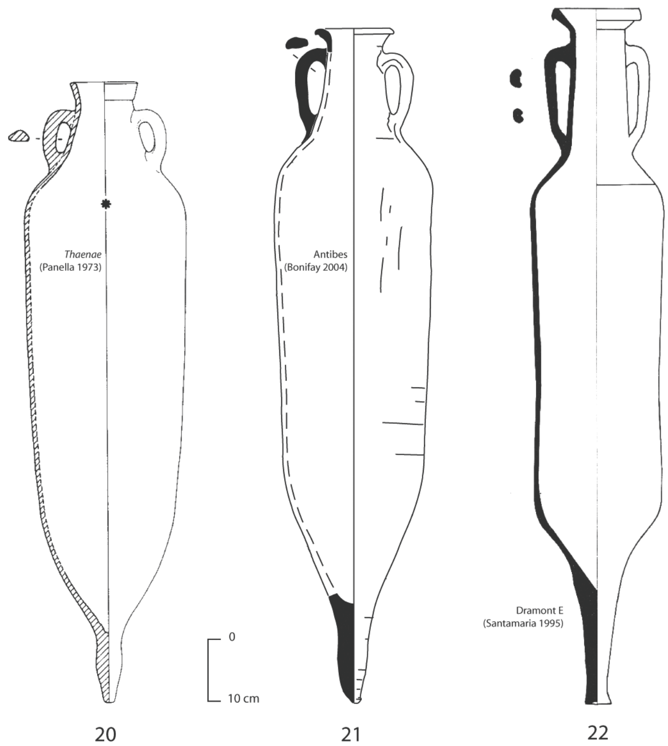
4 African amphorae. Diversification phase (2nd half of the 3rd cent.). Eastern Zeugitana and Byzacena types: Africana II B (17), C (18), and D (19) (© see the individual numbers)

time[36], but the lack of large numbers of complete examples prevents us from having good information on capacity variations in the same period of production.

The lower degree of standardization in comparison with the African amphorae produced at the same time in Byzacena is probably due to the distribution of workshops in the countryside of Tripolitania. The documentation from the Tarhuna plateau, south of Oea and Leptis Magna, is the most significant for Tripolitania. The survey carried out by Muftah Ahmed Alhddad in the hinterland of these cities allowed him to discover more than 15 workshops linked to Roman farms with remains of olive presses[37]. This survey shows us a high degree of specialization in olive oil production, in which the elites of Leptis Magna as well as sometimes the emperor were involved, as demonstrated by the stamps. A series of amphora workshops have also been discovered along the coast[38], most of them probably linked to possible *villae maritimae*, which is perhaps also the case for those found in the surroundings of the present-day city of Tripoli. The situation is more diverse in the western part of Tripolitania, where some workshops are clearly located in the suburbs of port cities (like Meninx) or cities not far from the sea (like Zitha). This is perhaps the particularity of a region at the border with Byzacena, which assumes some of its production patterns[39].

Even if the lifespan of the Tripolitana I and III types was very long – from the first variants of the end of the 1st century A.D. (perhaps the evolution of the local ovoid type, as mentioned above) to the last ones at the end of the 4th or beginning of the 5th century – it seems that the second half of the 3rd century brought a major change, with a reduction in production in the Leptis Magna hinterland, or even a complete collapse in western Byzacena[40]. Some of the latest variants shared morphological similarities (rim profile) with the Africana III type.

36 Bonifay 2004, fig. 55 a.
37 Ahmed 2010.
38 Jerray 2016, fig. 12, 7 (map).
39 Jerray 2016, 163.
40 Jerray 2016, 164 f.



5 African amphorae. Standardization phase (4th cent.). Ubiquitous type: Keay 25/Africana III A–C (20–22) (© see the individual numbers)

The Reorganization of the 4th Century A.D.

African amphora production underwent a major reorganization at the end of the 3rd century or the beginning of the 4th century A.D. A new standard of container appeared: the Keay 25 or Africana III type, which is a medium-sized cylindrical amphora with a capacity of 26–27 liters (= the *amphora* unit of measure)[41]. The morphology was not completely uniform, and many variants have been determined, the majority of which can be grouped into three subtypes (fig. 5, 20–22).

This variability might be able to be explained by the distribution of the workshops, located not only in the suburbs of the port cities – for example in Thaenae[42], Sullecthum[43], Leptiminus[44], Nabeul[45], and Carthage[46] – but also close to the foodstuff production plants (estates and salted-fish factories)[47] from western Tripolitania to perhaps Mauretania Caesariensis. This new African type is rare in that it was imitated outside of Africa, notably in the Iberian Peninsula[48].

Another explanation for the typological variation might be found in the diverse nature of its contents. Wine seems to have been the major content of the most distributed subtype, Keay 25.1, as shown by chemical analyses[49]. It has been proposed that the birth of this type could have been linked with the introduction of the *canon vinarius* at the end of the 3rd or beginning of the 4th century[50]. Subtype Keay 25.3 is typical of the workshop of the Nabeul region and was perhaps

41 Bonifay 2004, 119–122, with bibliography.
42 Bonifay 2004, 31; PhD thesis in progress, by Rémi Rêve.
43 Nacef 2015a.
44 Mattingly et al. 2011, tab. 6, 3.
45 Bonifay et al. 2010b.
46 Ariana workshop: Panella 1982, 179.
47 See, most recently Ben Tahar – Capelli 2018; Ben Tahar et al. 2018.
48 See, for example, Berrocal 2012.
49 Woodworth et al. 2015.
50 Bonifay 2018, 342.

devoted to the transport of fish products. It is still difficult at present to assign a specific subtype of Keay 25 to the transport of olive oil. Lastly, variant Keay 25.2 is a late evolution of the type in general, which foreshadows the changes of the first half of the 5th century.

TRANSFORMATIONS OF THE LATE ROMAN, VANDAL AND BYZANTINE PERIODS

From the beginning of the 5th century onwards, African amphora production experienced significant changes, with a phase of broad diversification during most of the late Roman and Vandal periods, followed by a new attempt at standardization during the 6th and part of the 7th century A.D.

Small-sized Amphorae (so-called Spatheion Type)

We must first deal with the question of the small-sized containers improperly called *spatheia*[51], which are a phenomenon of the 5th century (fig. 6, 23). In fact, as has already been demonstrated by J.-P. Joncheray 45 years ago[52], *spatheia* are nothing more than small models of the type Keay 25.2, the latest variant of the 4th-century type. Their size may vary from 77 to 92 cm in height, and from 13 to 18 cm in diameter, not far from the medium size of type Keay 25.2 (77–92 cm in height and 20–25 cm in diameter).

Their contents seem to be completely interchangeable, without links to specific typological variations, as shown by different traces of contents found in amphorae of the same type. For example, fish remains were preserved in a *spatheion* bottom at Tarragona[53], while a complete example discovered in the port of Pisa could have carried oil (as it did not present any visible traces of pitch)[54], and pickled olives were transported in the amphorae from the Dramont E wreck (as shown by the remains of olive pits found inside)[55].

Moreover, the distribution of the *spatheia* within the cargo of Dramont E wreck shows that they were quite regularly inserted between the large amphorae of types Keay 35A and B[56]. For this reason, the current presumption is that these containers were pure space fillers, designed for the optimization of the shipments from the beginning of the 5th century onwards. The appearance of this new standard of small-sized amphora, which coincides with the development of new types of large-sized amphorae, is probably the sign of major change in the organization of late Roman trade. In this case, standardization just meets the technical requirements of maritime trade.

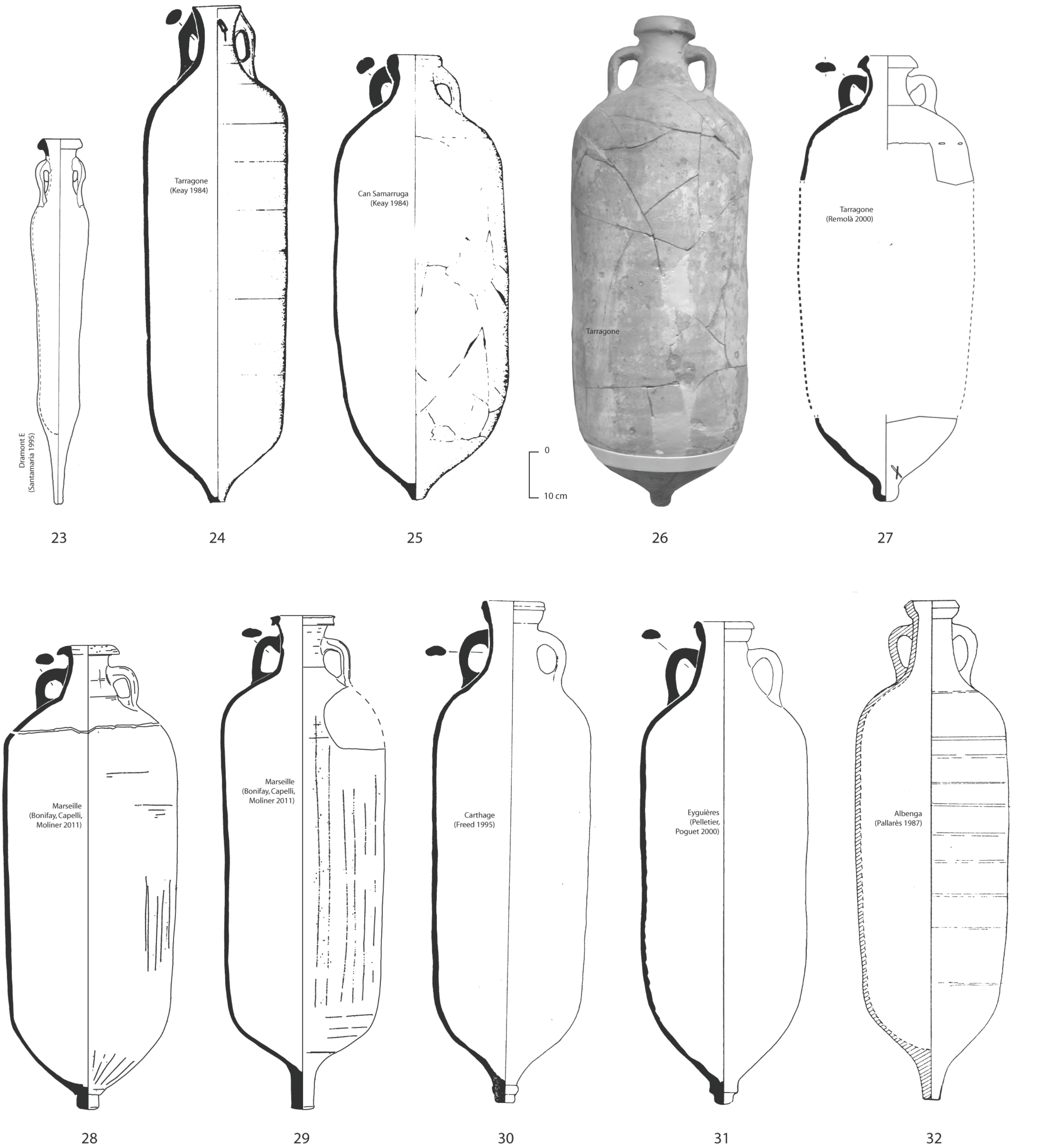
Diversification Phase: 5th Century A.D.

The 5th century is the moment of broad typological diversification through a huge series of large-sized cylindrical containers. A good example of this situation is given by the African containers reused in the 5th-century necropolis of the Christian Basilica at Malaval Street, Marseille, with not less than 28 different types in an assemblage of only 49 African amphorae[57].

Among these numerous types, it is worth noting that some of them are intrinsically homogeneous:

– The types Keay 27 and 36 (fig. 6, 24–25), with two different capacities (ca. 55 and 65 l), and perhaps two different contents (oil could be one content), were produced in a quite homogeneous fabric, pale pink-orange in color, with the presence of darker or paler streaks

51 Bonifay 2004, 125.
52 Joncheray 1975, pl. 2.
53 Morales 1989.
54 Personal observation M. Bonifay.
55 Santamaria 1995, 123.
56 Santamaria 1995, fig. 9.
57 Bonifay et al. 2011.



6 African amphorae. Diversification phase (5th cent.). *Spatheion* 1 (23), types Keay 27 and 36 (24–25), types Keay 40 and 41 (26–27), type Keay 35A/B transitional (28), type Keay 59 (29), types Keay 62R, 62Q, and Albenga 11–12 (30–32) (© see the individual numbers)

due to the imperfect mixing of clay components during the creation of the fabric. According to their distribution in Africa, these types seem to have been produced in a single workshop in the Carthage region, perhaps in the lower Mejerda Valley[58].

– The types Keay 40 and 41 (fig. 6, 26–27), with the same general shape and the same details of rim and bottom morphology, can only be differentiated through fabric, even if both seem to originate from the northwest region of Tunisia[59].
– Within the prolific 5th-century amphora production along the eastern coast of Cape Bon (mainly Nabeul but also Korba, and perhaps Kelibia), it is interesting for our purposes to focus on the types Keay 35A and B. These two types were produced at the same time, in the same workshop, and commercialized together but were probably devoted to different contents: oil (?) for variant A and fish products (?) for variant B. Details of the rim and the bottom are distinctive, allowing for distinguishing each type on the basis of simple sherds. Nevertheless, some transitional variants are known, with intermediate characteristics (fig. 6, 28)[60], and also three different sizes for type B.
– The types Keay 59 (fig. 6, 29) and 8B are also interesting, as they were first completely separate in their typologies, but they represent, in fact, two different developmental stages of the same amphora type. This reflects a long-lasting standardization of production from the end of the 4th century, the possible date of birth of the type Keay 59, to the mid-6th century, the probable date of the latest Keay 8B variants. The general homogeneity of the fabric, even if some petrographic particularities are noted, reveals a restricted area of production in southern Byzacena, where two rural workshops have been discovered[61]. These types were probably devoted to the transport of olive oil.

In contrast, some other types are more heterogeneous. This is notably the case of the large ›family‹ represented by types Keay 62R, Keay 62Q, and Albenga 11/12 (fig. 6, 30–32), with a similar general shape but many differences regarding detail in the shape of the rim, neck, handles, bottom, and of course fabrics. These amphorae, the contents of which are completely unknown, seem to have been produced from the end of the 5th century to the first third of the 6th century in more than one region[62]. The low homogeneity of each type but the undeniable similarities between examples produced in remote regions could prefigure the standardization on a large scale, which will occur during the Byzantine period.

The cessation of activity in the large suburban workshops of the eastern coastline of Tunisia put an end to the large-scale standardization of amphora production in Zeugitana and Byzacena. The location of the new 5th-century workshops, which seem to have moved closer to the center of foodstuff production, shows a huge development in production in Cape Bon, specifically in Nabeul. This was also the time at which the south Byzacena workshops were very active. On the other hand, the production seems to have almost completely ceased in the Sahel region, for example in Leptiminus and Salakta[63]. Of course, the irregular distribution of the production centers over the territory inhibited a high level of standardization.

Standardization Phase: 6th–7th Century

A new phase of standardization began with the first decades of the 6th century, the date generally accepted for the onset of the Keay 62 type, even before the Byzantine conquest. As a matter of

[58] Capelli et al. 2016, 286.
[59] Capelli et al. 2016, 289.
[60] Bonifay et al. 2011, 240.
[61] Majoura: Bonifay 2004, 31; Nasr – Capelli 2018. Meknassi: Ben Moussa 2017. On the other hand, the hypothesis of a workshop in the suburbs of the Roman city of Iunca could not be confirmed by the recent survey in 2017–2018.
[62] Capelli et al. 2016, 289.
[63] Mattingly et al. 2011, 266 (Leptiminus); Nacef 2015a, 107 (Salakta).

fact, the production of the 6th and 7th centuries A.D., perhaps until the first third of the 8th century, was dominated by the types Keay 62, 61 and 8A (fig. 7, 33–35), which share similar details of shape for almost two hundred years, including its very specific foot, with its characteristic bulb (or ring) around the spike. The complete examples are too few to attempt a comparison of sizes and capacities, but the similarities of form are quite striking. In particular, the type Keay 62A of the first half of the 6th century was produced in both the Nabeul and Sahel regions, and it is sometimes difficult to distinguish the two different origins without an archaeometric approach, demonstrating a high level of interregional standardization. Types Keay 61 and 8A are more specifically linked with the amphora production of Moknine in the Sahel region[64] but still with a high level of standardization. Contents are still unknown, but olive oil and *salsamenta* have been suggested.

The 7th century is also marked by the development of very small amphorae of about half a liter, sometimes without handles. Even without any link to the examples of the 5th century, they are also called *spatheia*. They are produced in several parts of the African territory, for example in Nabeul (type *spatheion* 3C) and Moknine (*spatheion* 3D) (fig. 7, 36–37). The contents of these bottles are unknown, but *garum* has been suggested on the basis of some *tituli picti* from Egypt[65].

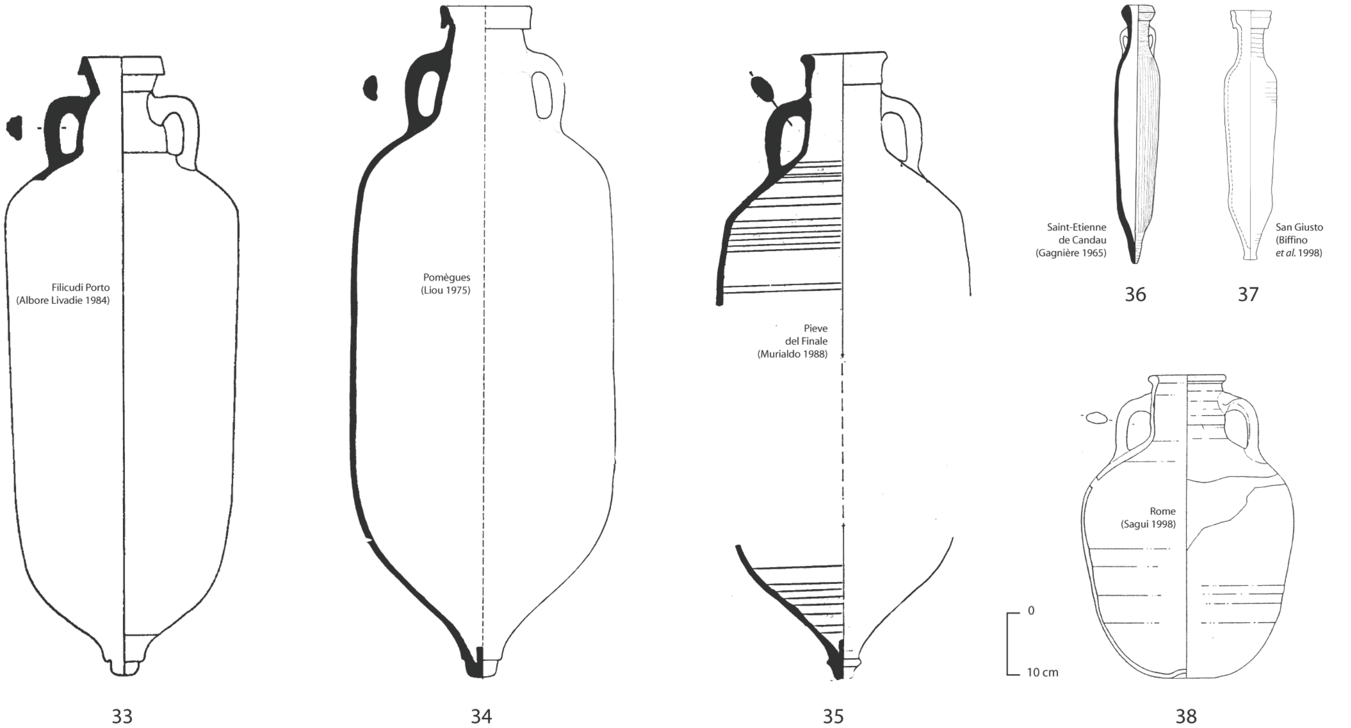
Finally, the last evidence attesting to the standardization of African ›Roman‹ amphorae is shown by the dissemination in Africa of the Byzantine model of globular amphora from the beginning of the 7th century onwards. At least four types have been identified, which differ quite considerably in their details, but their general shape seems to derive from the eastern Mediterranean types LRA 1 (which was also imitated in Africa during the Byzantine period)[66] and LRA 2. Only the so-called Castrum Perti type (Bonifay's ›Globulaire 3‹) (fig. 7, 38) achieves a genuine consistency in terms of production centers, the Sahel region, maintained throughout the mid- and late 7th century[67]. The lack of complete examples (except the one from Rome)[68] as well as of chemical analyses of residues prevents us from reflecting on other elements of the standardization of this specific type aside from its morphology. However, it is worth noting that this general globular shape survived during the Islamic period, as shown by the amphorae of the Aghlabid period[69], while the cylindrical shape, characteristic of most of the amphora production during the Punic and Roman periods, disappeared. With this last example, standardization became synonymous with typological impoverishment.

CONCLUSION

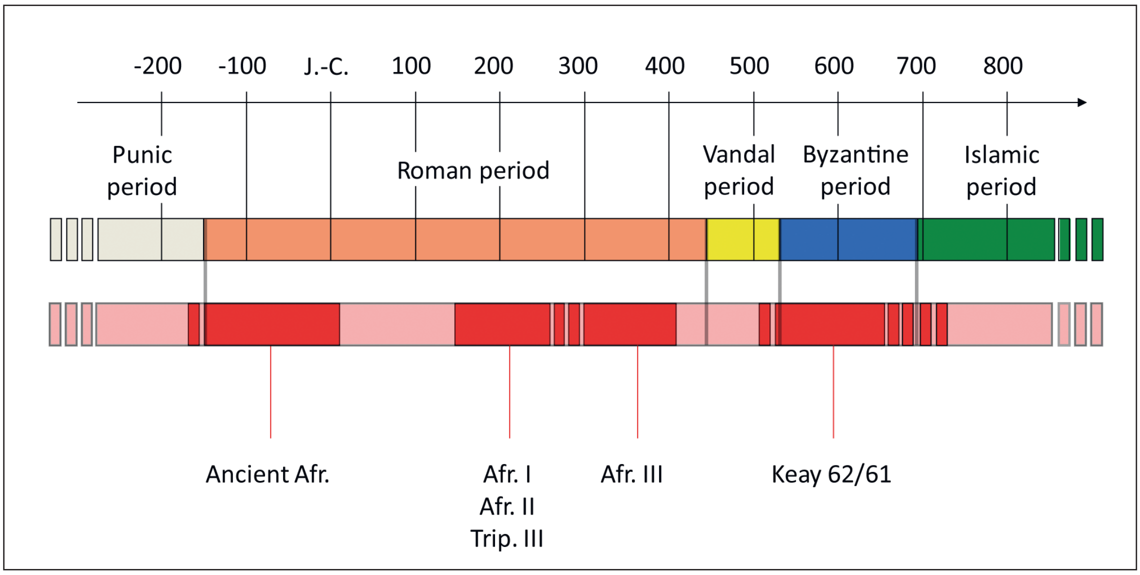
If we compare these data with the general chronology of Africa from the mid-2nd century B.C. to the end of the 7th century A.D., we observe that the four main phases of standardization do not correspond to the main historical divisions (fig. 8):

– Phase 1: The first phase took place during the Republican period with the introduction of the Greco-Roman type of amphora, which represented a standardization at a Mediterranean level. Nevertheless, the pattern of production showed a standardization of the shape but a very low metrological standardization and a dispersed system of workshops perhaps linked to the *fundi*.
– Phase 2: The second major phase of standardization developed between the mid-2nd century and the mid-3rd century, with the classic types Africana I and II in Africa Proconsularis and Tripolitana III in Tripolitania. The most interesting point here is the coexistence during this phase of two different patterns of production: the first one (in Zeugitana and Byzacena) centralized in the port cities and the second (in Tripolitania) linked to the estates. These

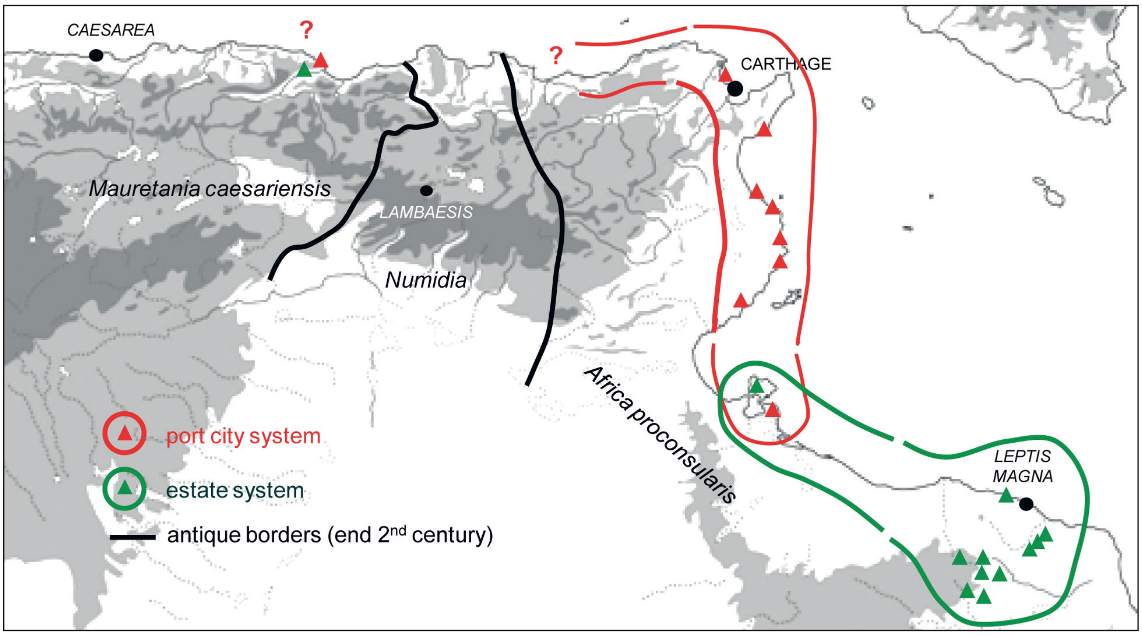
64 Nacef 2014; Nacef 2017; Nacef – Capelli 2018.
65 Fournet – Pieri 2008.
66 Nacef 2007a.
67 Type produced in Moknine, in a seperate workshop: Nacef 2017; Bonifay – Capelli 2018.
68 Saguì 1998, fig. 8, 4.
69 Reynolds 2016, 154.



7 African amphorae. Standardization phase (6th–7th cent.). Types Keay 62, 61, and 8A (33–35). *Spatheia* 3 C and D (36 f.). Globular amphora type ›Castrum Perti‹ (38) (© see the individual numbers)



8 African amphorae. Standardization and diversification phases through time (© M. Bonifay)



9 African amphorae. Geographical extension of the two main patterns of standardization (late 2nd–mid-3rd cent.) (© E. Jerray, M. Bonifay)

two patterns imply a standardization of amphora types, very strict (very similar shapes and fabrics) in the first case and looser (quite different details regarding shapes and fabrics) in the second one. Western Tripolitania (Jerba and the city of Zitha) is at the intersection of the two systems.

– Phase 3: A third phase during the 4th century with the Africana III type testifies to a complete reorganization of production. The pattern of production combined the two previous ones, with a production linked to the suburbs of the port cities and the estates. The shape was highly standardized but the contents were probably diversified in relation to the system of production and agricultural products.
– Phase 4: The fourth and last phase, at the end of the Vandal period and during at least a part of the Byzantine period, shows a new effort at standardization with the large-sized cylindrical amphorae (Keay 62, Keay 61 and Keay 8A) and the Byzantine globular amphorae. It is difficult to understand the production system during the Byzantine period: were the workshops linked either to private or church estates or grouped in craftsmen villages?

In this panorama, the 1st century A.D. and the 5th century, with the development of a great variety of different types, appear to be phases with major shifts in production systems. On the other hand, in the second half of the 3rd century, the strict standardization of African amphorae seems to waver for a while, but it is rapidly stabilized at the beginning of the 4th century with the creation of a new ubiquitous type. In fact, the first phase of standardization in Zeugitana during the Republican period is very similar to the system used in Tripolitania during the mid-Roman period, while uniform standardization is only attested during a short period, from the end of the 2nd century to the mid-3rd century in a limited area, namely the eastern coast of Africa Proconsularis from Carthage (?) – or at least Nabeul – in the north to Thaenae in the south (fig. 9). This very specific and coastal organization of production probably had something to do with the geographic configuration of North Africa, which unlike the Baetica region lacked perennial rivers (except the Mejerda), and, with its east-west topography orientation, did not facilitate terrestrial transport of heavy amphorae. But it also probably had to do with the economic system of the mid-Roman Empire. Indeed, this uniform system, partly renewed during the 4th century, totally ended at the beginning of the 5th century when Rome-centered trade collapsed[70]. Nevertheless, the new organization of production in the 5th and 6th centuries still preserved some aspects of concentration, as shown by the large potter groupings identified in the vicinity of Sullecthum and Nabeul.

The documentation in Numidia and Mauretania Caesariensis is very poor for the moment and does not allow for the decipherment of any economic pattern except for the phenomenon of the Gaulish amphora (Dressel 30 type) imitation in the second quarter of the 3rd century, associated with city name stamps. Lastly, the production of African amphorae of Punic tradition continued throughout the entire Roman period, with local attempts at standardization but limited distribution in the Mediterranean market.

BIBLIOGRAPHY

Ahmed 2010 — M. A. M. Ahmed, Rural Settlement and economic Activity: Olive Oil and Amphorae Production on the Tarhuna Plateau during the Roman Period (PhD thesis University of Leicester 2010).

Ben Jerbania 2013 — I. Ben Jerbania, Observations sur les amphores de tradition punique d'après une nouvelle découverte près de Tunis, AntAfr 49, 2013, 179–197.

Ben Jerbania 2017 — I. Ben Jerbania, La production des amphores ovoïdes de type »africaine ancienne« à Utique, avec une annexe de Claudio Capelli, Analyses pétrographiques, AntAfr 53, 2017, 175–192.

Ben Moussa 2017 — M. Ben Moussa, Nouvelles découvertes d'ateliers de céramique antique en Tunisie, in: A. Mrabet (ed.), Le peuplement du Maghreb antique et médiéval (Sousse 2017) 165–176.

Ben Tahar – Capelli 2018 — S. Ben Tahar – C. Capelli, L'atelier céramique d'Henchir Chouggaf (Ouedhref, Tunisie), AntAfr 54, 2018, 157–166.

Ben Tahar et al. 2018 — S. Ben Tahar – M. Bonifay – C. Capelli, L'atelier céramique d'Oued el Akarit (Tunisie), AntAfr 54, 2018, 167–178.

Berrocal Caparros 2012 — M. C. Berrocal Caparros, Producciones anforicas en la costa meridional de Carthago-Spartaria, in: D. Bernal-Casasola – A. Ribera Lacomba (eds.), Cerámicas hispanorromanas II. Producciones regionales (Cádiz 2012) 255–278.

Bonifay 2004 — M. Bonifay, Etudes sur la céramique romaine tardive d'Afrique, BARIntSer 1301 (Oxford 2004).

Bonifay 2007 — M. Bonifay, Que transportaient donc les amphores africaines?, in: E. Papi (ed.), Supplying Rome and the Empire, JRA Suppl. 69 (Portsmouth, RI 2007) 8–32.

Bonifay 2018 — M. Bonifay, Distribution of African pottery under the Roman Empire: evidence vs. interpretation, in: A. Wilson – A. Bowman (eds.), Trade, Commerce, and the State in the Roman World, Oxford Studies on the Roman Economy (Oxford 2018) 327–352.

Bonifay 2021 — M. Bonifay, African amphora contents: an update, in: D. Bernal-Casasola – M. Bonifay – A. Pecci – V. Leitch (eds.), Roman Amphora Contents: Reflecting on the Maritime Trade of Foodstuffs in Antiquity (In honour of Miguel Beltrán Lloris). Proceedings of the Roman Amphora Contents International Interactive Conference (RACIIC) (Cadiz, 5–7 October 2015), Roman and Late Antique Mediterranean Pottery 17 (Oxford 2021) 281–297.

Bonifay – Capelli 2018 — M. Bonifay – C. Capelli, Observations archéologiques et archéométriques sur les amphores globulaires de l'Afrique byzantine, in: R. M. Carra Bonacasa – E. Vitale (eds.), Studi in memoria di Fabiola Ardizzone. III, Ceramica, Quaderni Digitali di Archeologia Postclassica 12 (Palermo 2018) 61–74.

Bonifay et al. 2010a — M. Bonifay – C. Capelli – S. Muçaj, Amphores tardives de tradition punique: observations sur le type Benghazi LR Amphora 7, in: C. Ebnöther – R. Schatzmann (ed.), Oleum non perdidit. Festschrift Stefanie Martin-Kilcher, ASchw 47 (Bern 2010) 151–159.

[70] As shown by the study of African amphorae from Portus: Franco 2012.

Bonifay et al. 2010b M. Bonifay – C. Capelli – A. Drine – T. Ghalia, Les productions d'amphores romaines sur le littoral tunisien: archéologie et archéométrie, ReiCretActa 41, 2010, 319−327.

Bonifay et al. 2011 M. Bonifay – C. Capelli – M. Moliner, Les amphores africaines de la basilique de la rue Malaval à Marseille (V[e] siècle), SFECAG, Actes du congrès d'Arles (Marseille 2011) 235–254.

Bonifay et al. 2015 M. Bonifay – E. Botte – C. Capelli – A. Contino- D. Djaoui – C. Panella – A. Tchernia, Nouvelles hypothèses sur l'origine et le contenu des amphores africaines Ostia LIX et XXIII, AntAfr 51, 2015, 189–210.

Capelli – Contino 2013 C. Capelli – A. Contino, Amphores tripolitaines anciennes ou amphores africaines anciennes?, AntAfr 49, 2013, 199–208.

Capelli et al. 2016 C. Capelli – M. Bonifay – C. Franco – C. Huguet – V. Leitch – T. Mukai, Etude archéologique et archéométrique intégrée, in: D. Malfitana – M. Bonifay (eds.), La ceramica africana nella Sicilia romana – La céramique africaine dans la Sicile romaine, Monografie dell'Istituto per i Beni Archeologici e Monumentali, C.N.R. 12 (Catania 2016) 273–351. 651–736.

Contino 2015 A. Contino, Anfore africane tardorepubblicane e primo imperiali dal Nuovo Mercato di Testaccio a Roma (tipo-cronologia, ipotesi di provenienza e diffusione nel Mediterraneo) (PhD thesis Aix-Marseille Université – Università Cattolica del Sacro Cuore 2015).

Contino – Capelli 2016 A. Contino – C. Capelli, Nuovi dati archeologici e archeometrici sulle anfore africane tardorepubblicane e primo imperiali: rinvenimenti da Roma (Nuovo Mercato Testaccio) e contesti di confronto, in: R. Járrega Domínguez – P. Berni Millet, Amphorae ex Hispania. Paisajes de producción y de consumo (Tarragona 2014) 539–556.

Contino – Capelli 2019 A. Contino – C. Capelli, Late Republican and Early Imperial ovoid amphorae: the African production, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. Sáez Romero, The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 43–61.

Contino et al. 2016 A. Contino – C. Capelli – M. Milella – F. Pacetti – L. Ungaro – M. Bonifay, L'anfora Dressel 26 del Castro Pretorio, AntAfr 52, 2016, 145–156.

Contino et al. 2017 A. Contino – C. Capelli – D. Djaoui – G. Rizzo, Anfore neo-puniche del I secolo d.C. di Arles, Ostia, Roma: classificazione tipo-petrografica, origine e diffusione, The journal of Fasti On Line 391, 2017, 1–43.

Contino et al. 2019 A. Contino – L. D'Alessandro – G. L. Pascual – A. Ribera, Distribution of African and Hispanic ovoid amphorae in Italy: the cases of Pompei and Rome, in: E. García Vargas – R. R. de Almeida – H. González Cesteros – A. Sáez Romero, The Ovoid Amphorae in the Central and Western Mediterranean. Between the last two centuries of the Republic and the early days of the Roman Empire, Roman and Late Antique Mediterranean Pottery 13 (Oxford 2019) 237–273.

Djaoui et al. 2015 D. Djaoui – N. Garnier – E. Dodinet, De l'huile de ben identifiée dans quatre amphores africaines de type Ostia LIX provenant d'Arles: difficultés d'interprétation, AntAfr 51, 179–188.

Dressel 1879 H. Dressel, Di un nuovo deposito di anfore rinvenuto nel nuovo quartiere del Castro Pretorio, BCom 7, 1879, 36–112.

Empereur – Hesnard 1987 J.-Y. Empereur – A. Hesnard, Les amphores Hellénistiques du Bassin Occidental de la Méditerranée, in: P. Lévêque – J.-P. Morel (eds.), Céramiques Hellénistiques et Romaines II (Besançon 1987) 24–71.

Fentress 2001 L. Fentress, Villas, wine and kilns: the landscape of Jerba in the late Hellenistic period, JRA 14, 2001, 249–268.

Fournet – Pieri 2008 J.-L. Fournet – D. Pieri, Les dipinti amphoriques d'Antinoopolis, in: R. Pintaudi (ed.), Antinoupolis I (Florence 2008) 175–216.

Franco 2012 P. Franco, African Amphorae from Portus (PhD thesis University of Southampton, Faculty of Law, Arts and Social Sciences, School of Humanities 2012).

Garnier et al. 2011 N. Garnier – T. Silvino – D. Bernal-Casasola, L'identification du contenu des amphores: huile, conserves de poissons et poissage, SFECAG, Actes du congrès d'Arles (Marseille 2011) 397–416.

Hobson 2015 M. Hobson, The North African Boom. Evaluating Economic Growth in the Roman Province of Africa Proconsularis (146 B.C. – A.D. 439), JRA Suppl. 100 (Portsmouth, RI 2015).

Jerray 2015 E. Jerray, La production d'amphores romaines en Tripolitaine occidentale: les ateliers de Zitha et de sa région en Tunisie méridionale (PhD thesis Aix- Marseille Université, Université de Sousse 2015).

Jerray 2016 E. Jerray, Les ateliers d'amphores de Zitha et le potentiel économique de la Tripolitaine tunisienne, in: N. Mugnai – J. Nikolaus – N. Ray (eds.), De Africa Romaque: Merging Cultures across North Africa, Society for Libyan Studies Conference I (London 2016) 157–170.

Joncheray 1975 J. C. Joncheray, L'épave E du cap Dramont, sigillée claire D et amphores rescapées du pillage, CahASubaqu 4, 1975, 141–146.

Keay 1984 S. J. Keay, Late roman amphorae in the Western Mediterranean, A typology and economic study: the Catalan evidence, BARIntSer 196 (Oxford 1984).

Laporte 2010 J.-P. Laporte, Les amphores de Tubusuctu et de Saldae (Ostia V = Keay IA): Une mise au point, in: Estudios sobre el Monte Testaccio (Roma) V, Instrumenta 35 (Barcelona 2010) 601–625.

Manacorda – Pallecchi 2012 D. Manacorda – S. Pallecchi, Le fornaci romane di Giancola (Brindisi), Bibliotheca Archaeologica 27 (Bari 2012).

Marlière – Torres 2007 E. Marlière – J. Torres Costa, Transport et stockage des denrées dans l'Afrique romaine: le rôle de l'outre et du tonneau, in: A. Mrabet – J. Remesal Rodríguez (eds.), In Africa et in Hispania: Études sur l'Huile Africaine, Instrumenta 25 (Barcelona 2007) 85–106.

Martin-Kilcher 1999 S. Martin-Kilcher, Karthago 1993. Die Füllung eines frühkaiserzeitlichen Pozzo, in: F. Rakob (ed.), Karthago 3. Die deutschen Ausgrabungen in Karthago (Mainz 1999) 403–434.

Mattingly et al. 2011 D. J. Mattingly – D. L. Stone – L. M. Stirling – J. P. Moore – A. Wilson – J. N. Dore – N. Ben Lazreg, Economy, in: D. L. Stone – D. J. Mattingly – N. Ben Lazreg (eds.), Leptiminus (Lamta). Report no. 3. The field survey, JRA Suppl. 87 (Portsmouth, RI 2011) 205–272.

Morales 1989 A. Morales Muñiz, Annex 2. Informe sobre la fauna ictiologica recuperade en una amfora tardo-romana del typus Keay XXVI (spatheion), in: Ted'a, Un abocador del segle V D. C. en el forum provincial de tàrraco (Tarragone 1989) 324–328.

Nacef 2007a J. Nacef, Nouvelles données sur l'atelier de potiers de Henchir ech Chekaf (Ksour Essef, Tunisie), in: M. Bonifay – J.-C. Tréglia (eds.), LRCW 2. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry, BARIntSer 1662 (Oxford 2007) 581–591.

Nacef 2007b J. Nacef, Note préliminaire sur la production de la céramique dans la région de Salakta et Ksour Essef, in: A. Mrabet – J. Remesal Rodriguez (eds.), In Africa et in Hispania: études sur l'huile africaine, Instrumenta 25 (Barcelona 2007) 41–54.

Nacef 2014 J. Nacef, Nouveaux témoignages sur la production de la céramique antique du Sahel tunisien, in: N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. The Mediterranean: A market without frontiers, BARIntSer 2616 (Oxford 2014) 103–111.

Nacef 2015a J. Nacef, Production de la céramique antique dans la région de Salakta et Ksour Essef, Tunisie, Roman and Late Antique Mediterranean Pottery 180 (Oxford 2015).

Nacef 2015b J. Nacef, Un atelier de potier à la périphérie de la ville de Thapsus aux premiers siècles de l'Empire, avec une annexe de C. Capelli et S. Baklouti, AntAfr 51, 2015, 17–44.

Nacef 2017 J. Nacef, Moknine 2. Nouvelles données sur un atelier d'époque tardive en Byzacène, avec une contribution de C. Capelli, in: D. Dixneuf (ed.), LRCW 5. Late Roman Coarse Wares and Amphorae in the Mediterranean. Archaology and archaeometry, Centre d'Etudes Alexandrines (Alexandrie 2017) 491–515.

Nacef – Capelli 2018	J. Nacef – C. Capelli, L'atelier céramique de Dkhila, AntAfr 54, 2018, 151–156.
Nasr – Capelli 2018	N. Nasr – C. Capelli, Archéologie et Archéométrie des productions de l'Atelier de Majoura (Tunisie), ReiCretActa 45, 2018, 765–770.
Panella 1973	C. Panella, Le anfore, in: A. Carandini – C. Panella (eds.), Ostia 3, Studi Miscellanei 21, 1973, 463–633.
Panella 1982	C. Panella, Le anfore africane della prima, media e tarda étà imperiale, tipologia e problemi, in: Actes du colloque sur la céramique antique de Carthage, 23–24 juin, 1980 (Carthage 1982) 171–186.
Panella 2013	C. Panella, Postfazione, in: P. Palazzo, Le anfore di Apani (Brindisi) (Rome 2013) 191–196.
Peña 1998	J. T. Peña, The mobilization of state olive oil in roman Africa: the evidence of late 4th-c. ostraca rom Carthage, in: J. T. Peña – J. J. Rossiter – A. Wilson – J. Freed – D. Godden, Carthage Papers: the Early Colony's Economy, Water Supply, a Public Bath, and the Mobilization of State Olive Oil, JRA Suppl. 28 (Portsmouth, RI 1998) 117–238.
Revilla 2007	V. Revilla Calvo, Las ánforas tunecinas y tripolitanas de mediados del siglo III d. C., in: J. M. Blázquez Martínez – J. Remesal Rodríguez (eds.), Estudios sobre el Monte Testaccio (Roma) 4, Instrumenta 24 (Barcelona 2007) 317–344.
Reynolds 2016	P. Reynolds, From Vandal Africa to Arab Ifrīqiya, Tracing Ceramic and Economic Trends through the Fifth to the Eleventh Centuries, in: S. T. Stevens – J. P. Conant (eds.), North Africa under Byzantium and Early Islam. Papers Originally Presented at the Seventieth Dumbarton Oaks Byzantine Studies Symposium, »Rome Re-Imagined: Byzantine and Early Islamic North Africa, ca. 500–800«, 27–29 April 2012, Dumbarton Oaks Research Library and Collection (Washington DC 2016) 129–172.
Saguì 1998	L. Saguì, Il deposito della Crypta Balbi: una testimonianza imprevidibile sulla Roma del VII secolo?, in: L. Sagui (ed.), Ceramica in Italia: VI–VII secolo, Atti del Convegno in onore di J. W. Hayes (Rome, 11–13 mai 1995) (Florence 1998) 305–330.
Santamaria 1995	C. Santamaria, L'épave Dramont E à Saint Raphaël (Ve s. ap. J.-C.), Archaeonautica 13 (Paris1995).
van der Werff 1977/1978	J. H. van der Werff, Amphores de tradition punique à Uzita, BABesch 52/53, 1977/1978, 171–198.
Woodworth et al. 2015	J. Woodworth – D. Bernal-Casasola – M. Bonifay – D. De Vos – N. Garnier – S. Keay – A. Pecci – J. Poblome – M. Pollard – F. Richez – A. Wilson, The content of African Keay 25/Africana 3 amphorae: initial results of the CORONAM project, in: C. Oliveira – R. Morais – A. Morillo Cerdán (eds.), ArchaeoAnalytics. Chromatography and DNA Analysis in Archaeology (Esposende 2015) 41–57.

THE EASTERN MEDITERRANEAN & BLACK SEA

Dominique Kassab Tezgör

THE STANDARDIZATION OF AMPHORAE AT SINOPE

A NEW SYSTEM FOR DISTRIBUTION OF THE ANNONA

Abstract
In order to discuss the standardization of amphorae produced at Sinope in Late Antiquity, we shall examine the last amphora types manufactured in the workshop of nearby Demirci between the 4th and 5th century (amphorae type C Snp III) and the late 5th to 7th century (amphorae types D Snp I and III). Although the packaging concept was different for each type, all these vessels had a similar volumetric capacity of ±6 liters. This consistent capacity should result from the decision to implement a standard to facilitate the delivery of the *annona civica* or *militaris*. It was easier to control the volume of small containers at the departure point as well as at arrival. The shapes were also easier to handle and to stack in a ship's hull. The archaeological evidence shows that amphorae departing from Sinope could convey *annona civica* to Constantinople and *annona militaris* to the Roman forts along the Danubian Limes, as well as the eastern Mediterranean garrisons in Cilicia and Syria, on which we focus here. The probable product transported in these amphorae was wine since it was an important part of the soldiers' daily ration. The need for the well-organized production and use of standardized amphorae for supply purposes may have started with the reforms of Diocletian in the 4th century and was evidently the case in succeeding centuries, as is indicated by repeated legislation on the matter. On the other hand, the private use of these containers is indicated by their discovery at civilian settlements. The Church also was seemingly involved in these activities and should have had an important role at each stage, perhaps from the very beginning of the manufacture of these types of amphorae. It is remarkable that, on the basis of the distribution of Sinopean amphorae, Sinope maintained a maritime trade in the Mediterranean well into Late Antiquity, despite the decline of long-distance navigation that has been observed in the 6th and 7th century.

INTRODUCTION[1]

The need to establish a standard system of volume size for amphorae seems to be as old as the existence of amphorae themselves since they are containers designed for an organized trade, whether short distance by coastal navigation or long distance using trans-maritime traffic[2]. The uniformity of the shapes and proportions of some groups of amphorae from different origins points to this as a guarantee that the same required volume was provided in each[3]. In the southern Black Sea, for instance, at the end of the Classical period and in the Hellenistic period, we can compare the amphorae of Sinope, Heraclea Pontica, and Chersonesos as examples of this ›guarantee factor‹[4]. In the Aegean world, the similarity in shape and size of some amphorae, such as the Rhodian, Chian, Koan, and Knidian ones, could be explained in the same way[5].

Studies dedicated to the standardization of amphora volume have been at the center of large-scale research on the amphorae of the 11th-century Glass Wreck at Serçe Limanı[6] and the 7th-

1 I am grateful to my colleagues and friends for the information that they have generously provided to me: Dr. Julian Bennett for sharing with me his expertise on Roman history and the Roman army, and for editing the English text of this article; Dr. Philip Bes for communicating his unpublished article about Limyra and Horvat Kur, and Ahmet Özsalar for the lengthy discussions about the technique of manufacture of amphorae.

2 Wallace 2004, 431.

3 Rauh et al. 2013, 149 f. also mentions a standardization of amphora types. For another interpretation, see Garlan 2000, 73. See also Finkielsztejn 2006, 24.

4 Monachov 2003, pls. 86. 87 (Heraclea Pontica) and pl. 100–102 (Sinope); Garlan 2000, 72 fig. 40.

5 Rauh et al. 2013, 147–149.

6 van Doorninck 2015a, 35–48.

century wreck at Yassıada[7]. The results of the first systematic research conducted on the piriform amphorae of the Serçe Limanı wreck led to the conclusion that a complex system of standardization was implemented by the 11th century, using different capacities according to the category of wine: red, white, dry, or sweet[8]. The subsequent study of the Type 2 (LRA 2) amphorae from the Yassıada wreck has shown how that system was in existence from as early as the 7th century[9].

The conclusions of these two studies have indicated the need to work further on the matter of amphora volume standardization and to extend this investigation to amphorae of other types and other periods in order to detect if these also display evidence for a standardized system and if so, how to interpret it. The Late Roman amphorae produced in the Demirci workshop near Sinope provide an appropriate sample for such research[10]. In constructing the typology for this atelier, it proved possible to classify these amphorae into groups, which consist of different types with common morphological features, themselves divided into variants[11]. In the process, it appeared that the dimensions of the vessels of Type C Snp III, the so-called carrot amphorae were linked sequentially to each other, perhaps relating to their capacity. On the other hand, the homogeneous overall dimensions of the amphorae within each type of the Group D Snp vessels seem to be intended to provide the same volume.

The aim of this article is to understand whether a standardization system was applied to the late Sinopean amphorae, as seems to be the case. We shall propose an interpretation of this factor in light of the destination of the amphorae themselves. For our demonstration, the study has been limited to the more informative sites in Cilicia and north Syria[12].

THE SINOPEAN AMPHORAE TYPES C SNP III AND D SNP I–III

Typology

The typology of the Demirci amphorae was established using the complete vessels preserved in the museums of the Turkish Black Sea coast[13]. The types we are concerned with here can be identified by their distinctive fabrics and forms. We can clearly speak of the mass production of Types C Snp III and D Snp I in particular because the wasters and the kilns in the workshop of Demirci show that they were produced there in large quantities.

Group C Snp amphorae are characterized by an orange to reddish fabric[14] and are dated to the 4th and 5th century A.D. They can be divided into three main types – C Snp I, II and III – which are themselves subdivided into variants, most of them corresponding to different modules. Type C Snp III shares some common features with the other types but has much smaller proportions[15]; its two variants, C Snp III-1 and 2, are distinguished by their different dimensions[16]. Type C Snp III probably appeared late in the overall Group C Snp, and probably continued to be produced when the earlier Types C Snp I and II were discontinued.

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7 van Alfen 2015; van Doorninck 2015a, 48–52.
8 van Doorninck 2015a, 38. 45 f.; see Garlan 2000, 81 for a different opinion.
9 van Alfen 2015, 17 f. It has been preceded by a study of the typology and metrology of LRA 1 amphorae from the same ship: van Alfen 1996, 190–210.
10 For the excavations at Demirci, see Kassab Tezgör 2010a, 43–94.
11 For the typology, see Kassab Tezgör 2020, 18–40.
12 Another possible choice as a geographical area for a case study was the Danube Limes: however, it would have partly repeated the work of O. Karagiorgou (2001) on the LRA 2.
13 Specifically, the museums of Ereğli, Amasra, Sinope, Samsun, Giresun, and Trabzon. These amphorae are studied and described in more detail in Kassab Tezgör 2020.
14 Kassab Tezgör 2020, 21–34.
15 Kassab Tezgör 2020, 25.
16 See below, n. 32.

The Group D Snp amphorae are dated to the late 5th, 6th, and probably early 7th century A.D., and mark the end of amphora production at Sinope[17]. The fabric has a lighter color, whitish to yellowish. They can be divided into three types – D Snp I, II and III – all of a small volume and sharing a long and a narrow neck bordered by a rolled, small, and irregular rim, and grooved handles. Type D Snp I is closely related to the LRA 1 amphora by shape and rounded bottom but has its own distinctive features and is specific to Demirci-Sinope. Type D Snp II is similar but slightly longer, perhaps indicating the use of a different production module. Type D Snp III is elongated and has a solid tubular foot. The amphorae of Type D Snp I are more common than the others, while the ones of Type C Snp III seem to have been produced in lesser quantity, and the Type D Snp II is quite rare, as is the larger module D Snp I L. These two last types are not considered here since only two complete Type D Snp II vessels are represented in the museums of the Turkish Black Sea coast, and one only of the Type D Snp I L.

The reason for the radical difference in shape and production technique between the amphorae of Groups C Snp and D Snp is uncertain. Perhaps the choice of shape used for Type D Snp I was deliberate to imitate that of the LRA 1? A higher firing made the amphorae of Group D Snp turn a whitish color and, at the same time, lighter in weight; this may also have been the reason for this change in the manufacture.

Contents

This article is not the place to embark on a detailed analysis of what products may have been transported in the Sinopean amphora types of concern here. Broadly speaking, although there is no agreement, wine or olive oil has been claimed for Types C Snp III and D Snp I–III but fish sauce for Type D Snp[18]. The question is made more complex by the possibility that they may not have been first designed for a specific product but as multipurpose containers[19]. To add to the problem, scientific analyses have recognized that a resin coating was present on some amphorae used for transporting olive oil, contradicting the general understanding that it was reserved exclusively for wine containers[20]. Hopefully the increasing use of chemical and DNA analyses to identify the content(s) of amphorae and other vessels will prove to be as promising a field of investigation as early results indicate[21]. In the meantime though, while only a few of the amphorae studied here have a *dipinto* or a graffito, many of those discovered in the harbor of Seleucia Pieria have a *dipinto*, and their decoding could provide valuable information on the particular matter of the contents of Sinopean amphorae[22].

Advantages and Disadvantages of the Study Material

All individuals in the study sample were of shapes and fabrics indicating their manufacture at Sinope and also most probably from the workshop of Demirci[23]. It was possible to secure the direct measurements of 173 complete amphorae of Type C Snp III, 24 of Type D Snp I, and 19 of Type D Snp III.

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17 Kassab Tezgör 2020, 34–40.
18 Reynolds 2013, 105.
19 Panagou 2016, 319 n. 12; Kassab Tezgör 2020, 8. Pieri 2012, 43 n. 35 f. rejects the possibility of a multipurpose use except for only few cases (i.e., LR2): the main argument is that the buyer expects the packaging to be related to a specific product.
20 Pecci – Cau 2014, 835; Garnier et al. 2011, 407–410. See also the observations of Karagiorgou 2001, 146 n. 101 on the Yassıada amphorae.
21 Panagou 2016, 319 n. 11.
22 The Seleucia Pieria amphorae are discussed further below.
23 So far, no other center of production for amphorae of Group C has been identified, but a kiln producing amphorae of Type D Snp I has been excavated at Çiftlik, in operation after the church was partly destroyed: Hill 1995, 230.

Although the ›advantage‹ of a large number of individual amphorae available for study presented some distinct rewards in refining their study as a group, it nevertheless had its limitations. Specifically, it was impossible to calculate properly the volume of each individual amphora, and such an analysis can be meaningful only if it is made systematically on a large number. What made this approach unattainable was partly a simple lack of time, precisely because of the number involved but also because they are scattered in several museums along the 900 km of the Turkish Black Sea coast between Ereğli and Trabzon. In any case, however, we would have met the understandable reluctance of the various museum officials to allow the handling, filling, and emptying of inventoried amphorae with some form of material that could then be quantified by volume. Hopefully, new digital technologies will permit such a project in the future and provide the indispensable information to complete the present study.

On the other hand, a distinct ›disadvantage‹ in analyzing the material as a single group was that unlike the amphorae found on the Serçe Limanı and the Yassıada shipwrecks, the amphorae we examined do not originate from a known closed context. They were discovered by fishermen trailing their nets while at sea, suggesting that more wrecks exist on the seabed of the southern Black Sea besides those already known[24]. This absolute absence of information regarding original context is regrettable, but the important fact for us is that all those we examined belong clearly to a well-defined series of dated types made on a commercial basis to satisfy the requirements of traders for an appropriate transport vessel.

ESTABLISHING A SYSTEM OF STANDARDIZATION

Linear versus Capacity Measurements

As was demonstrated with the piriform amphorae of the Serçe Limanı wreck, the combination of linear measurements with capacities was an accurate way of establishing whether these were made to a standard specification(s). As explained above, this holistic approach was not possible in our efforts to determine if the Sinopean amphorae were similarly made to some consistent series of volume standards since our present investigation could not measure their volumes. We therefore followed the same approach as that used with the globular jars of Type LRA 2 found at Yassıada, that is to say, using the linear measurements only[25]. Without any exceptions, the dimensions were recorded for all the complete amphorae of Type C Snp III, and D Snp I and III preserved in the museums of the Turkish Black Sea coast. The relevant measurements for the amphorae of Type C Snp III are the total height, the maximum diameter, and the height of the neck above the attachment of the handles[26]. For the amphorae of Type D Snp I and III, the total height and the maximum diameter of the vessels were deemed sufficient since the dimensions of the neck are in the same range for all known examples.

Some of the Sinopean amphorae in the museums of the Turkish Black Sea coast were measured on a random basis in an initial study of these types. Some other studies of Sinopean amphorae provide measurements of capacity, but they only offer an approximate indication for the purpose of our analysis, as usually they give no indication as to what substance was used to measure, or the level to which the relevant amphora was filled, or if the volume was simply calculated from a profile drawing using one or another of the available applications[27].

In any case, we should emphasize the difficulty of calculating capacity of amphorae in antiquity due to some ›known unknowns‹, most obviously, the level to which the amphorae were

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24 See below and n. 77. 80.

25 van Alfen 2015, 20–30.

26 The height of the neck between its junction to the shoulder and the handles is not meaningful, being similar on all the amphorae; there is no change in the height of the handles either.

27 We cannot rely decisively on the calculation of the volume from a profile drawing for the simple reason that the thickness of the wall is unknown, which can drastically alter the results. See Garlan 2000, 78 n. 39.

filled[28]. Some criteria regarding this factor need to be taken into consideration. One is regarding the neck: should it be included when calculating the capacity? A part of it was used for inserting the stopper, which could be made of clay, plaster, cork, or even a broken piece of ceramic. Even if it was flat with a thickness of a few centimeters, it was deeply pushed into the neck; other stoppers made of clay were high, having a mushroom shaped cross-section with a wide head and short tail that occupied a part of the neck[29]. Under the stopper, a vacuum was necessary if the product was wine. When modern potters are asked about the capacity of a container they make, they only look to the body and give no consideration to the neck[30]. For them the neck is only functional. This seems clearly to have been the case also with, for example, the amphorae of the Type C Snp III with a neck pinched at the level of the handles such that it takes the shape of a funnel (figs. 3–4). Actual capacity aside, it should be kept in mind that the densities of oil and wine differ, hence the volume and weight differ as well; for wine it also varies according to whether it is a red, white, dry, or sweet wine[31].

Type C SNP III

Analysis of the dimensions of the 173 Type C Snp III amphorae reveals the existence of a system in their manufacture not previously observed in any other type of Sinopean production from earlier times. The dimensions allow the division of this amphora type into four series, with the two middle ones overlapping each other. This system of proportions is evidently stable and consistent in that other amphorae of the same type from other collections conform with the observed parameters as do incomplete examples and matching sherds from the Demirci excavations.

The first series includes amphorae with a total height between ±65 and ±73 cm, with a maximum diameter varying between ±22 and ±24 cm and the neck rising between ±8 and ±9.5 cm over the handles (fig. 1). Those amphorae of the second series are between ±73 and ±75 cm high but with a diameter and neck matching those in the first series (fig. 2). The third series share the same height with the second, at between ±73 and ±75 cm, but the diameter is between ±19 and ±22 cm, and the neck rises above the handles by between ±10.5 and ±13 cm (fig. 3). This series marks the jumping-off point for the taller fourth series of amphorae, which usually measure up to ±80 cm high or even more, with a diameter between ±19 and ±22 cm and a neck rising up to ±17 cm above the handles (fig. 4)[32].

Type D SNP

Close scrutiny of the Type D Snp I and III amphorae likewise shows an interesting stability in their own dimensions. The height of the Type D Snp I varies between 47 and 57 cm, with a maximum diameter between 19 and 22 cm (fig. 5); the Type D Snp III varies in height between 61 and 72 cm, with a maximum diameter between 23 and 24 cm (fig. 6).

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28 However, an experiment may yet be meaningful as long as the same procedure is used for all the vessels involved in the study, preferably by calculating the capacity of the body up to the junction with the neck (as done by van Doorninck: see below n. 30). Even if it does not give the exact volume as required, it provides an order of magnitude for comparison purposes in that differences in capacity between the amphorae of the same type will indicate a lack of precision in production.

29 For an example of such a stopper, see Yekutieli – Akus 2014, fig. 8. Similar stoppers have also been found in Patara (unpublished).

30 van Doorninck 2015a, 36 also noted how the capacity of the piriform amphorae was determined by the body since this was made before the addition of the neck.

31 One liter of oil weighs 0.92 kg and one of wine 0.99 kg.

32 In other words, there is a natural progression in sizes from one variant to the next, and our division into the two variants C Snp III-1 (assembling the amphorae of the first and second series) and III-2 (series three and four) that we had done in our typology hinges on a clear turning point in the change of the dimensions between series two and three.

1 Amphora Variant C Snp III-1. Giresun Museum, inv. 174. Height: 70; diameter: 24.2; neck height: 8.3/8.6 cm (© by the author)

2 Amphora Variant Type C Snp III-1. Amasra Museum, inv. 181. Height: 73.6; diameter: 24.2; neck height: 9/9.4 cm (© by the author)

3 Amphora Variant Type C Snp III-2. Samsun Museum, inv. 10.2.78. Height: 75.7; diameter: 20.7; neck height: 10.5/1 cm (© by the author)

Implementation of a Standardization System

When manufacturing Type C Snp III amphorae, it seems evident that the potter or potters were aware of the need to adhere to set dimensions. Three variables had to be kept in mind: the height of the body, its diameter, and the height of the neck above the handles. A diminution in the diameter was complemented by substituting a greater height, while a greater diameter was paired with a lower height. We could say that in a way, one ›over-sized‹ dimension was compensated for by diminishing the other. We should interpret this well-established system of alternative dimensions as a will to maintain a standard and unique capacity for all the containers of this type. If so, it points to the introduction of the Type C Snp III being connected with the implementation of amphora standardization in the 4th to 5th century, as it was not the case for the other types of the Group C Snp amphorae. Their sizes correspond to broad categories, such as large, medium, and small. As it is, these types appeared earlier and were probably no longer being produced or, if so, in limited quantities when the Sinopean carrot amphorae were undergoing their peak period of mass production. What is more, a similar set of standard dimensions applied to the manufacture of the Type D Snp I and III until amphora production ended at Sinope. As mentioned above regarding the typology, however, for this group two different modules were used, namely one for Type D Snp II and another for Type D Snp I L, with both types being made on a seemingly marginal basis, to judge from the rare surviving examples.

It is only natural that we should attempt to estimate the capacity of these various amphorae and more pertinently how the potters achieved the relevant standard in their products. To begin with capacity, according to the few calculations that have been made, it is estimated that the amphorae of Type C Snp III as well as the later Types D Snp I and III contained ±6 liters[33]. Turning

33 Among the amphorae we have studied, the capacity of the two Type C Snp III-2 amphorae has been calculated as 5.95 l and 6.5 l (Sinope Museum, inv. 18.3.77 and 5.1.87) as well as the capacity of three amphorae of the Type D Snp I as 5.6 l, 6.4 l and 6.5 l (Sinope Museum, inv. 1.12.89, 13.2.91, and 13.1.86). The volume has been obtained

4 Amphora Variant Type C Snp III-2. Samsun Museum, inv. 9.1.80. Height: 84; diameter: 21; neck height: 14.8 cm (© by the author)

5 Amphora Type D Snp I. Ereğli Museum, inv. 2006-4. Height: 53.3; diameter: 20 cm (© by the author)

6 Amphora Type D Snp III. Amasra Museum, inv. 161. Height: 70.4; diameter: 25.3 cm (© by the author)

to the matter of the individual potter and how he could provide containers of the required volume, he had to decide first on the right dimensions to ensure the necessary capacity. He was probably working by rote repetition, reproducing the same parts (i.e., the neck, the upper and the lower body, and the foot) of a same type for subsequent assembly into the individual amphorae[34]. Even if a template of some kind was employed, in order to attain the desired dimensions and the necessary capacity required for each individual amphora while wheel-throwing the separate sections, the potter was continually monitoring the size of each piece and its thickness, taking into consideration the shrinkage of the clay that would occur during the drying and the firing[35]. As such, an individual potter would likely incorporate a safety margin by slightly augmenting the size of the container to guarantee it was of the correct capacity.

Volume and Weight Standards

Augustus set in place a system of unified weights and measures to replace the various systems then in use in the various regions of Italy and the Roman Empire, and this continued to be ap-

by filling each one with wheat up to the neck to a point below the lower handle attachment, although if we should have the opportunity to repeat this method, we would stop at the neck junction: see above and n. 30. The capacity of some amphorae from the Site B wreck close to the Sinope coast has been calculated by excavators as between 5.7 and 6.3 l: Ward 2012, 195.

34 The neck was made separately, and the body was in two segments, the shoulder and upper part of the body, then the lower part. These were joined together, and the foot was added to close the container, with the handles shaped by hand and attached as the last step.

35 The ›shrinkage‹ factor varied according to the preparation of the clay, the quantity of water it contained, the addition and the nature of any temper, and the kneading before wheel-throwing.

plied into Late Antiquity[36]. The *sextarius* (*xestes*) at ca. 0.539 liters was the usual unit of capacity used for amphorae[37], but the continuation of local systems of weights and measures in parts of the Roman and Byzantine Empire at different periods and, in some cases, the demands of targeted clientele[38], meant that the true value varied between ±0.540 and 0.550 liters[39]. Because Sinope was refounded by Caesar as a Roman colony, we may assume that the Roman *sextarius* was the volumetric system of our amphorae. It implies then theoretically a value of 0.539 liters for Sinopean amphorae, but only the calculation of the volume of the amphorae could show if this was the unit used. In that case, the capacity of our amphorae was ±11 *sextarii*.

Starting in the 4th century, the imperial units of volume began to give way to the units of weight[40]. According to the Byzantine system of weight measurements, the key unit was the *logarike litra*, with a *metron* being a multiple of this at 30 *litrai* and a *mina* at three *litrai* equivalent to ⅒ of a *metron*[41]. Any change in the value of the *litra* modified all the other values. With regard to the Serçe Limanı wreck, a *mina* equivalent to 320 g corresponded to the standard of the piriform amphorae found there, but a *mina* of 315 g was more relevant for the LRA 1 amphorae found at Yassıada[42].

In the case of the amphorae we are concerned with here, we do not know if the standard was calculated by volume or by weight. A future study of the *dipinti* present on the Sinopean amphorae in the Hatay museum, as mentioned below, may give us some information on the system(s) in use[43]. For our purposes, we consider the volume to be more relevant to our study, as this was the unit the potter applied in mental terms to the making of the amphora's constituent parts before being converted into weight when filled with whatever contents[44].

As it is, though, amphorae with the same shape and similar dimensions as Types C Snp III-1 and D Snp I, and hence also the same capacity, were produced in other centers, albeit in lesser quantity[45]. These ›imitations‹ or *similis* types should be taken into consideration also when looking at these vessels from the perspective of standardization. Generally speaking, the amphorae Type C Snp III-1 *similis* have a single range of dimensions, which correspond to the second series of the original Sinopean type: the height is between ±60 and 68 cm, the diameter between ±19 and 22 cm, and the height of the neck over the handles ±7 to 10.5 cm[46]. The Type D Snp I *similis*, however, display a range of dimensions slightly smaller than the Sinopean ones, with a height between ±40 and 53 cm and a diameter between ±17 and 20 cm[47]. As at Sinope, a larger module exists, the Type D Snp I *similis* L. The fabric and its texture of the Type C Snp III-1 *similis*, the Type D

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36 Morrisson 2012, 383; Klenina – Biernacki 2018, 290.

37 This measure is given for the *xestes* by Pitarakis 2012, 414. It should be noticed that there is no consensus on the ration of the *sextarius/xestes* (see, for example, n. 110 below).

38 For example, a specific weight unit, the *argyrike litra*, was used for commercial relations with the Islamic world since it was close to a unit of the Arab weight system: van Doorninck 2015a, 37.

39 van Alfen 1996, 204; Pieri 2012, 44; Pitarakis 2012, 414 for the value of the different *sextarii/xestes*.

40 van Alfen 1996, 205. Already in the Roman Republic, the *Lex Silia de ponderibus publicis* introduced between 287–218 B.C. decreed that the contents of amphorae were sold by weight; but see also Cato agr. 148 for wholesale by volume: Paterson 1982, 157 n. 85.

41 van Alfen 1996, 205; van Doorninck 2015a, 35 f.

42 van Doorninck 2015a, 36. 48.

43 Some *dipinti* on Late Roman amphorae indicate if the contents were measured in volume or weight: Pieri 2012, 44; van Alfen 1996, 205. See below for the *dipinti* on the amphorae of Antinoopolis.

44 van Alfen 2015, 36.

45 We consider that the Type C Snp III originated in the workshop of Sinope, as the earlier versions of Type C Snp I were produced at Sinope and we can establish a continuous evolution of the shapes there; therefore, the amphorae produced elsewhere were the ›imitations‹, although this term may not in fact be appropriate. The argument for the Type D Snp I originating at Sinope is more tenuous: this type, which can be interpreted as a satellite of the universal type LRA 1 is quite distinctive and was produced on a commercial basis at Sinope, while there are far fewer examples of Type D Snp I *similis*, which suggests their ad hoc manufacture on a needs-must basis rather than full-scale commercial production.

46 Kassab Tezgör 2011, 260 f.

47 Kassab Tezgör 2011, 262 f.

Snp I *similis*, and the Type D Snp I *similis* L show clearly that these were produced at different and as yet unknown centers, although their fabrics indicate that these amphorae were produced in the Black Sea region. These imitations have been interpreted in different ways in the scholarly literature, such as indicating a fraudulent intention or a practical rationale as an attractive or a useful shape for handling[48]. It may also be because these amphorae were using the same trade routes and depending on the same economic system. In that case, we can think of an Empire-wide standardization system or at least of a supraregional commercial net involving the same actors.

Ergonomics and the Shape of the Sinopean Amphorae

The fact that the amphorae of the Type C Snp III have differing dimensions but the same capacity looks surprising at first. The purpose could be to provide a packaging more suitable when loading the cargo into a ship's hull. As it is, thanks to the good preservation of some shipwrecks, we have some excellent information about the loading layout of amphorae in these[49]. In general, the amphorae were stowed in several rows and in one or more layers in such a way as to leave the least possible empty space, not only to allow the transport of a large number of vessels but also to avoid rolling in heavy seas and the walls of these containers crashing against each other[50]. Being full-bodied with a long and slim ›tail‹, the Type C Snp III amphora had a very convenient design to fit alongside each other in parallel overlapping rows. As such, the reason they had different dimensions could be to fit better alongside each other and also to fill a ship's hull more efficiently: the longer amphorae would be placed first along the sides of the hull, then smaller ones between them in the following row, and so on, with each successive row using amphorae of a decreasing length. To put it another way, the differences of size were programmed for better use of the space in the ship. Thus, a form like the carrot amphora may be considered as representing the endpoint of a long process to make lighter, taller, and narrower containers designed to fit better as a cargo[51]. A well-organized and properly distributed cargo was essential for stability at sea and for unloading at the destination(s), and much thought would have been given to this when amphorae were loaded.

The same factors lie behind the form of Types D Snp I and II, although these represent a completely different mental concept based presumably on experience with the LRA 1 amphorae they broadly copy. In this case, a compact elongated sub-cylindrical form was preferred, which meant that when stacked together in the hull, little space remained between them. On the other hand, the design of the Type D Snp III amphora is interesting, with its long cylindrical foot appended to the sub-cylindrical shape of the Type D Snp I, making it an intermediate form between the Type D Snp I and the Type C Snp III. The combination of these amphorae when loaded on the ship would also serve to save space.

Overall, the Sinopean amphorae presented many ergonomic advantages over earlier forms – a shape that was easy to produce (in spite of the constraints in the dimensions of the carrot amphorae), handy to carry, and relatively light – the end product being a small-volume container that was simpler all round for both manufacture and transport.

GUARANTEEING STANDARDIZATION

It is self-evident that each of these hand-made amphorae could not be made to the precise required capacity, and so perfect homogeneity in their production was an unachievable aim. This was so not only because of technical reasons related to the manufacture as described above but also

[48] Garlan 2000, 74 f.; van Alfen 2015, 34 n. 21.
[49] Parker 1992, 28; Boetto 2012, 155 f. fig. 8, 3, which illustrates well the amphorae remaining in the hull.
[50] Ropes, small branches, and brushwood filled the spaces between the amphorae and were also used as a bed for the vessels.
[51] Rauh et al. 2013, 146.

because we assume they were mass-produced under pressure. In fact, the unrefined attachment of the handles, with the clay stretched on the neck, clearly indicate hasty work aimed at quantity over quality. The body sherd fragments collected during the excavation show quite clearly different wall thicknesses; although they use the same range of proportions, the actual dimensions vary so that there is no exact consistency between heights and diameters. These variations suggest manufacture by several potters of varying abilities working in the same workshop or a single production center that incorporated more than one workshop[52].

The upshot was that simply filling each amphora of the same type up to the same level would not guarantee that it contained the required capacity because of the inevitable variation between the actual containers. Thus, a system was needed for the exporter to be able to pour the same quantity of product into all the amphorae and for the buyer to control that quantity upon arrival. In this case, to precisely calculate the volume of a product, solid or liquid, two official devices could be used: the standard measures and the *sekomata*.

Small pitcher-shaped containers were used to calibrate standard measures, liquid or dry, and they were given the name of the relevant measure. They were usually made of bronze[53], and it is believed that they were distributed to the cities of the Empire as exact replicas of the originals at Rome, subsequently being kept in an official place for reference purposes, with versions presumably being made for local use[54]. Observance of the standard units was strictly controlled, and any swindlers were severely punished[55].

Another device to guarantee the volume of any container was the so-called *sekoma*[56]. It was a block of stone designed with three or more concave basins, sometimes closed, sometimes with a hole at the bottom, with each basin corresponding to a specific standard measure and the exact number of basins and their sizes in each example differing from one place to another in response to the needs of local traders. Closed basins were for solid products (e.g., grains), and pierced ones like a funnel were for liquids (e.g., oil, wine). A small plug was used for closing the hole in the bottom when filled and then removed for the liquid to pour into a container placed under it[57]. In some examples, the basins are roughly finished, which suggests that they were originally lined or fitted with a removable metal container which represented the actual standard measure[58]. Several examples of these *sekomata* have been found in public places (e.g., marketplaces, etc.) and even in shops in the western and Aegean worlds[59] as well as in the Black Sea region[60], but they are rare in the Levant[61]. On some examples, the measures are inscribed next to the basins, such as that found at Naxos[62], or one from Caunos[63], or an example discovered in a shop of Maresha in Israel[64]. Especially noteworthy, though, is the *sekoma* found at Emporium Piretensium near Nicopolis ad

52 van Alfen 2015, 27. For the other Sinope workshop manufacturing Type D in addition to that at Demirci, see above and n. 23.

53 Pitarakis 2012, 412 f.; Klenina – Biernacki 2018, 290.

54 Morrisson 2012, 383. An apparently unpublished large clay funnel evidently of Sinope origin, seen by the writer in the museum at Rostov-on-Don and found at Gorgippia or its region, may have served as some form of standard measuring device. It could have been used with the tube closed by a stopper for measuring purposes as the contents were decanted into the amphora(e) to establish a ›standard‹ capacity and then exported together with the cargo and used to verify the capacity when the amphorae were emptied.

55 Finkielsztejn 2006, 18; Morrisson 2012, 388.

56 It is not certain that this stone was called *sekoma* by the Greeks, while the Latin term *mensa ponderariae* was adopted for this artifact in the 19th cent. (Cioffi 2014, 41 f. n. 4; Klenina – Biernacki 2018, 289). It was called *rabo* in Latin (Pitarakis 2012, 411).

57 Cioffi 2014, 46; Finkielsztejn 2010, 193.

58 Pitarakis 2012, 411.

59 Pitarakis 2012, 411 f.; Klenina – Biernacki 2018, 295–297. See below and n. 106.

60 Klenina – Biernacki 2018, 291–295.

61 Finkielsztejn 2006, 20; Finkielsztejn 2010, 193.

62 Ciolli 2014, 44 and for the interpretation, 52–55.

63 Pitarakis 2012, 411. 412 n. 82.

64 Finkielsztejn 2010; Finkielsztejn 2012, 310.

Istrum in Moesia Inferior[65]. The volumetric units here were inscribed in Greek for olive oil on the upper row and for wine on the lower one, illustrating how the difference in volume of the two products was taken into account. Moreover, as olive oil was not produced in that area, it demonstrates how the *sekoma* was used for controlling imported products[66].

The standard measures represented by basins on *sekomata* are too small to be used to fill an amphora, even those of a small module as with the Type C Snp III or D Snp I amphorae, never mind the filling of hundreds of containers when departing as a bulk cargo or emptying them on arrival at their destination. Several scenarios have been proposed for how capacity control was activated upon the departure and arrival of the amphorae, and it was probably organized differently according to the centers of export and import. That said, one possible way was for one amphora or a selection of them to become themselves the standard or official measures for export purposes in a single cargo. They would have been those stamped vessels when this practice was usual or identified as standards by a *dipinto* or graffito[67]. These would be filled from the *sekoma* or by an official measure as many times as necessary to reach the required capacity and then used as references at the delivery point of the cargo, assuming that amphorae of the same module made at the same time would have the same capacity. On arrival, the reverse procedure could have taken place in order to check whether the volume was in accordance with the agreement. Another possible and perhaps more probable method, however, can be deduced from the text of Epiphanios of Salamis (ca. A.D. 315–403). According to this, one or more vessels were filled with the required volume using the official measures, thereby becoming the standard container. These were then repeatedly filled and decanted into all the others destined for export before they were sealed[68]. This text mentions that the wine was drawn directly from the winepress and seems to be well suited for the small amphorae we are concerned with here.

Besides the variation in the available volume in amphorae of the same type, the manual filling of hundreds of containers would have been a difficult process and surely could not have been done with a high degree of precision. One suspects that the rules were strict in principle but less so in practice and that the buyer relied on a guarantee of sorts that the contents were more or less accurate, as the process was supervised by an accredited officer using official standards of volume control. However, a certain degree of acceptance probably prevailed, favoring the producers and buyers equally. We could speak, in other words, of an ›empirical standardization‹ when dealing with a bulk shipment, in which the quantity of the missing product would have been proportional to the size of the containers. This would be the case with small containers, such as Type C Snp III-1 or 2 or Type D Snp I or III, where a difference of a small fraction of a liter in each would not be significant when multiplied at the scale of the total cargo[69]. For example, if we assume as a rough calculation that a cargo consists of 1,000 amphorae, with each amphora containing 6 liters, then the total quantity is 6,000 liters. If there is a loss of 0.1 liters/amphora: 1,000 × 0.1 = 100 liters, this would be equal to the volume of only ±17 amphorae, that is 1.7 % of the total[70]. The corollary is, of course, that some amphorae could be overfilled, in which case the margin of imprecision favored the buyer. All in all, we might reasonably assume that such ›errors‹ as over- or under-filling were probably allowed for in the profit and loss margin on the sides of both the seller and the buyer.

Weighing the amphorae was another way of quantity control. Indeed, *dipinti* on amphorae found at Antinoopolis indicate how some of these containers were weighed empty and then full,

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65 Klenina – Biernacki 2018, 293 f. fig. 2, 2–5.
66 Klenina – Biernacki 2018, 294.
67 Finkielsztejn 2006, 30–32.
68 Mayerson 2001, 100.
69 See Finkielsztejn 2006, 27.
70 The maximum capacity of some groups of amphorae has been calculated and shows similar percentages in the variations of volume within the same type: Wallace 2004, 430 f.; see also Garlan 2000, 79.

with both measures then written on the neck[71]. This indicates an organization and handling system at the point of origin in order to secure these measurements, while the evidence that not all of the amphorae were systematically treated this way suggests that only a few were chosen for this purpose to use as standard controls, as suggested above. As it is, the presence of a steelyard on some wrecks[72], such as at Yassıada[73], shows that a control-by-weight system was possible on board, probably at the arrival point.

WHY STANDARDIZATION AFTER THE 4TH CENTURY A.D.?

In order to understand the reason for the adoption of single standard-sized amphorae at Sinope in the 4th century A.D., starting with the Type C Snp III and continuing with the Type D Snp I and III, we should look at their historical and economic contexts. This is an ambitious aim, to say the least, as we lack all of the necessary tools to achieve a suitable conclusion on this matter. However, this does not prevent us from presenting a few facts and proposing some lines of research, beginning with the probable importance of the many civil, political, and military reforms enacted by the emperor Diocletian (r. 284–305). These established inter alia a division of the Roman provinces into more manageable units for administrative purposes, reforms of the currency and army, the »Edict of Maximum Prices« of 301 that established a strict system of (technically at least) Empire-wide price controls, and notably for our purposes, the requirement that the Diocesan populations supply goods and services for military and other official use[74]. The importance of defined standards of weight and capacity in connection with supplies for the army and other entitled groups was later emphasized by an imperial edict of Valentinian II in 386 and by similar edicts promulgated subsequently by the emperor Theodosius II in 438 and then by Justinian in 545[75]. In addition, however, as we shall see below, the church may eventually have begun to play an active role in the conveyance of the *annona* and standardization may have been one of its requirements[76]. The point is that containers used to transport the *annona* had to be strictly controlled in terms of their capacity, hence the need to establish a universal standard for this purpose. A small size for all such containers would also make the transport process much easier and more efficient, as well as making it easier to check their capacity, which would help explain why small amphorae were widely used in Late Antiquity.

We know of three wrecks discovered off the coast of Sinope containing amphorae of Type C Snp III and a fourth one with those of Type D Snp I together with amphorae of Type LRA 1[77]. The fact that their cargos consisted mostly of a single type of amphora has been a key element in shaping the hypothesis that these ships were used to deliver the *annona* owed by Sinope[78]. However, we have no means of telling if they were transporting the *annona civica* or the *annona militaris*[79], let alone guessing at their ultimate destination. A fifth wreck investigated in 1997 on the seabed close to Sinope is associated with Type D Snp I amphorae, but we have no further information about the rest of the cargo, and it may have been a ship for private trade, transporting different types of containers from diverse origins[80]. With its cargo consisting of around 900 amphorae, at

71 Pieri 2012, 45; see also Paterson 1982, 157.
72 For the discovery of steelyards at marketplaces and on wrecks, see McCormick 2012, 87–89; Pitarakis 2012, 407–410.
73 Pieri 2012, 45; van Doorninck 2015b, 205.
74 Rauf et al. 2013, 165.
75 Morrisson 2012, 385 n. 35; 388.
76 van Alfen 2015, 30 f.
77 Ward 2012, 191–195.
78 Durliat 1990, 517. 527.
79 For a recent definition of the *annona*, see Erdkamp 2016; see also, for the *annona civica* and *militaris*, Kingsley – Decker 2001, 2–9; for the *annona militaris*, see Pollard 2000, 101–103.
80 Kassab Tezgör et al. 1998, 445.

least 719 of which were of the type LRA 2 alongside more than 103 LRA 1, the Yassıada wreck has been interpreted as carrying the *annona militaris*[81].

DESTINATIONS OF SINOPEAN TYPE C AND D AMPHORAE

In recent years, new findings have considerably improved our information about the commercial contacts of Sinope in Late Antiquity, especially with military areas, as with the *annona militaris* delivered to the Danube Limes and into the Eastern Mediterranean[82]. The archaeological evidence from Cilicia and from north Syria provides information on the distribution of amphorae from Sinope and therefore also the mercantile contacts of those regions.

The Military

Even now there is no agreement on the system of the *annona militaris*. Was it a specific tax in kind levied on the provinces to provide food rations to the soldiers, or was it a part reserved for the army, taken from a non-specific taxation system? As set up by Diocletian, it remained in force until it was gradually replaced by tax in coin; in later times, it may simply have been the name given to the soldier's ration, not the tax[83]. This ration included wine, olive oil, and salted fish or *garum*, transported in amphorae by ship if not available locally.

One of the most important destinations for the delivery of supplies to the military forces operating in the northern Levant during Late Antiquity was Seleucia in Pieria, the harbor of Antioch. It was long known that the supplies for the army in the region came »from all over the Eastern Mediterranean«[84], but the archaeological evidence confirms that many of these supplies came from the Black Sea region and more precisely from Sinope. This has been shown by an important batch of amphorae, some with *dipinti*, discovered during rescue excavations ›near the harbor‹ at Seleucia in Pieria in 1975, now preserved in the Hatay Archaeological Museum and still awaiting detailed examination[85]. The find included ten or so amphorae of Type C Snp III and about 70 of Type D Snp I, along with a single example of the Type D Snp III. In addition, the settlement area itself has produced an assemblage of carrot amphorae, and some LRA 1 amphorae also, from a site first identified as a workshop[86] and subsequently as a warehouse[87]. If this latter identification is correct, then perhaps these amphorae were sent to Seleucia with their contents as *annona militaris* and stored there for distribution to the military units in the city itself[88], or at Antioch and even further afield[89].

To be sure, Sinopean amphorae are found relatively widely distributed at military sites throughout north Syria, and some of the land and water routes used for this can be identified, as the transport of the *annona* between military stations was under army control. For example, they were transported via the Orontes upriver to Gephyra and from there by land to the Euphrates, where the *limitanei* were based. These amphorae also made their way along the Euphrates, where they are well attested in Zeugma. Indeed, it is interesting to note that Type D Snp III is present at Zeugma in some quantities, even though this type is found less frequently outside the Sinope region than the Type D Snp I – at least, that is, on the basis of recorded finds – while one sherd only of Type D

81 van Alfen 1996, 212; van Alfen 2015, 17. 30 f.; van Doorninck 2015b, 208 f.
82 For a preliminary study of the distribution of Sinopean amphorae in Late Antiquity, see Kassab Tezgör 2010b, 167–173; for Thracia, see Dobreva 2018.
83 Pollard 2000, 101 f.; Kingsley – Decker 2001, 6.
84 Pollard 2000, 185.
85 Kassab Tezgör – Touma 2001, 111.
86 Empereur – Picon 1989, 232 f. figs. 9. 10.
87 Reynolds 2005, 566; Reynolds 2013, 96.
88 For the military units stationed in Seleucia Pieria, see Pollard 2000, 279–283.
89 Pollard 2000, 277–279.

Snp I has been positively identified there. One might reasonably speculate about whether the amphora of that type found in the rescue excavations at the Seleucia harbor may have been intended for Zeugma. Whether that was the case or not, the Euphrates was a logical point of departure for other destinations by water to other militarized sites, such as Dibsi Faraj, a walled city with a garrison and a military post, and where amphorae of Type D Snp I have also been found.

Private Trade

The archaeological evidence also indicates, however, that amphorae of Types C and D were widely distributed among civilian sites in the Aegean and Eastern Mediterranean, presumably thanks to private traders with Sinopean connections. After passing the Bosporos and the Dardanelles, coastal trade resulted in Type C Snp III amphorae arriving at Ephesos[90], then at Limyra[91], and further east at Kelenderis, an important harbor on the coast of Cilicia west of Silifke[92], and then down on the Levantine coast as far as Berytus, where examples are numerous[93]. As for Type D Snp I amphorae, a single example was discovered in the southern Prasonisi shipwreck (Site 10) between Chios and the Anatolian coast[94], while coastal trade also took these Type D Snp I amphorae to Limyra, where numerous examples have been discovered[95], and then to the Levantine coast; examples have been found at Ras Ibn Hani and at least as far south as Berytus, where they are also numerous[96], at least in contexts that predate the earthquake of A.D. 551[97], subsequent to which they are rare[98]. Inland, they are present at Horvat Kur, where fragments of this type are more common among the long-distance imports, while Type C Snp III is absent[99]. In general, they have been recorded at a number of sites both on the coast and inland in Syria, Israel, Jordan, and also Iraq, where they arrived via the Euphrates[100]. They indicate an increase in the export of Type D Snp amphorae in the 6th and 7th century compared to the dominance of the carrot amphorae type in the 4th and 5th century but also a broadening of mercantile contacts since Type D Snp I amphorae are not simply more widely spread than the earlier Type C Snp III but are also more numerous in site assemblages.

ROLE OF THE CHURCH

We leave to the end the less studied impact of the established church and its involvement in the *annona* system by way of a tithe on amphora production in the Sinope region. With the de facto creation of an established church under Theodosius the Great, this increasingly formalized the position and role of the church as landowner, controlling large estates dedicated to agriculture and producing basic but essential products, such as olive oil, wine, and wheat[101]. Sinope was gradually evangelized from the time of Trajan onwards, and in Late Antiquity the Church was an increas-

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90 Bezeczky 2013, 176 f., Type 62.
91 Bes 2021, 503–505.
92 Three amphorae of the Type C Snp III-1 and 2 have been published: Tekocak – Zoroğlu 2013, 114–116. 125 f. n. 6–8 ; 138 fig. 8–10; the example published as cat. 8 seems to be a C Snp III-1 *similis* (see above).
93 Reynolds 2010, 95 f. 107 fig. 4 a (C Snp III-1) ; 110 fig. 7 c (D Snp I).
94 Theodoulou et al. 2015, 49 f. fig. 10; as the author stresses the fact that there is so far only a single example from this site, it naturally raises the question concerning its presence there.
95 Bes 2021, 501 f.
96 Reynolds 2010, 95 f. 107 fig. 4 a (C Snp III-1); 110 fig. 7 c (D Snp I).
97 Pieri 2007, 307–309. 322 fig. 10; Reynolds 2013, 94.
98 Reynolds 2013, 98.
99 Bes 2021, 513 f.
100 Uscatescu 2003, 549. At Gerasa (Jerash), it was the most commonly imported type of amphorae: Uscatescu 2003, 549 n. 14; see Bes (forthcoming) for the latest review of the findings of this type. Also, a list of the findspots of D Snp I amphorae in the Eastern Mediterranean is provided in Pieri 2007, 307 f. n. 29–42.
101 Kingsley – Decker 2001, 9–11. See also Bernal-Casasola 2010, 20–24 for the role of the church in the production and trade in the Mediterranean.

ingly important institution in the city and the region[102]. Not far from Demirci was the church of Çiftlik, where the remains of a pottery workshop of a later period have been found among what was evidently a previously ruined structure[103]. In the city itself, a church was established in the 4th century on the site of the now-disused Roman bath at Balat, retaining its religious identity until abandoned in the early 20th century. Both churches disputed the privilege of being the church of Saint Phokas, the patron saint of the city.

Beginning in the 4th century, we see religious marks, abbreviations, or formulae incised before and after firing on Sinopean amphora[104]. Should we interpret these signs as a wish by the potter(s) to put their production under the protection of God or as a sign of their dependence on the church as their patron, or perhaps both? It brings to mind the monastery of Samos, which controlled the transport of the *annona* by the Yassıada ship[105]. Indeed, the presence of two *sekomata* in the episcopal quarter of Byllis in Albania might confirm the role of the church in organized trade and exchange[106].

CONCLUSION

The consistency of the linear measurements of the Sinopean amphorae during Late Antiquity is clearly connected to the implementation of a standardization system related to their capacity. It can be seen for the first time in the course of the 4th century with the Type C Snp III amphorae and continued into the 5th and 6th or 7th centuries with Types D Snp I and III amphorae. Because of the concurrence between the introduction of the carrot-shaped amphorae and their manufacture on a standardized model, this type may have been specially designed as a convenient packaging for this purpose.

Standardizing the containers may have been deemed a necessity to carry the *annona*: the stable and small volume (±6 l) of all the amphorae of Sinope starting in the 4th century (with a few exceptions, such as the rare Types D Snp II and D Snp I L) permitted a better and easier control at the departure port and upon the arrival of the quantity of goods transported. On the other hand, small amphorae had advantages: they were easy to fill and decant, to manipulate, to load and unload, and to stack in the hull of a ship. If our interpretation is right, it means that the concept of a rational and systematic standardization as a part of a transactional system appears even before the 7th-century date established following the LRA 2 amphorae in the Yassıada wreck. However, the standardization implemented in the 4th century and which lasted until the 6th or the 7th century seems much simpler and basic than the one used on the Yassıada LRA 2 amphorae and especially on the piriform amphorae of the Glass Wreck at Serçe Limanı in the 11th century.

We might make a reasonable guess as to the possible destinations of the wrecks discovered off the coast of Sinope. One possibility was Constantinople, where the *annona civica* was sent. On the other hand, the Eastern Mediterranean and the Levantine regions were not the only destinations for the *annona militaris*. As the site finds show, Sinopean amphorae were also distributed to the garrisons based along the Danube in Late Antiquity[107]. In general, the *annona* system provided what the local resources could not supply in sufficient quantity[108]. For this reason, it is tempting to propose that the Sinopean amphorae found in the Eastern Mediterranean region were supply-

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[102] Bryer – Winfield 1985, 71.
[103] See above n. 23.
[104] Fossey – Kassab Tezgör 1999, 169–177. Christian graffiti are also present on Type C Snp II amphora: see Kassab Tezgör 2020, 27.
[105] van Alfen 1996, 211 f.; van Alfen 2015, 30 f.; van Doorninck 2015b, 209 f.
[106] Pitarakis 2012, 412 figs. 16, 9. 10.
[107] Dobreva 2018, 314–326.
[108] That is how it likely proceeded for the garrisons on the Danubian Limes: olive oil was transported in the LRA 2 amphorae since there was no local production. Karagiorgou 2001, 147.

ing wine, since olive oil was abundant there[109]. The consumption of wine in the Roman army was substantial: in the 6th century, a soldier's ration included one *sextarius*, and 16.35 liters monthly, or ±2.7 amphorae of 6 liters[110]. If we think of a small unit as a legionary detachment of 500 men[111], approximately 1,360 amphorae were needed exclusively for the supply of their required wine ration per month.

Sinope, however, not only exported amphorae to the Eastern Mediterranean region in connection with the requirements of the *annona*, for numerous Sinopean amphorae have been discovered at civilian settlements on the western and southern Anatolian coasts, as well as in the Levant, presumably arriving there with their contents as open commercial trade. This trade may have required other modules to be produced in Sinope in addition to the standardized Types D Snp I and III: for example, Types D Snp II and D Snp I L as well as some amphorae of the ever-popular LRA 1 type[112]. All these last containers are rare finds, which suggests their production on a ›by order‹ basis to suit a particular trader's requirements. If we take into consideration the decline of navigation in the Mediterranean in the 6th and 7th century[113], it is remarkable that Sinope had an important role in this activity in the region, probably mainly thanks to the *annona*, whether the *annona civica* or the *annona militaris*, but also due to private trade. The church should have been an important actor and supervisor also for the organization and the efficiency (and success [?]) of trade.

In conclusion, the intention of this article has been to combine our knowledge of the production of amphorae in Sinope with their distribution in the Eastern Mediterranean during Late Antiquity and to understand how this relates to official and other exchange systems of required goods at that time. Specifically, it must be considered only as a prelude to a larger study of standardization of certain classes of Late Antique Sinopean amphorae. To complete this study, what is clearly required is a precise method of calculation for the volume of these amphorae and also a study of the various *dipinti* and graffiti found on certain examples to learn the nature of the content(s) and whether the control of the goods was made according to the volume or weight of the containers.

BIBLIOGRAPHY

Bennett 2013 — J. Bennett, Agricultural Strategies and the Roman Military in Central Anatolia during the Early Imperial Period, Olba 2013, 303–304.

Bernal-Casasola 2010 — D. Bernal-Casasola, Iglesia, producción y comercio en el Mediterráneo tardoantiguo: De las ánforas a los talleres eclesiásticos, in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3: Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Comparison between Western and Eastern Mediterranean, 3rd International Conference on Late Roman Coarse Wares, Parma and Pisa 2008, BARIntSer 2185, I (Oxford 2010) 19–31.

Bes 2021 — P. Bes, Late Roman Pontic Amphorae Found in Limyra (Turkey) and Horvat Kur (Israel): Typology, Provenance, Context, in: E. Sökmen – A. Schachner (eds.), Understanding Transformations: Exploring the Black Sea Region and Northern Central Anatolia in Antiquity, Byzas 26 (Istanbul 2021) 495–535.

Bezeczky 2013 — T. Bezeczky, The Amphorae of Roman Ephesus, FiE 15, 1 (Vienna 2013).

[109] Some amphorae of Type C Snp III and D Snp I and III found in Seleucia have traces of pitch, which indicates wine as a content (personal observation), as well as Type D Snp I amphorae in Beirut: Pieri 2007, 309.

[110] Bennett 2013, 323 using a *sextarius* calculated as 0.545 l. We cannot go any further in our calculation since we do not know the exact composition of the garrisons in the provinces of Cilicia and Roman Syria.

[111] Pollard 2000, 27.

[112] Sinope also produced apparently LRA 1 amphorae but in small numbers: Kassab Tezgör 2020, 40–43.

[113] McCormick 2012, 84 fig. 3, 12.

Boetto 2012 — G. Boetto, Les épaves comme sources pour l'étude de la navigation et des routes commerciales: une approche méthodologique, in: S. Keay (ed.), Rome, Portus and the Mediterranean, Archaeological Monograph of the British School at Rome 21 (London 2012) 153–173.

Bryer – Winfield 1985 — A. Bryer – D. Winfield, The Byzantine Monuments and Topography of the Pontos, Dumbarton Oaks Studies 20 (Washington, DC 1985).

Cioffi 2014 — C. Cioffi, Documenting, measuring and integrating sekomata: An example from Naxos, DialA Suppl. 12, 2014, 41–56.

Dobreva 2018 — D. Dobreva, Thracian city economy as part of the global Sinopean wine trade, in: L. F. Vagalinski – M. Raycheva – D. Boteva – N. Sharankov (eds.), Cities, Territories and Identities. Proceedings of the First International Roman and Late Antique Thrace Conference, Plovdiv 3rd–7th October 2016, Bulletin of the National Archaeological Institute 44, 2018, 309–321.

Durliat 1990 — J. Durliat, De la ville antique à la ville byzantine. Le problème des subsistances, École Française de Rome 136 (Rome 1990).

Erdkamp 2016 — P. Erdkamp, s. v. Annona, in: Oxford Classical Dictionary, Subject: Ancient Economy, Online Publication Date: Mar 2016; DOI: 10.1093/acrefore/9780199381135.013.8000 (10. 06. 2019).

Empereur – Picon 1989 — J.-Y. Empereur – M. Picon, Les régions de production d'amphores impériales en Méditerranée orientale, in: Amphores romaines et histoire économique. Dix ans de recherche. Actes du Colloque de Sienne 22–24 mai 1986, École Française de Rome 114 (Rome 1989) 223–248.

Finkielsztejn 2006 — G. Finkielsztejn, Production et commerce des amphores hellénistiques récipients, timbrage et métrologie, Entretiens d'Archéologie et d'Histoire 7, 2006, 17–35.

Finkielsztejn 2010 — G. Finkielsztejn, The Sekoma: A Volume Standard for Liquids, Maresha III, Israel Antiquities Authority Reports 45, 2010, 193–203.

Finkielsztejn 2012 — G. Finkielsztejn, Instruments inscrits, boutiques, agora et cités au Levant sud hellénistique, in: V. Chankowski – P. Karnovis (eds.), Tout vendre, tout acheter. Ausonius, Actes du Colloque d'Athènes 16–19 juin 2009, Scripta Antiqua 42 (Paris 2012) 303–317.

Fossey – Kassab Tezgör 1999 — J. Fossey – D. Kassab Tezgör, Quelques inscriptions de Sinope, Anatolia Antiqua 7, 1999, 167–178.

Garlan 2000 — Y. Garlan, Amphores et timbres amphoriques grecs: entre érudition et idéologie (Paris 2000).

Garnier et al. 2011 — N. Garnier – T. Silvino – D. Bernal-Casasola, L'identification du contenu des amphores: huile, conserves de poissons et poissage, SFECAG. Actes du congrès d'Arles juin 2011 (Marseille 2011) 397–416.

Hill 1995 — S. Hill, The first season of rescue excavation at Çiftlik (Sinop), AnSt 45, 1995, 219–231.

Karagiorgou 2001 — O. Karagiorgou, LR2: a container for the military annona on the Danubian border?, in: S. Kingskey – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity. Proceedings of a Conference at Somerville College Oxford 29 May 1999 (Oxford 2001) 1–27.

Kassab Tezgör 2010a — D. Kassab Tezgör (ed.), Les fouilles et le matériel de l'atelier amphorique de Demirci près de Sinope, Varia Anatolica 22 (Istanbul 2010) 121–140.

Kassab Tezgör 2010b — D. Kassab Tezgör, Le réseau commercial des amphores sinopéennes entre les IIe–IIIe s. et le VIe s. de notre ère, in: D. Kassab Tezgör – N. Inaishvili (eds.), Production and Trade of Amphorae in the Black Sea. PATABS I. Table Ronde internationale Batumi-Trabzon 27–29 April 2006, Varia Anatolica 21 (Istanbul 2010) 167–173.

Kassab Tezgör 2011 — D. Kassab Tezgör, Types amphoriques romains tardifs produits simultanément à Demirci près de Sinope et dans d'autres centres de mer Noire, in: C. Tzochev – T. Stoyanov – A. Bozkova (eds.), Production and Trade of Amphorae in the Black Sea. PATABS II. Table Ronde internationale Kiten, Nessebar et Sredetz, Bulgaria, 26–30 September 2007 (Sofia 2011) 259–264.

Kassab Tezgör 2020 D. Kassab Tezgör, Corpus des Amphores de l'Époque Romaine Produites dans les Centres de Mer Noire. Musées de la Côte Turque de la Mer Noire (Eregli, Amasra, Sinop, Samsun, Giresun, Ordu, Trabzon et Amasya), Archaeopress Roman Archaeology 74 (Oxford 2020).

Kassab Tezgör – Touma 2001 D. Kassab Tezgör – M. Touma, Amphores exportées de mer Noire en Syrie du Nord, Anatolia Antiqua 9, 2001, 105–115.

Kassab Tezgör et al. 1998 D. Kassab Tezgör – İ. Tatlıcan – H. Özdaş, Prospection sous-marine près de la côte sinopéenne: transport d'amphores depuis l'atelier et navigation en mer Noire, Anatolia Antiqua 6, 1998, 443–449.

Kassab Tezgör et al. 2003 D. Kassab Tezgör – S. Lemaître – D. Piéri, La collection d'amphores d'Ismail Karakan à Sinope, Anatolia Antiqua 11, 2003, 169–200.

Kingskey – Decker 2001 S. Kingskey – M. Decker, New Rome, New Theories on Inter-Regional Exchange: East Mediterranean Economy in Late Antiquity, in: S. Kingskey – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity. Proceedings of a Conference at Somerville College Oxford 29 May 1999 (Oxford 2001) 1–27.

Klenina – Biernacki 2018 E. Klenina – A. B. Biernacki, Mensae Ponderariae from The North-Western Black Sea Region. Preliminary Approach, in: Proceedings of the First International Roman and Late Antique Thrace Conference, Bulletin of the National Archaeological Institute 44, 2018, 289–298.

Mayerson 2001 P. Mayerson, Sekomata: Measures of Wine, not Jars, BAmSocP 38, 2001, 97–101.

McCormick 2012 M. McCormick, Movements and Markets in the First Millennium. Information, Containers, and Shipwrecks, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection (Washington, DC 2012) 51–98.

Monachov 2003 S. Yu. Monachov, Grečeskije amphory v Pričernomor'e. Tipologija amfor veduščih centrov-eksporterov tovarov v keramičeskoj tare. Katalog-opredelitel' (Moscow 2003).

Morrisson 2012 C. Morrisson, Weighing, Measuring, Paying, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection (Washington, DC 2012) 379–398.

Panagou 2016 T. Panagou, Transport Amphoras and their Contents, in: Τιμητικός τόμος για τη Στέλλα Δρούγου, ηχαδιν II (Athens 2016) 313–344.

Parker 1992 A. J. Parker, Ancient Shipwrecks of the Mediterranean and the Roman Provinces, BAR-IntSer 580 (Oxford 1992).

Paterson 1982 J. Paterson, »Salvation from the Sea«: Amphorae and Trade in the Roman West, JRS 72, 1982, 146–157.

Pecci – Cau 2014 A. Pecci – M. A. Cau Ontiveros, Residue analysis of Late Roman cooking pots and amphorae from Sa Mesquida (Mallorca, Balearic Islands), in: N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae: Archaeology and Archaeometry. The Mediterranean: A market without frontiers, BARIntSer 2616, II (Oxford 2014) 833–841.

Pieri 2007 D. Pieri, Béryte dans le grand commerce méditerranéen. Production et importation d'amphores dans le Levant protobyzantin (V^{e}–VII^{e} s. ap. J.-C.), Topoi Suppl. 8, 2007, 297–327.

Pieri 2012 D. Pieri, Regional and Interregional Exchanges in the Eastern Mediterranean during the Early Byzantine Period. The Evidence of Amphorae, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection (Washington, DC 2012) 27–49.

Pitarakis 2012 B. Pitarakis, Daily Life at the Marketplace in Late Antiquity and Byzantium, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Research Library and Collection (Washington, DC 2012) 399–426.

Pollard 2000 N. Pollard, Soldiers, Cities, and Civilians in Roman Syria (Ann Arbor, MI 2000).

Rauh et al. 2013 N. Rauh – C. Autret – J. Lund, Amphora Design and Marketing in Antiquity, in: M. Frass (ed.), Kauf, Konsum und Märkte, Wirtschaftswelten im Fokus. Von der römischen Antike bis zur Gegenwart (Wiesbaden 2013) 145–181.

Reynolds 2005 P. Reynolds, Levantine amphorae from Cilicia to Gaza: a typology and analysis of regional production trends from the 1st to 7th centuries, in: J. M. Gurt Esparraguera – J. Buxeda i Garrigós – M. A. Cau Ontiveros (eds.), LRCW I. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and Archaeometry, BARIntSer 1340 (Oxford 2005) 563–611.

Reynolds 2010 P. Reynolds, Hispania and the Roman Mediterranean (AD 100–700). Ceramics and trade (London 2010).

Reynolds 2013 P. Reynolds, Zeugma: Transport amphorae of the First to Seventh Centuries (Early Roman to Byzantine Periods), in: W. Aylward (ed.), Excavations at Zeugma, Conducted by Oxford Archaeology, II (Los Altos, CA 2013) 93–161.

Tekocak – Zoroğlu 2013 M. Tekocak – K. L. Zoroğlu, Kelenderis'te bulunan bir grup Roma dönemi ticari amphorası ve düşündürdükleri, Olba 21, 2013, 109–139.

Theodoulou et al. 2015 T. Theodoulou – B. Foley – D. Kourkoumelis – A. Preka-Alexandri, Roman amphorae cargoes in the sea of Chios – the 2008 mission, in: S. Demesticha (ed.), Per Terram, per Mare. Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean (Uppsala 2015) 41–54.

Uscatescu 2003 A. Uscatescu, Report on the Levant Pottery (5th–9th century AD), in: M. Bonifay – J.-P. Sodini – G. Démians D'Archimbaud – J. Hayes (eds.), Table-ronde De Rome à Byzance, de Fostat à Cordoue: évolution des faciès céramiques en Méditerranée (Ve–IXe s.) (Thessaloniki 2003) 546–549.

van Alfen 1996 P. G. van Alfen, New light on the 7th-c. Yassı Ada shipwreck: capacities and standard sizes of LRA1 amphoras, JRA 9, 1996, 189–213.

van Alfen 2015 P. G. van Alfen, The restudy of the LR2 amphoras from the Seventh-Century Yassıada shipwreck: preliminary evidence for standardization, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (Texas 2015) 17–34.

van Doorninck 2015a F. H. van Doorninck, Jr., The Metrology of the Piriform Amphoras from the Eleventh-Century Byzantine Ship at Serçe Limanı. New Designs but an Old System, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (Texas 2015) 35–54.

van Doorninck 2015b F. H. van Doorninck, Jr., The Seventh-Century Byzantine Ship at Yassıada and Her Final Voyage: Present Thoughts, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell, Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (Texas 2015) 205–216.

Wallace 2004 M. Wallace, Standardization in Greek Amphora, in: J. Eiring – J. Lund (eds.), Transport amphorae and trade in the Eastern Mediterranean. Acts of the international colloquium at the Danish Institute at Athens September 26–29, 2002, Monographs of the Danish Institute at Athens 5 (Aarhus 2004) 429–431.

Ward 2012 C. Ward, Four Ships of late Antiquity in the Black Sea, in: D. Kassab Tezgör (ed.), Sinope. The Results of Fifteen Years of Research – Les Résultats de Quinze Ans de Recherche. Symposium international Sinop 7–9 Mai 2009, Ancient Civilizations from Scythia to Siberia special volume (Leiden 2012) 189–198.

Yekutieli – Akus 2014 Y. Yekutieli – I. Akus, Netanya, Final Report (19/08/2014), e-Journal Hadashot Arkheologiyot – Excavations and Surveys in Israel (HA-ESI), 126.

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ACHIEVING STANDARD VOLUMES IN AMPHORA PRODUCTION

NEW EVIDENCE FROM THE 7TH-CENTURY YASSIADA SHIPWRECK

Abstract

This chapter explores how, and by extension why, late Roman potters may have achieved standard sizes and capacities of transport amphorae. Drawing on a case study of largely intact LR2-related amphorae from the 7th-century shipwreck at Yassıada (southwest Turkey), we combine computational analyses of 3D point clouds of whole jars – captured using structured light scanning – with fine-grained study of their morphological features and production sequences, in the process offering a new and multifaceted approach to detecting and evaluating such standards. The resulting observations help shed light on the political, social, and economic context of distribution during the Late Antique eastern Mediterranean and the shifting trajectories of amphora production that accompanied this transformation.

Linear measurements demonstrate that potters, in producing a particular set of containers for this shipment, correlated height and diameter and conceived of the jar's shape in terms of a sphere. That this basic approach guided production is supported by systematic comparison of these 3D models to ideal circles and spheres, allowing us also to gauge the remarkably high precision and accuracy with which this process was executed. Producers not only created groups of cargo amphorae that were visually similar and could stack conveniently, but they also aimed at carefully controlling capacities to within a few percent while simultaneously increasing container efficiency – both in individual terms and when stacked – and potentially also achieving several discrete volume sizes through the same basic shape. That is, the spherical body facilitated simple calculation and quick replication of capacities and could be adjusted thereafter to certain practical demands of the production sequence, such as the assembly of bodies from two uneven parts and precise attachment of a separately made neck. The sphere may have been preferred as the most efficient container in terms of volume of product for surface area and jar weight, an observation supported also by the overall trajectory toward smaller necks and thinner body walls during this late period of LR2-related production. The resulting modified spherical shape afforded an even more compact stacking and therefore greater efficiency in loading and transport.

This evidence from the Yassıada shipwreck cargo demonstrates how such targeted standards may have been achieved within individual Aegean production centers and potentially communicated farther afield across the Late Antique world. Such a view becomes particularly important given the changing dynamics of Late Antique amphora production, which saw several fewer forms (i.e., the Late Roman series) replace a greater diversity of shapes. From a methodological perspective, moreover, the approach employed here emphasizes the versatility of high-quality 3D models for continuing and extending in the lab the detailed formal studies that have traditionally been reserved for on-site study in storerooms. Building on these initial observations and laying out future steps, we aim to offer a path forward toward a more holistic morphological analysis of systematic standardized production of ancient Mediterranean transport amphorae.

For any discussion of standardization of transport amphorae, shipwrecks become an invaluable source of material evidence. As large assemblages of jars that are generally better preserved than in contexts on land, these sites can present robust datasets that facilitate a wide range of formal analyses, linear and capacity measurements, and observations of production sequences. Since cargos include amphorae that were specifically in circulation together and often include groups of jars that were produced together in workshops, they also provide a precise chronological control not routinely available in other archaeological deposits. Short time frames of production and closed contexts of circulation help minimize certain variation that can obscure identification and study of intentional standardization in amphora datasets brought together from many assemblages and over longer spans. As a result, cargos take on critical importance in exploration of the practices though which tight control over forms and capacities was achieved and, ultimately, the mechanisms and motivations behind standardization. It is on these fundamental advantages of shipwreck cargos – in particular, one cargo of the 7th century A.D. that sank between the island of Cos and the Bodrum (Halicarnassus) Peninsula in southwest Turkey – that the analyses and observations offered here rest[1].

A CONTEXT AND CASE STUDY OF STANDARDIZATION: STATE SUPPLY

The early 1960s investigations at Yassıada, the first seabed excavation of an ancient shipwreck with substantial hull remains, provided a landmark for underwater field techniques; decades later, the project continues to inform studies of Late Antique and early Byzantine seaborne economy and interaction[2]. The wooden vessel itself was a major focus of discovery given the early and sustained interest in exploring ancient ship construction technologies. Its preserved remains allowed extensive reconstruction of a ship of moderate size, just under 21 m in length and 60 tons of burden, well-appointed with a tile-covered cabin and galley (fig. 1)[3]. The cargo under which the hull timbers were buried, however, gained ever more attention over the decades that followed, slowly revealing clues that overturned the initial interpretation of the assemblage as that of an ordinary coastal commercial trader. Rather than commerce, the ship appears to have been engaged in official imperial supply, having been organized and sailed under the supervision of the church to support Heraclius' military forces on campaign against the Persian armies in the east during the late 620s[4].

These state needs were met by supply mechanisms that have slowly become clear through the identification of strongly standardized forms and volumes among the amphorae, which were primarily destined to carry wine. Representing nearly 40 tons of cargo at the time of sinking and totaling over 800 in number, the jars belonged to two general shapes that, in the decades following the excavation, would come to be known within the LRA typology as Late Roman 1 (LR1) and Late Roman 2 (LR2)[5]. The larger LR2-related jars were stacked three to four deep within the hold and represented 85–90 % of the count, making them by far the major cargo component by number and especially by product volume. The less numerous and smaller LR1 amphorae appear to have been placed on their sides between the necks of the upper layer of LR2s, situating them conveniently to maximize space under the decking[6]. Approximately 110 cargo amphorae were raised from the seabed for study, while the vast majority were mapped and then moved adjacent to the site to allow access to the hull remains. Even from this limited sample, certain variations in form and decoration hinted at more complexity than two basic types would immediately suggest[7]. The discovery of graffiti on the amphorae in 1980 added further clues to their individual histories and shared economic context and helped prompt a long-term and multifaceted study of the cargo assemblage under the direction of F. H. van Doorninck, Jr. that continues to this day[8]. To support this restudy, amphorae left behind during the initial excavation were raised over the course of

1 We are grateful to many people who have supported the ongoing work related to the Yassıada amphorae: Tuba Ekmekçi Littlefield and Esra Altınanıt Bicer at INA's Bodrum Research Center; Oğuz Alpözen, Yaşar Yıldız, Tayfun Selçuk, and Hande Savaş at the Bodrum Museum of Underwater Archaeology; George F. Bass, who directed the fieldwork at Yassıada; and Claude Duthuit, Robin Piercy, Aleydis Van de Moortel, Peter van Alfen, and Elizabeth Vo-Phamhi, who each facilitated the study over the years in many different ways. For helpful discussion throughout and careful thoughts on the text, we thank Khaled Nikro and Horacio González Cesteros.

2 On the Yassıada shipwreck, see generally Bass – van Doorninck 1982; Carlson et al. 2015.

3 Steffy 1982, 86. On the galley, see van Doorninck 1982.

4 For the contrasting interpretations, see Bass 1982a; van Doorninck 2015.

5 Bass 1982a, 316; Bass 1982b, 163.

6 van Doorninck 2015, 206.

7 Bass 1982b, 155–160. On the LR1 amphorae and their variation, see van Alfen 1996; Leidwanger 2014.

8 For graffiti, see Bass 1982b, 161 f. fig. 8, 8. On the restudy more generally, see van Doorninck 1989; van Doorninck 2015.

surveys conducted during the early 1980s, resulting in about 600 additional jars becoming available[9].

1 Reconstruction of the loaded cargo and cabin from the Yassıada shipwreck formerly in the Bodrum Museum of Underwater Archaeology (© Courtesy of the Institute of Nautical Archaeology)

This more robust dataset formed the basis for the identification of several distinct groups among the LR2-related amphorae, three groups of which may include some 70, some 160, and around 200 examples that were strongly standardized by shape and volume[10]. By contrast, other amphorae belonging to both the LR2 and LR1 groups exhibit considerable variation. There is some evidence of reuse throughout the assemblage, and certain rarer jars in the cargo appear to have enjoyed particularly long lives before this final voyage, having been produced perhaps as early as the latter 6th century[11]. This contrast of a few larger groups of highly standardized jars against a backdrop of high variability and reuse would seem to support two major observations: first, in at least some workshops or production areas and for some distributors, amphora manufacture in the years just before the ship's loss focused on carefully standardized volumes alongside shapes; and second, emergency conditions of military supply may have necessitated mobilizing older containers belonging to a range of forms that were seemingly unstandardized. A shift may therefore be detectable in the dynamics of serial manufacture of amphorae over the decades around the early 7th century. Preliminary fabric study indicates that the major LR2-related amphorae at Yassıada were the products of Aegean workshops, although more work is necessary on the smaller groups to determine their likely origin and in turn the extent to which these shifts occurred within the same workshops or through the introduction of new producers. The context and timing have raised the prospect that the shift may form part of an official imperial effort to reform supply, perhaps under Heraclius[12]. Whether efforts to standardize in this way were primarily a state initiative or extended broadly to routine commerce and market distribution remains unclear.

In this context of state supply, the Yassıada assemblage provides an opportunity to examine how and to what technical level standardization was achieved. The implications go beyond one cargo or even imperial infrastructure, raising broader issues about the extent of coordination in production, distribution, and consumption, and what people knew in antiquity about the volume and quality of consumables from their packaging. To investigate these issues, we rely here largely on a combination of traditional and new digital analytical approaches applied to a case study drawn from among the well-preserved larger groups of amphorae that were produced shortly before the ship sailed. Among those groups that aimed to achieve not only set forms but also particular volumes, one known as the ›spiral-combed‹ type for its distinctive surface treatment –

9 Slightly over 100 amphorae remained on the seabed thereafter.
10 For earlier work on the various LR2-related jars, see van Alfen 2015.
11 van Doorninck 1989, 247–253.
12 E.g., see van Doorninck 2015, 210–213.

2 Well-preserved amphorae from the dataset (n = 41) (© by the authors)

a band of combing that spirals down from the shoulder – has been the focus of recent intensive work (fig. 2). The type includes approximately 200 examples, of which a few dozen survive intact; relying on up to 41 of the best-preserved examples, the analysis that follows offers insights into the formal conceptualization and production techniques that facilitated the manufacture of standardized amphorae during this tumultuous period[13].

NEW APPROACHES TO MEASURING STANDARDIZATION

Traditional approaches to systematically evaluating standardization within groups of ceramics tend to emphasize certain linear measurements that broadly govern shape, especially maximum diameter and height[14]. These metrics may provide a basic gauge of consistency in serial production, but they hardly reflect the range of features through which a complex ceramic shape might be defined or, in the case of amphorae, a particular volume of capacity achieved. Direct physical measurements on ceramics are limited also practically by the human error introduced through the process. Such reliance on linear dimensions may also inhibit incorporation into analysis of the less well-preserved examples that are typical of most archaeological contexts.

Quantitative morphological analysis offers an opportunity to overcome some of these challenges and limitations. This approach relies on data that integrate the entire ceramic shape. Point

[13] All discussions of amphorae below, and all amphora numbers included in the text, refer to jars from this ›spiral-combed‹ group at Yassıada unless otherwise noted. The ›spiral-combed‹ amphorae are mostly larger examples, although a few (four) in smaller sizes have also been included as they provide useful comparanda for their larger counterparts. These smaller jars are therefore only incorporated when analysis and discussion focus on shape and the associated methods of achieving it rather than when specific volume is under study.

[14] E.g., Riley 1979/1980; cf. Roux 2003.

clouds are a highly versatile and powerful format to describe precisely the shapes and surfaces of objects in 3D space[15]. These 3D models are now standard practice in archaeology, with such technologies as laser scanning and structured light scanning supporting diverse applications from conservation to reconstruction and public engagement[16]. The work described here draws on high-quality point clouds generated by structured light scanning technology using a commercial Artec Eva system[17]. High-resolution data gathered using other approaches, however, could also form a reliable basis for analysis, including photogrammetry that increasingly represents one of the most cost-effective and widely available technologies for archaeological research in the field and museum.

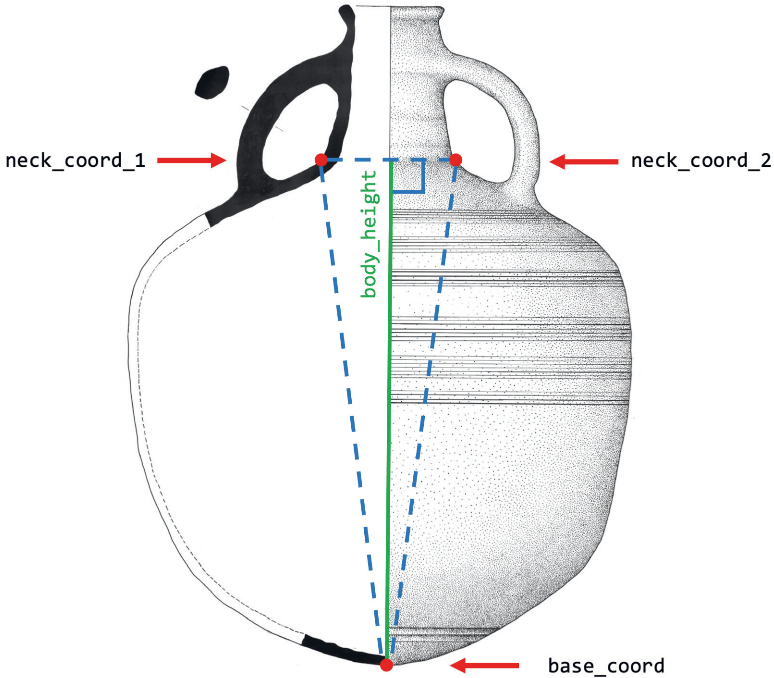
The analysis here builds on previous work that aimed to develop systematic methods to evaluate how similar jars were overall within a given dataset[18]. That work compared pairs of amphorae across a group of typologically similar jars by dividing their shapes into segments that corresponded to different aspects of the forming process, from toe and base to neck and rim. Working with small sets of amphorae from two different Late Antique and early Byzantine shipwrecks in southwest Turkey (including the 7th-cent. Yassıada cargo analyzed here), this approach proved a feasible and effective method for exploring in 3D how well potters were able – or cared – to control different parts of the shape of an amphora. The present work builds on this previous proof of concept, focusing quantitative morphological methods on a larger dataset and incorporating more facets of shape and careful attention to the production sequence. This approach allows us to explore how potters may have effectively ensured standardized volumes to meet the specific demands of state supply evident in the Yassıada cargo and to gain insights into the limits of such mass production to prescribed standards in antiquity.

Analyzing high-resolution point clouds is demanding in both the data-gathering and computation stages. The point clouds used in the present analysis, for example, each contain tens of thousands of points. Prior studies have argued for such computation-heavy approaches, demonstrating the analytical rigor achieved by assessing entire point clouds rather than more limited landmark-based approaches that focus only on specific predetermined points[19]. The benefits of high-density point clouds can easily outweigh these costs, as B. R. Hassett and T. Lewis-Bale note: »While the distribution of points across the surface is not uniform, the redundancy in the sheer number of data points available to be compared in a high-density point cloud addresses concerns that, in order to appropriately compare surfaces, an even sampling strategy must be applied (as, for instance, in semi-landmark approaches).«[20]. The methods employed here therefore stress efficiency and scalability alongside cost-effectiveness for archaeological practitioners. The modular architecture facilitates inclusion of free, open-source algorithms that are constantly improving for performance and speed. All software relies on open-source Python libraries, ensuring unrestricted access for researchers. Flexible, powerful, clean, and free, Python is the programming language of choice across the sciences, engineering, and other fields, replacing costly commercial products with expensive add-ons. More technical aspects of the pipeline have been abstracted away to leave a streamlined user-friendly interface. Links to example iPython notebook scripts are included in the technical appendix at the end.

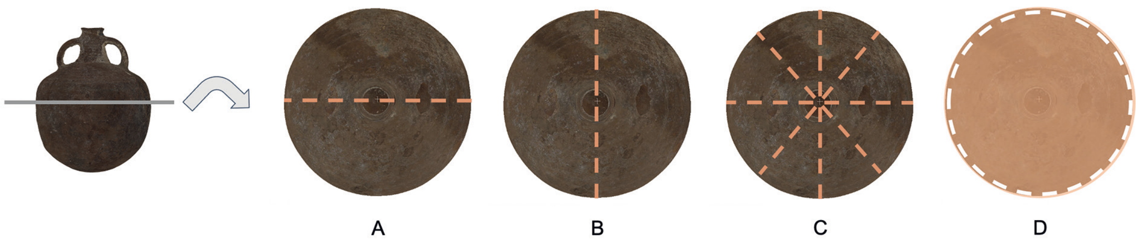
EVALUATING DIAMETER AND HEIGHT

At a most basic level, these models allow us to collect virtually the same traditional metrics that have long been used to evaluate standardization but in a more accurate, comprehensive, and easy

15 On pottery, see generally Karasik – Smilansky 2011.
16 E.g., Williams et al. 2019.
17 <https://www.artec3d.com/portable-3d-scanners/artec-eva> (28. 03. 2023).
18 Vo-Phamhi – Leidwanger 2020.
19 Birch – Martinón-Tórres 2019.
20 Hassett – Lewis-Bale 2016, 198.



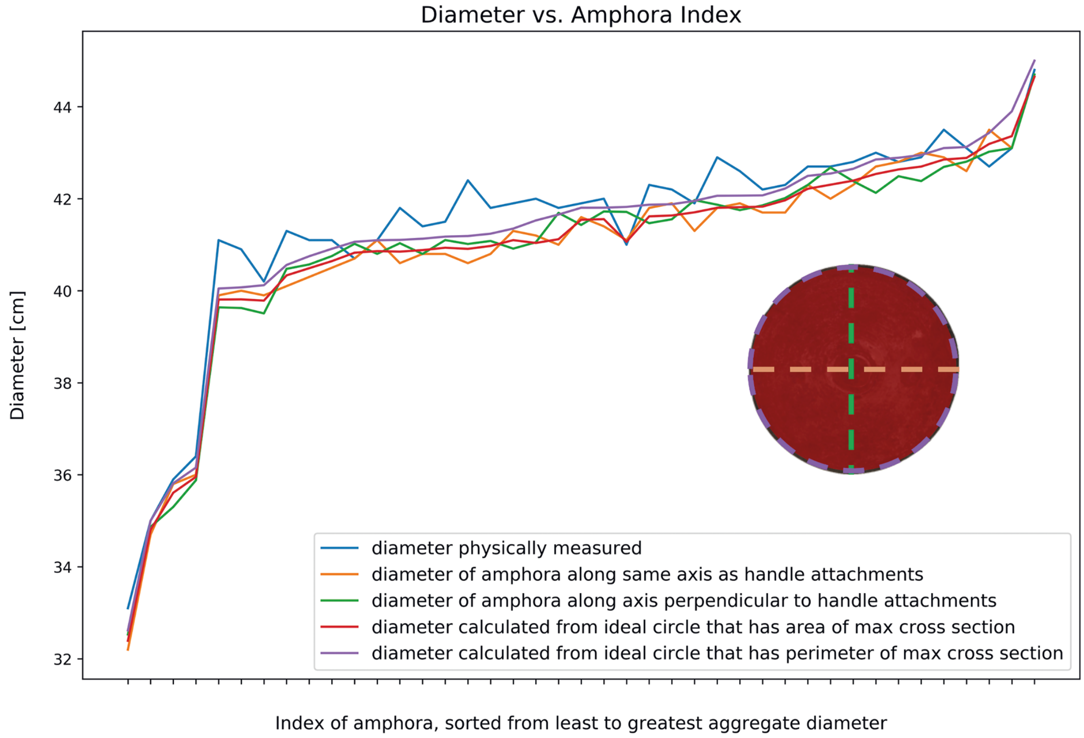
3 Triangulating body height (© Institute of Nautical Archaeology and authors)



4 Four ways of acquiring a diameter measurement at the cross section of maximum diameter, illustrated using Y126 (© by the authors)

manner. Measurements for dimensions like body height can be unwieldy and inaccurate on a large physical jar but easily triangulated on a point cloud using the 3D coordinates near the bottom of the neck and at the base (fig. 3). Yet more robust measurements of certain traditional metrics also become possible with these point clouds. Figure 4 shows the horizontal cross section of amphora Y126 at the point of maximum diameter. Traditionally, one might calculate the physical measurement for maximum diameter as a point-to-point distance along the same axis as the handles (fig. 4 a) given common conventions of archaeological illustration, or perhaps one might simply identify the largest diameter measurement one could find at this specific height. Other options include the point-to-point distance along the axis perpendicular to that of the handles (fig. 4 b). One could improve over a single ad hoc measurement by taking the average over multiple diameters (fig. 4 c), although this is scarcely done in practice at least in part due to its difficulty.

Here a computational approach proves immediately advantageous. The point cloud allows for a single diameter metric that aggregates over the entire cross section based on an ideal circle with either the same area or perimeter as the amphora cross section (fig. 4 d). This approach enables more accurate characterization of the overall diameter of a wheel-made jar so as to ensure systematic comparison. Figure 5 compares these different physically and digitally derived diameters for the amphorae in our dataset. The computational diameter measurements vary together consistently. Where computational measurements vary most, it is often a contrast between the diameters



5 Computational diameter measurements vary together consistently, and physically measured diameter consistently overestimates computational diameter measurements (n = 41) (© by the authors)

at the axis of handle attachment and at the axis perpendicular to this, presumably capturing some deformation of the shape from perfectly circular. Physically measured diameters consistently overestimate computational diameter measurements, although this may not be surprising given a measurer's common interest in finding the largest possible maximum diameter. To this end, the diameter calculated from an ideal circle of the same area is especially useful, since this minimizes the effects of surface wear and irregularities; unless otherwise noted, this is the maximum diameter measurement used throughout the analysis and discussion below.

An approach based on 3D models can allow us to extract any such basic metrics, and it can do so more securely, comprehensively, and efficiently. As a result, more time in the field might be dedicated to those tasks that can only be done in the field rather than spent retrieving any and all possible measurements that might later prove (or not) to be of analytical interest.

The computationally derived basic measurements for this amphora dataset also lend support to the correlation, hypothesized years ago, between maximum diameter and body height[21]. For the vast majority of amphorae, maximum diameter calculated from an ideal circle of the same area differs from the body height by no more than 2.5 %, and all but one of the remaining few by no more than 5 % (fig. 6). This ratio of nearly 1 : 1 suggests potters worked on the conceptual model of a sphere[22]. In other words, they used one diameter dimension to generate consistent production of standard spherical volumes.

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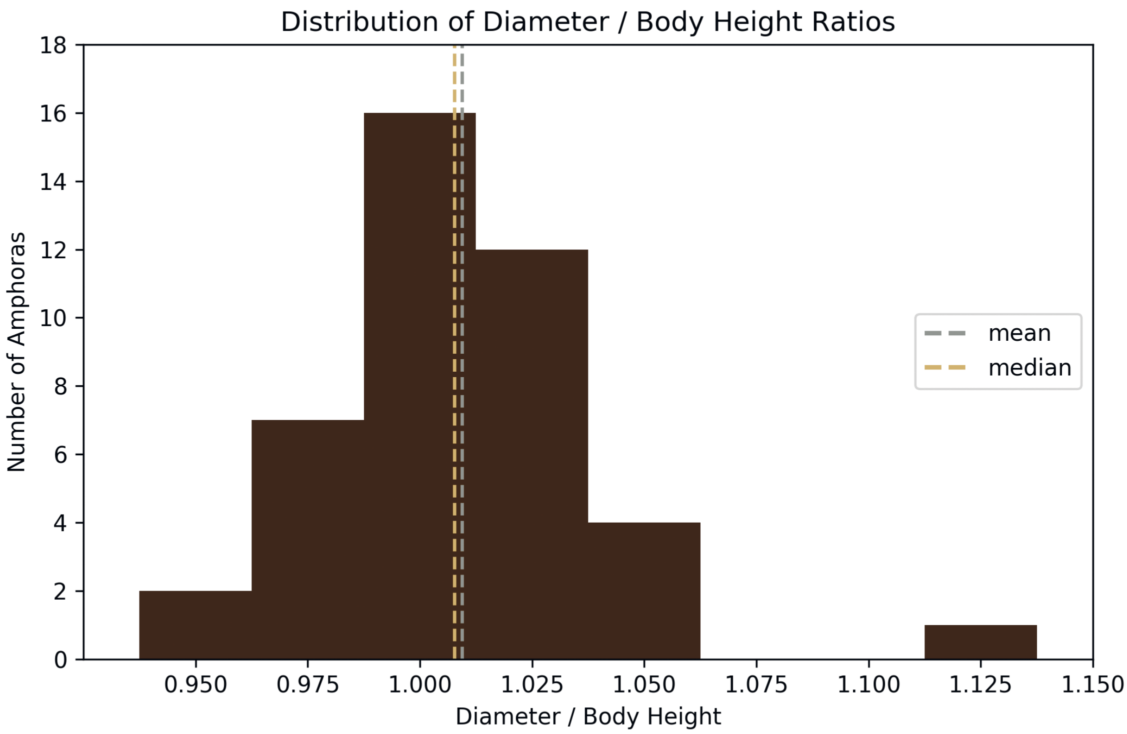
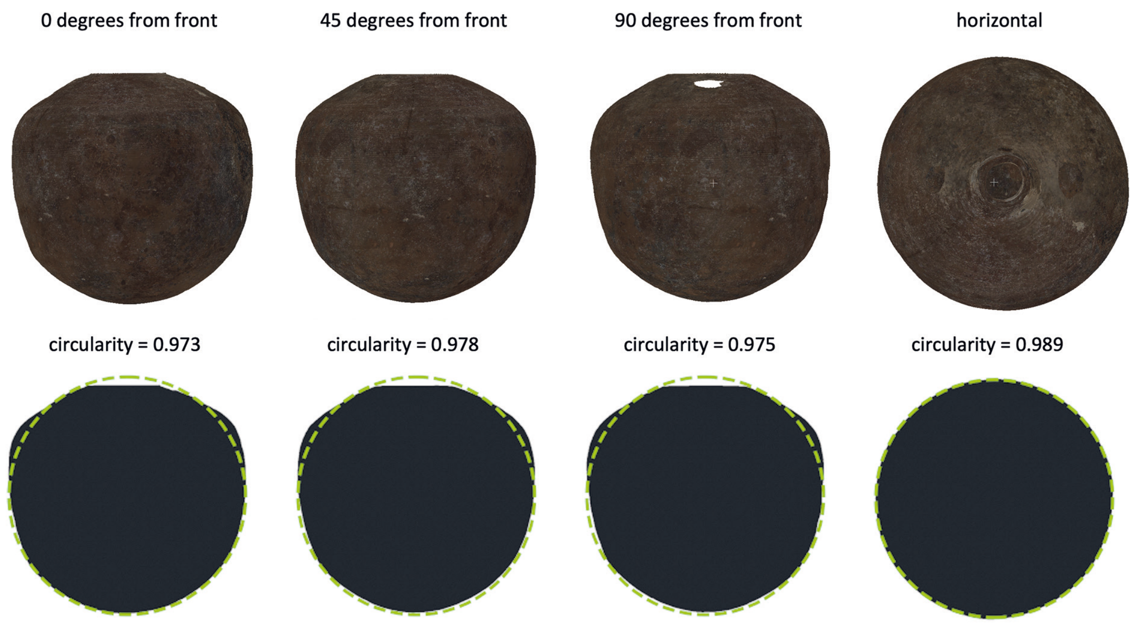
21 See generally van Alfen 2015.

22 Note that for the present analysis, body height measurements in the field were taken to the juncture of the neck and body as visible on the outside of the amphora. Subsequent study has suggested that an upturned shoulder collar was fashioned from the top of the body for seating the neck, suggesting a slightly greater height for the overall body calculations. The measurement of one of the jars included here (84/1) in this new manner would increase its height slightly and in turn bring this dimension even more in line with maximum diameter, resulting in a variation of only 0.4 cm or 1 %. Across the larger dataset, this small amount of additional height would likely place the overall ratio closer to a 1 : 1 relationship between maximum diameter and body height. For the production process involving this shoulder collar, see below.



6 For the vast majority of amphorae, maximum diameter and body height differ by less than 2.5 % (n = 41) (© by the authors)



7 Circularity analysis from 3D point clouds using 83-2 as the case study (© by the authors)

TESTING IDEAL SHAPES

To test this hypothesis of an ideal shape, we developed a process that could quantitatively analyze the circularity of the amphora bodies. The point cloud was preprocessed to remove stray particles and other points corresponding to noise from the scanning process that could confound the analysis[23]. The clean 3D point cloud was then rendered in CloudCompare, an open-source point cloud processing platform[24]. Handles and necks were removed using CloudCompare's visual interface, and 2D images were captured in four orientations (fig. 7, top row).

These cross sections – three vertical and one horizontal – were algorithmically compared to a perfect circle (fig. 7, bottom row). To do so, a Gaussian blur was applied to each cross-section image to smooth the pixelated edges of the shape. Otsu's method was then used to classify all pixels as background or foreground, and the foreground shape was flooded to produce a silhouette[25]. Implementations from the scikit-image Python library were used for both of these steps[26]. The area and perimeter of each cross-section silhouette were then computed and used to calculate the circularity (Equation 1). The closer the resulting circularity metric is to 1, the more circular the amphora section. This analysis was performed for all 41 jars in the dataset. Histograms were plotted for circularities from different perspectives based on vertical sections situated at 0, 45, and 90 degrees from the front and on a single horizontal section at maximum diameter (fig. 8, with standard deviations of 0.00466, 0.00468, 0.00541, and 0.00487, respectively).

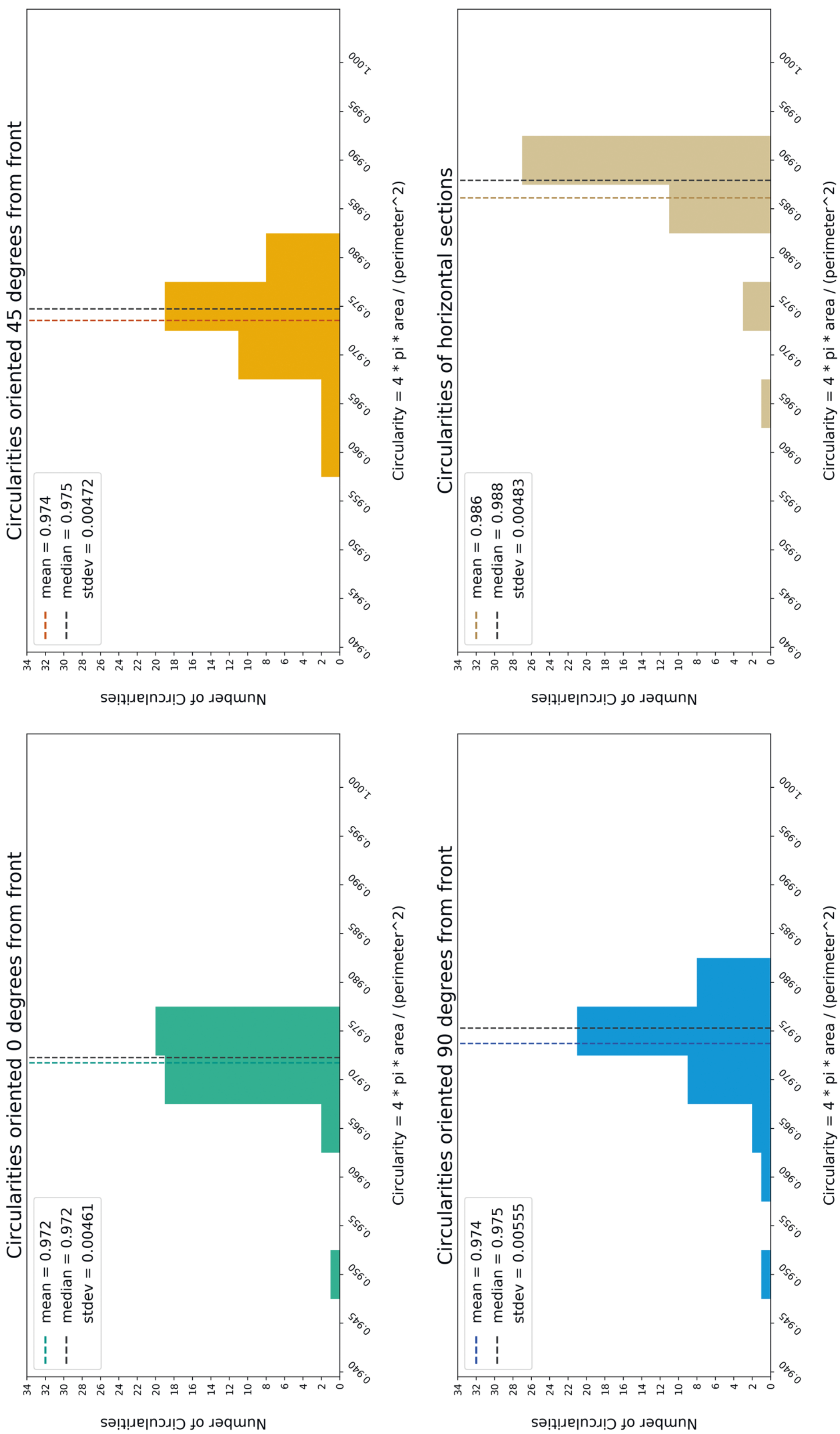
$$Circularity = \frac{4 \times \pi \times Area}{Perimeter^2} = 1$$

Equation 1. Circularity of a perfect circle

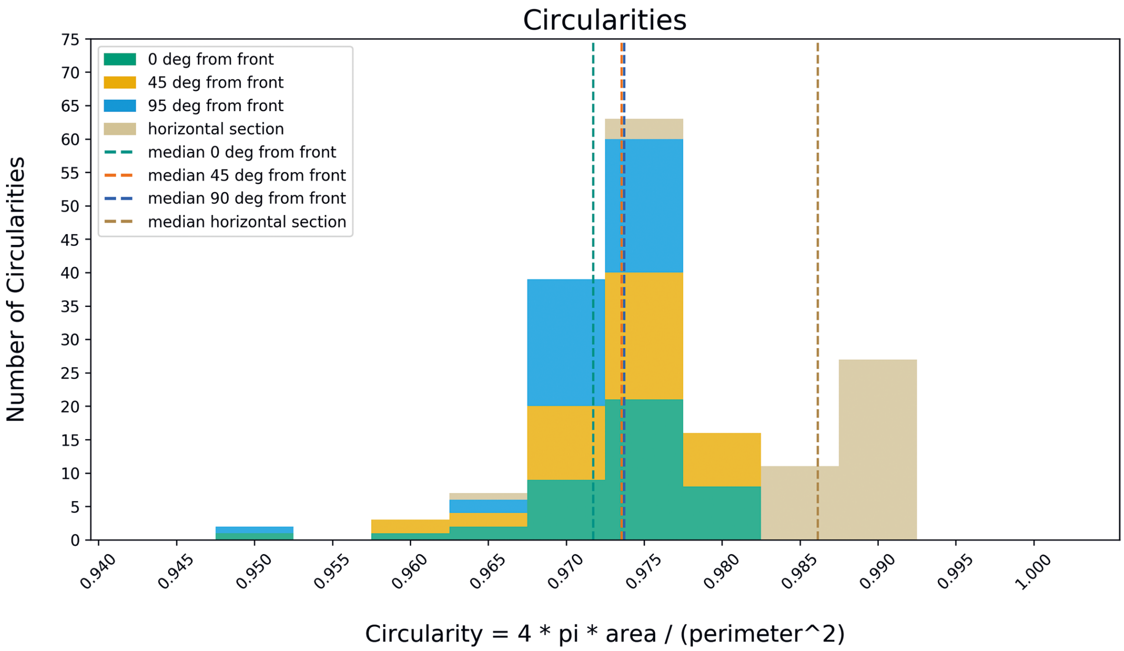
These results show that the amphorae in this dataset are close to ideal circles when viewed from any of these angles, as anticipated based on visual inspection. For all vertical orientations (0, 45, and 90 degrees from front), mean and median circularity are close. This indicates that the distribution of circularity measurements is generally symmetrical, with a small amount of left skew due to certain jars being lower in circularity. The standard deviation of the circularities facing the front (i.e., at 0 degrees) is smaller than that for circularities facing 45 degrees from the front, which in turn is smaller than that for 90 degrees from the front. This suggests that circularity facing the front is most consistent, and circularity facing the handle attachment area is the least consistent, even though circularity overall is higher for the nonfrontal orientations. For the horizontal orientation, the mean is slightly further from median circularity; there is slightly more left skew, again due to jars that are lower in circularity. The distributions can be stacked to facilitate comparison (fig. 9), revealing that circularities for the vertical orientations are especially close to each other and that circularities for the horizontal orientation at the maximum diameter are closer to ideal. Of course, part of the divergence from ideal in the vertical sections is the result of the hole created for the neck attachment (see below).

The fully 3D nature of these models, however, also allows analysis of shape using metrics of sphericity. As before, outliers were removed from the amphora point cloud, and the neck and handles were subsequently removed using CloudCompare's visual interface. Poisson shape interpolation with Neumann boundary conditions was used to fill in the holes left by the handles (fig. 10)[27]. The resultant mesh was inspected to ensure that it was mostly smooth, with distinct inside

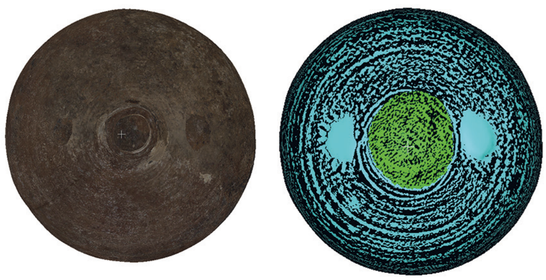
[23] See Vo-Phamhi – Leidwanger 2020, 58 f.
[24] CloudCompare (version 2.9.1) [GPL software]. (2021). Retrieved from <http://www.cloudcompare.org/> (28. 03. 2023).
[25] Otsu 1979, 62–66.
[26] van der Walt et al. 2014.
[27] Xu et al. 2006. Implementation in CloudCompare version 2.9.1.



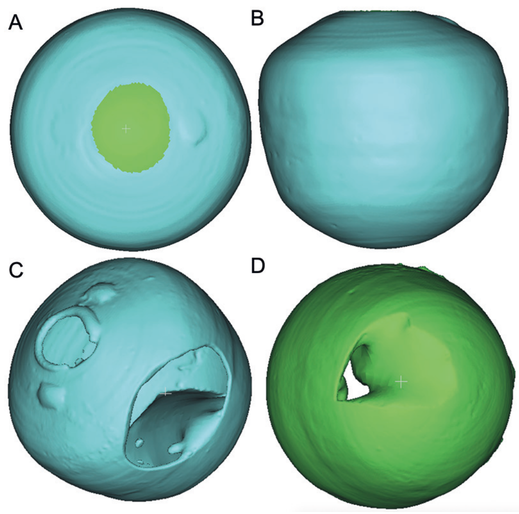
8 Histograms for circularities show that the vertical and horizontal profiles of the amphorae in this dataset (n = 41) are close to ideal circles (© by the authors)



9 Stacked histograms for circularities show that circularities for the vertical orientations are especially close to each other and that circularities for the horizontal orientation at the maximum diameter are closer to ideal (n = 41) (© by the authors)

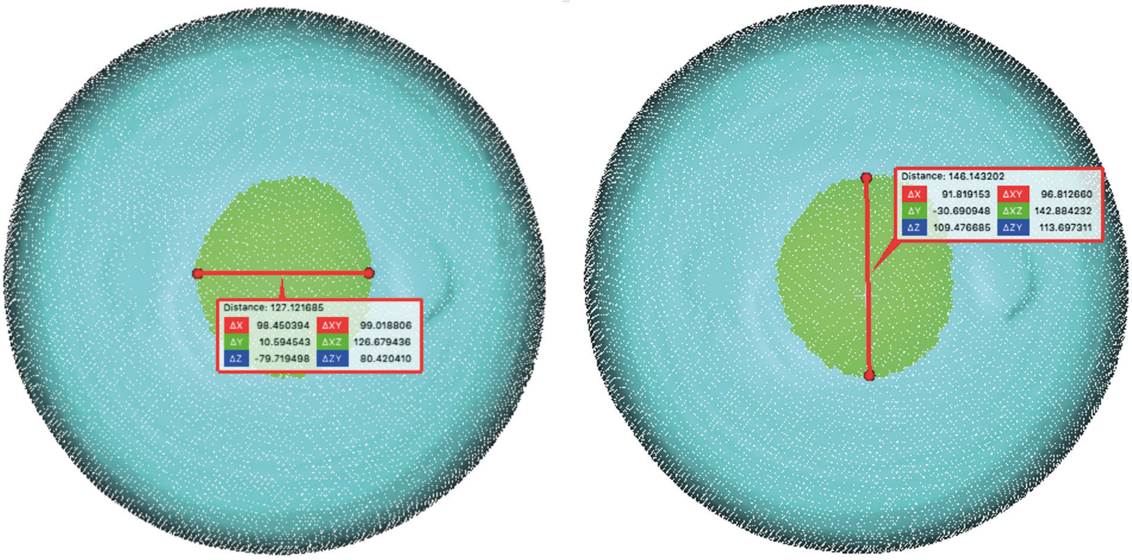


10 Poisson shape interpolation with Neumann boundary conditions used to fill holes left by handles (© by the authors)

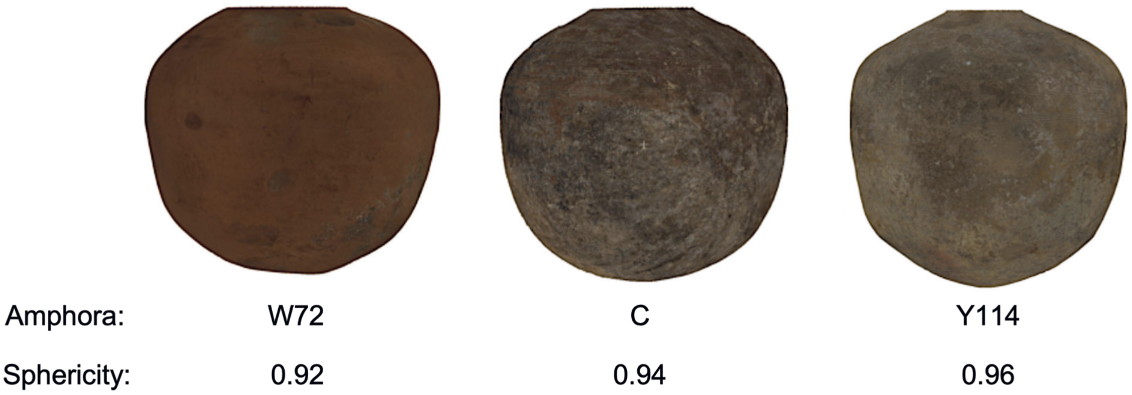


11 Top: successful sphere interpolation for 83-2, (a) aerial and (b) front perspectives; bottom: unsuccessful sphere interpolations for (c) W1 and (d) W70, both of which are missing large portions (© by the authors)

and outside surfaces (fig. 11 a–b). Sphere interpolation can fill other small holes, but large missing portions result in unusable interpolations (fig. 11 c–d). The surface area of the material needed to fill the neck hole was calculated from the hole's maximum and minimum diameters, modeling it as an ellipse (fig. 12). Sphericity was calculated from the volume and surface area of this closed surface using Equation 2, where the closer sphericity is to 1, the closer the shape is to a perfect sphere.



12 Surface area of material needed to fill the neck hole was calculated from the hole's maximum and minimum diameters, modeling the hole as an ellipse (© by the authors)

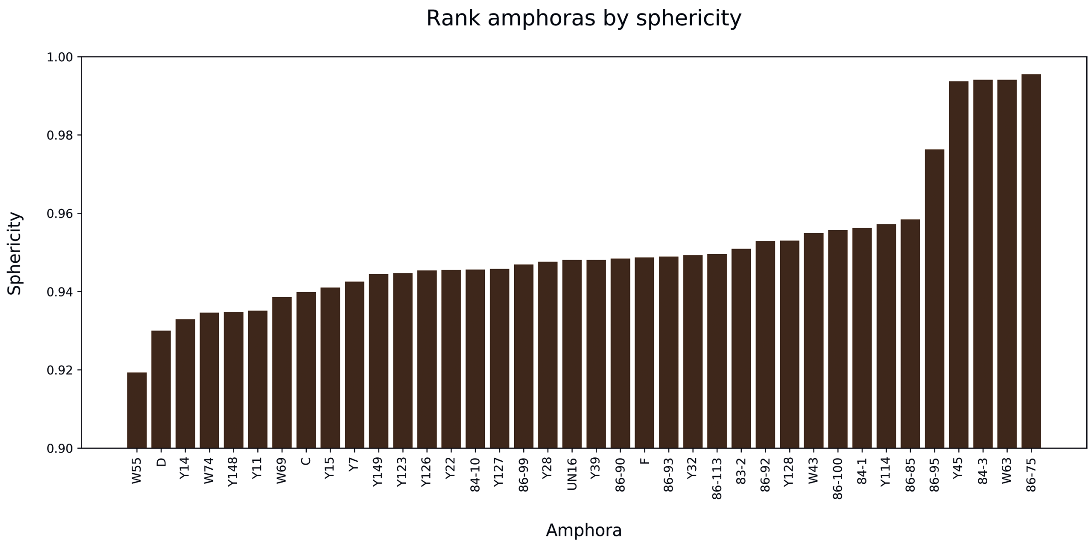


13 Sphericity calculations for W72, C, and Y114 (© by the authors)

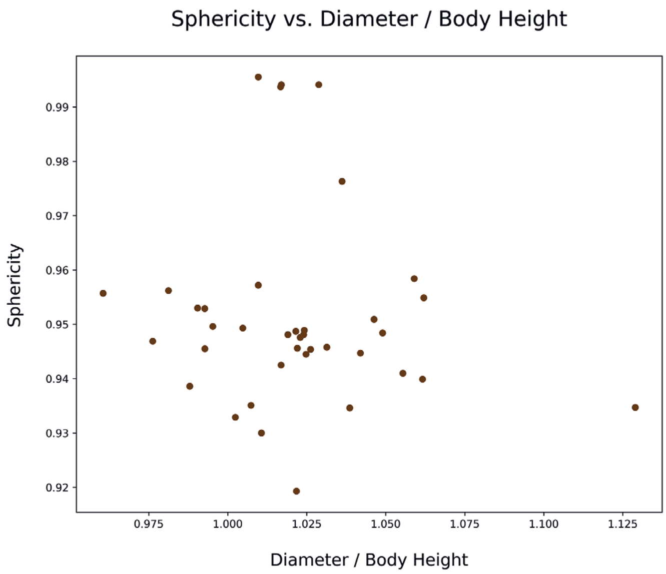
$$\mathit{Sphericity} = \frac{\pi^{1/3}\,(6 \times \mathit{Volume})^{2/3}}{\mathit{Surface\ Area}} = 1$$

Equation 2. Sphericity of a perfect sphere

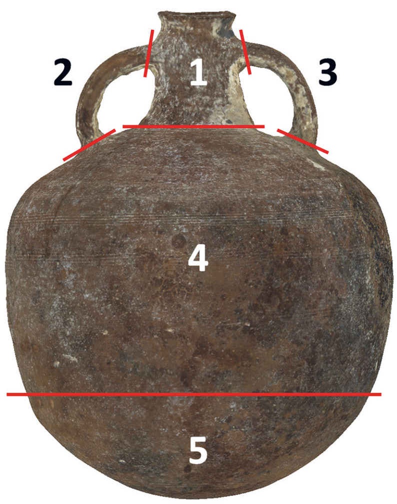
Sphericity was calculated in this manner for the 38 jars that were sufficiently intact for sphere interpolation. Three examples are shown in figure 13, while figure 14 presents all the amphorae ranked by sphericity. While few are almost completely spherical, the vast majority sit consistently in the range of 0.93–0.96. To what extent did this consistent subsphericity result from poor correspondence between diameter and body height? To test this, we can look at the relationship between sphericity and the ratio of diameter to body height (fig. 15). At the extreme end, sphericity decreases as the ratio increases. But for most amphorae, the difference between diameter and height was so small that it did not significantly affect sphericity. Instead, the less than perfect sphericity of the body seemingly originated from the practicalities of manufacture. The attachment of the neck – calculated here as a flat surface but originally reflecting a raised shoulder collar (see above, n. 22) – interrupts the spherical profile as does the consistent offset point of maximum diameter above the body midsection, situating it near the midpoint of the jar's overall height (fig. 16).



14 Amphorae ranked by sphericity (n = 38) (© by the authors)



15 Diameter/height ratio of body vs. sphericity (n = 38) (© by the authors)



16 Production of the spiral-combed amphorae occurred in five parts: neck, two handles, upper body, and lower body (© by the authors)

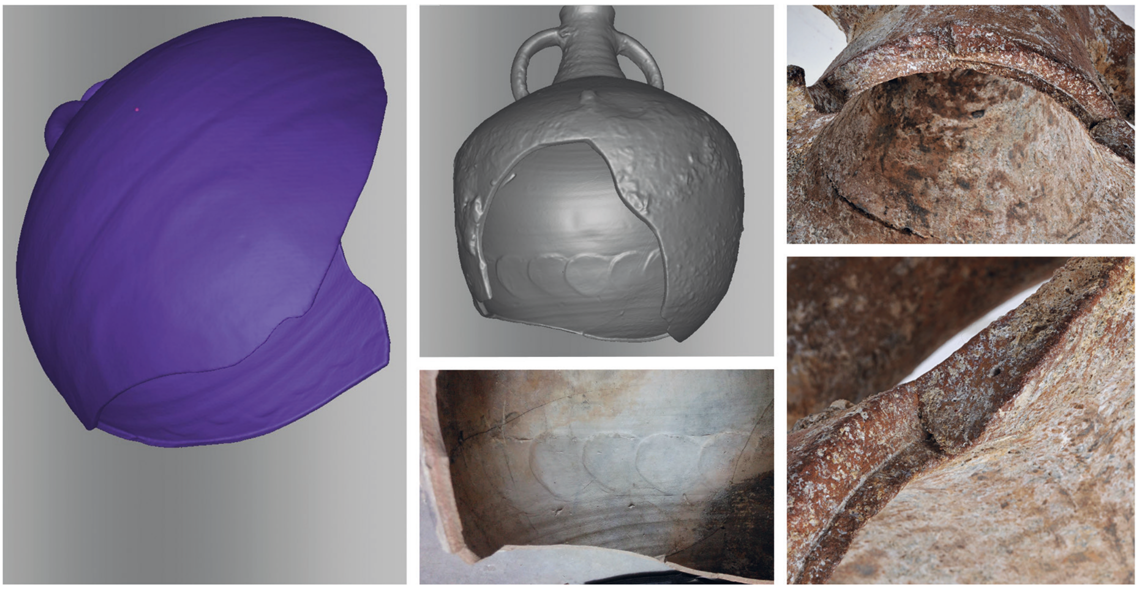
MANUFACTURING SPIRAL-COMBED AMPHORAE

The closeness of shape to the ideal sphere underscores this form as likely guiding the conceptualization of these spiral-combed amphorae. The specific variations from the ideal, then, offer an opportunity to explore how these concepts were translated into practice during production in a potter's workshop and how they responded to the specific task as containers for bulk packaging and transport.

The major deviations of sphericity would seem generally related to the jars' five-part assembly involving a neck, two handles, an upper body, and a lower body (fig. 16). The upper two-thirds and lower one-third of the body were separately fashioned and then joined. The presence of spiraling, continuous rilling on the interior of both parts indicates that they were formed from lumps of clay using a potter's wheel[28]. The lower body was likely formed right side up in the shape of a wide, rounded basin, while the upper body was formed in an inverted, top-down position and then cut from the wheel to leave a hole to accommodate attachment of the neck. The two pieces had to dry sufficiently for the base to support the weight of the rest of the body, perhaps accommodated by allowing each potter to work in stages along several wheels. Once dry, they could be joined together, leaving the maximum diameter close to what would later become the midpoint of the jar's overall height (including the neck). To strengthen and smooth the join, the potter(s) reached inside the body through the neck hole and impressed a circular paddle repeatedly along the full circumference of the seam. The traces of paddle impressions left on the interior have been noted on at least 13 examples so far, but in other cases the impressions were partially or completely smoothed away on the wheel. Although they are difficult to detect with the naked eye, the protrusions left by the paddle on the body can be clearly seen through careful observation of the detailed 3D models (fig. 17, left and middle). Fashioning the body from two pieces would have helped ensure the proper shape since the lower body may not have been able to support the weight of the upper section while still wet. To overcome this challenge, potters waited for the sections to dry to a leather-hard texture and then added a separately preformed piece or extra clay to seal the two[29]. S. Demesticha's reconstruction of the manufacturing process for LR1 amphorae reflects a different solution to the same problem. The upper section of the amphora was wheel-thrown with a thick base, left to dry, and then returned to the wheel, allowing the base to be opened and its clay used to form the lower body[30].

Once the two pieces were joined, the body was returned to the wheel for secondary forming and the application of surface decoration. For clarity, we describe the remaining manufacturing phases in the most plausible sequence, although the exact order of the steps is unclear. First, the body was placed upside-down on the wheel and the base was formed into its final shape. Spiral grooves on the amphorae' bases testify to this step. Next, the body was flipped right-side-up and 4–8 tines of a comb were applied to the exterior, leaving a band of combing that spiraled from the shoulder to around the midsection. The top edge of the body around the opening was then turned up to form a slight shoulder collar on which the separately made neck would be set[31]. Since the body lacks a flat base, it must have been held up with supports during these two and subsequent steps. The use of supports in the production of wheel-made pottery is well attested both generally and specifically in the production of Late Antique amphorae[32]. Demesticha suggested that a ring of wet clay was used as a support during the forming of the lower body of LR1 amphorae from Paphos, and ceramic supports were recovered from excavations at a 4th-century LR2 ampho-

[28] Rye 1981, 74–80.
[29] Rye 1981, 62.
[30] Demesticha 2002, 551 f.
[31] On discussion of the necks and rims, see van Doorninck 2014.
[32] Rye 1981, 63 f.



17 Left (86/98): paddle impressions on interior and protrusions on exterior; middle (X2): overlapping paddle impressions on interior; right (45): join between the body and the neck (© by the authors)

ra-producing workshop at Dilesi in Boeotia and a 7th-century workshop at Halasarna on Cos that produced LR2c and Byzantine globular amphorae[33].

The neck was produced separately and, based on the presence of rillings on both the interior and exterior, was formed on the wheel. After primary forming, the neck was cut from the wheel, and both its lower opening and rim were further shaped. The bottom of the neck was usually flat or rounded except for a small, knife-edge ridge along the interior, which helped to center the neck on the shoulder collar. Once formed and dried, the neck was placed on top of this upturned collar, and the exterior was smoothed over, perhaps using a small amount of added clay. On the interior, the join was not smoothed and is often clearly visible, likely because the rim diameter was too small now for the potter to reach inside (fig. 17, right). The two handles were rolled, bent to shape, and attached to the neck and shoulder; in a few instances, they overlap spiral combing on the body, indicating that their attachment was subsequent to the combing. The greater variability and comparative lack of precision suggests that another (less skillful or less caring) worker may have been responsible for mass producing the handles, which were of course integral to the function of the jar but peripheral to the concern for a precisely shaped body. Finally, the rim was seemingly finished very precisely with additional slip to ensure a careful fit with a standard stopper, probably the last step before final drying and firing[34].

PRODUCTION TO STANDARD SHAPE AND CAPACITY

This production sequence is integral to understanding how standardization may have been achieved. Two measurements needed to be carefully controlled in order for the amphora components to fit together correctly: the diameters at the joins between the upper and lower body and between the shoulder collar and the neck. Imperfect alignment in the dimensions of the body pieces would have resulted in a pinched appearance, which is visible around the join on some amphorae (fig. 18). In an experimental study in which Cypriot potters attempted to replicate LR1 amphorae,

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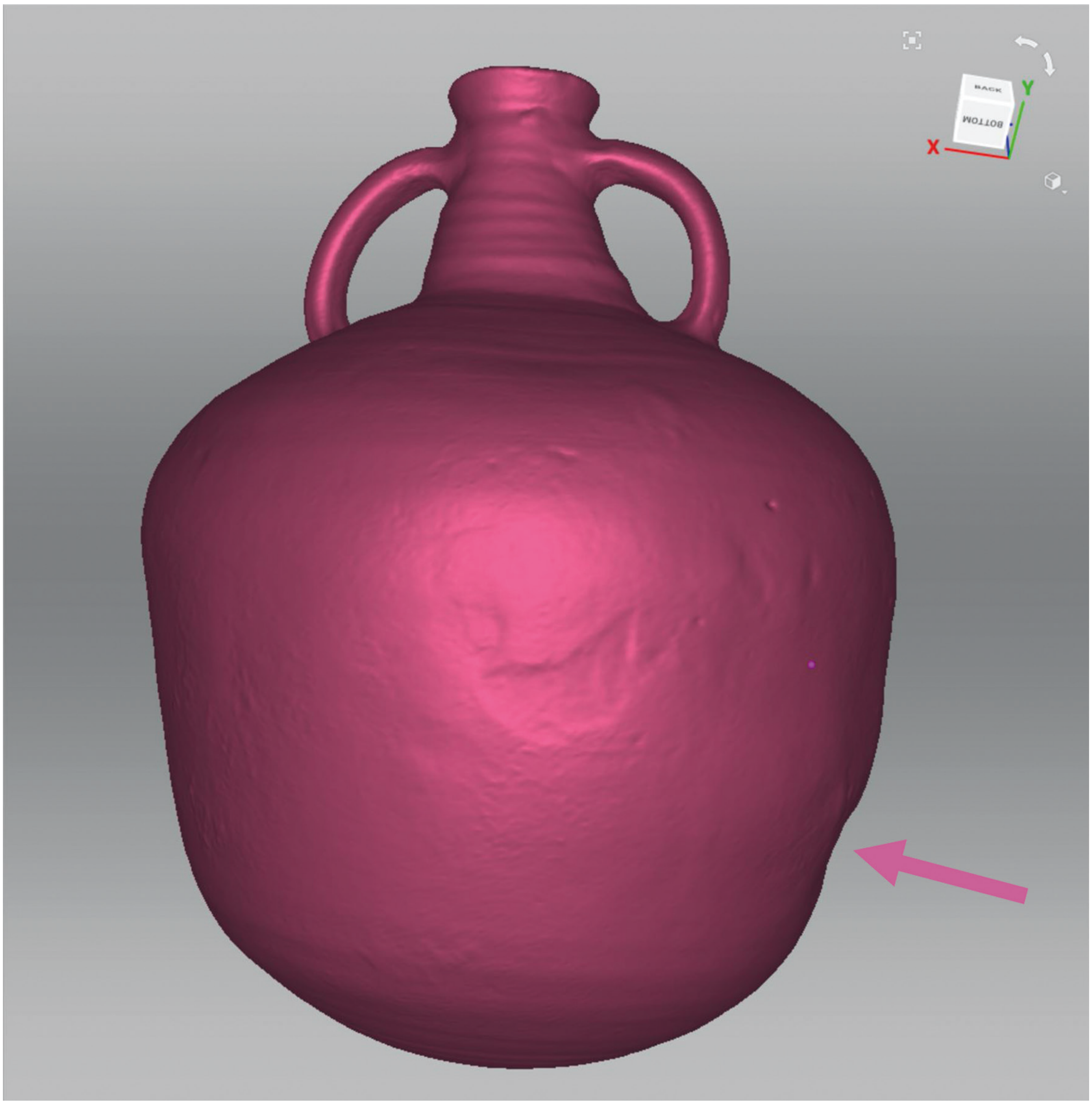
33 Gerousi 2014, 195 fig. 9; Poulou-Papadimitriou – Didioumi 2010, 742 fig. 6 f. Cf. the ›lebrillos‹ used in both forming and firing of Dressel 20 amphorae: see Bourgeon et al. 2016.

34 For more detailed discussion of production, including evidence that children may have been involved in at least some cases of putting on handles, see van Doorninck 2021, 73–79.



18 Imperfect alignment in the dimensions of the body pieces resulted in a pinched appearance visible at the join for amphora W55 (© by the authors)

Demesticha observed that the potters repeatedly measured the diameters of the different pieces and corrected their openings to ensure a proper fit[35]. For the present shape, we might expect a similar level of care and consistent checking throughout production.

From the standpoint of the production process, however, there was no need for maximum diameter and overall body height to be so tightly correlated. Repetition of tasks in the workshop by skilled professional potters could have ensured a level of consistency within diameters or overall height, but the remarkably close correspondence between these two measurements for each amphora suggests that they were intentionally and carefully controlled for a different purpose, namely to ensure a standard volume. The maximum diameter was likely monitored through the use of a simple gauge, but the body height was more complex to control efficiently. The shoulder collar that facilitated attachment of the neck tended to vary in breadth and the angle at which it was set. Producing the amphora in two unequal pieces required the potter to control the height of each of these two parts to set values, which, when added together, equaled the maximum diameter.

[35] Demesticha 1998, 144.

Producing the jars in two more equal body sections of the same height would seem to represent a simpler geometric solution but was likely more difficult technically; this question and the practical issues of producing these jars merit further analysis and experimentation.

Taking a subgroup of 16 of the spiral-combed amphorae that may represent one specific size group, based on their maximum diameter, provides more support for this point (tab. 1)[36]. Within this subgroup, all 16 amphorae are sufficiently intact to preserve their maximum diameter, 12 their body height, and five their capacity[37]. The height range is narrow and corresponds closely to diameter. Its coefficient of variation (CV), a measure that represents the ratio of standard deviation to mean, is just 2.16 %[38]. The volumes of the five intact examples in this group fall in a narrow range of 35.014–37.246 liters, with a CV of just 2.26 %. J. W. Eerkens and R. L. Bettinger have shown that a CV of 1.7 % represents about the best value humans can attain consistently for length measurements without the use of an independent standard[39]. Given that controlling body height required monitoring the height of two separately formed pieces and would have been affected by factors like sagging and clay shrinkage, a CV of 2.16 % is remarkably small and likely indicates that the potters were relying on measuring tools to ensure consistency. A CV of 2.26 % for the volume, although based on fewer examples, is also highly suggestive of a strong interest in standardization, particularly since any errors in the linear dimensions of amphorae would be compounded in their volume, giving capacities a naturally higher CV value. The low value for volume therefore attests to the potters' success in achieving strongly standardized capacities.

Table 1: Maximum diameters, body heights, and volumes for a subgroup of 16 spiral-combed amphorae. The coefficient of variation (CV) is expressed as a percent. CV = (standard deviation/mean)*100

	Range	**Average**	**CV (%)**
Max. Diameter (n = 16)	41.5–42.4 cm	41.9 cm	0.55
Body Height (n = 12)	39.2–42.2 cm	41.2 cm	2.16
Volume (n = 5)	35.014–37.246 l	36.237 l	2.26

This is not to suggest that potters mathematically calculated a container's spherical volume based on diameter. Nor was it necessary or helpful, though, given the practical concessions and adaptations that made these amphorae imperfectly spherical. Because of their fuller shape (at the shoulder, etc.), the actual volumes of these subspherical jars were generally larger than the hypothetical capacity of perfectly spherical containers of the same maximum diameters, a difference that was far more than could have been readily overlooked; Y114, for example, is 8 liters larger than a spherical counterpart. The relationship between a given diameter and volume was more likely established through trial and error, leading to broad ›rules of thumb‹ that could govern capacity. Preliminary evidence indicates that these jars were likely produced not only in single full-size and half-size variants within the same workshops but also in more incremental sizes around each of these[40]. Such size groups were potentially differentiated then by a half dactyl (ca. 1 cm) in this one key linear measurement, resulting in a change in volume by approximately 6 Byzantine pounds (slightly less than 2 l) for the full-size jars and 3 pounds for the half-size jars, as wine would have been measured[41]. Whatever the case, following a prescribed sequence in production based on this singular linear dimension seems to have reliably ensured consistent volumes.

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36 The following amphorae were included in this analysis: 56, 130, 195, 84/10, 84/3, 86/107, 86/113, 86/33, 86/41, 86/56, 86/70, UN27, W55, Y114, Y123, and Y14.

37 The maximum diameter and body height values presented here are measured directly on the jars rather than digitally; the volume is measured by filling the amphorae with a known quantity of polystyrene beads. For details on the method of volume measurement with beads, see Greene – Lawall 2015, 8.

38 For discussion of CV values, see infra, chap. 1.

39 Eerkens – Bettinger 2001, 495–497.

40 For a discussion about and listing of the apparent incremental sizes, see van Doorninck 2021, 81–83.

41 For Byzantine measurement systems, see the classic volumes by Schilbach: Schilbach 1970a; Schilbach 1970b.

INCREASING EFFICIENCY

But why choose the sphere if it was also a challenging shape to create in amphorae? The more typical cylindrical jars of earlier Roman centuries could have used simple relationships between linear dimensions of height and diameter to control volume. It is worth noting that the sphere was recognized in antiquity as the most efficient shape in terms of surface area to volume[42], offering a clear concept that might have helped inform how volume-to-weight efficiency could be improved over many other containers. This shape may have also made the body stronger, allowing for thinner walls and thus even greater tare efficiency. P. Berni Millet has suggested that this motivation may have been behind one of the most important earlier mass-produced and highly bureaucratized Roman amphorae that also happened to be largely spherical: Dressel 20 from Baetica[43]. These jars were considerably larger and featured thicker walls.

This basic shape had been a consistent feature throughout the development of the LR2 amphorae that gave rise to the forms under discussions here (fig. 19). Examples of the late 3rd and 5th century exhibit similar although somewhat lower sphericity values of 0.9093 and 0.9155, respectively[44]. The spiral-combed form from Yassıada, then, continued this tradition but seemingly employed refinements that provided certain new advantages. Over the course of the type's development, neck size and weight progressively decreased, and walls became thinner. The Yassıada jars have a particularly high average ratio of the volume of contents to amphora weight when empty of 4.32. This is a far higher value than some of the most common Roman amphorae. According to D. P. S. Peacock, the volume-to-weight ratio was 0.88 for Dressel 1B amphorae, 1.68–2.04 for Dressel 2–4, 1.65–1.70 for Haltern 70, and 1.94–2.46 for similarly spherical Dressel 20s[45]. The Africana grande and Tripolitanian amphorae had more comparable ratios of 3.27–3.73 and 3.12–4.07, respectively; these were, however, much larger and potentially harder to handle. When empty, the spiral-combed amphorae from the Yassıada wreck weighed just 7.75–10.12 kg, in comparison with weights of 15.86–19.50 kg for the two African amphora types. The 7th-century amphorae were therefore not only highly standardized but also comparatively weight efficient. When full, at around 43–46 kg, they were heavy but still sufficiently convenient to carry even for a single porter over short distances in comparison with the more massive jars that required either a specialized infrastructure or more manpower, as indicated by a 2nd-century wall painting at Augst of two porters carrying a Dressel 20 suspended from a stick[46].

The jars prove particularly efficient when brought together in the context of a shipment. The point clouds allow virtual packing into a hypothetical cargo, in this instance using repeated copies of one of the most ›average‹ amphorae from the group (Y114). In an effort to evaluate the jars more generally rather than in the specific context and complex shape of the Yassıada or another ship's hull, we have here packed them into a simple rectangular shape, 3–4 jars in length by 3–4 jars in width and 6 jars high (fig. 20). Nestling the jars carefully into dense rows allows us to compare the volume of product contained (72.88 l) within any instance of a small hypothetical rectangular unit against the overall volume of that specific unit (91.87 l); this approach reveals the amount of space lost in packing to the ceramic jars themselves and, more importantly, to the voids left between neighboring jars. The packing efficiency of a typical spiral-combed jar in this configuration is calculated as 79.3 %. In other words, of the total volume within this hypothetical rectangular cargo, nearly 80 % of it was filled by the product of interest (in this case, wine), and only about 20 % was lost. Naturally, this approach uses a repeating rectangular unit for calculating a maximum efficiency, which would have been reduced in practice somewhat along the edges of

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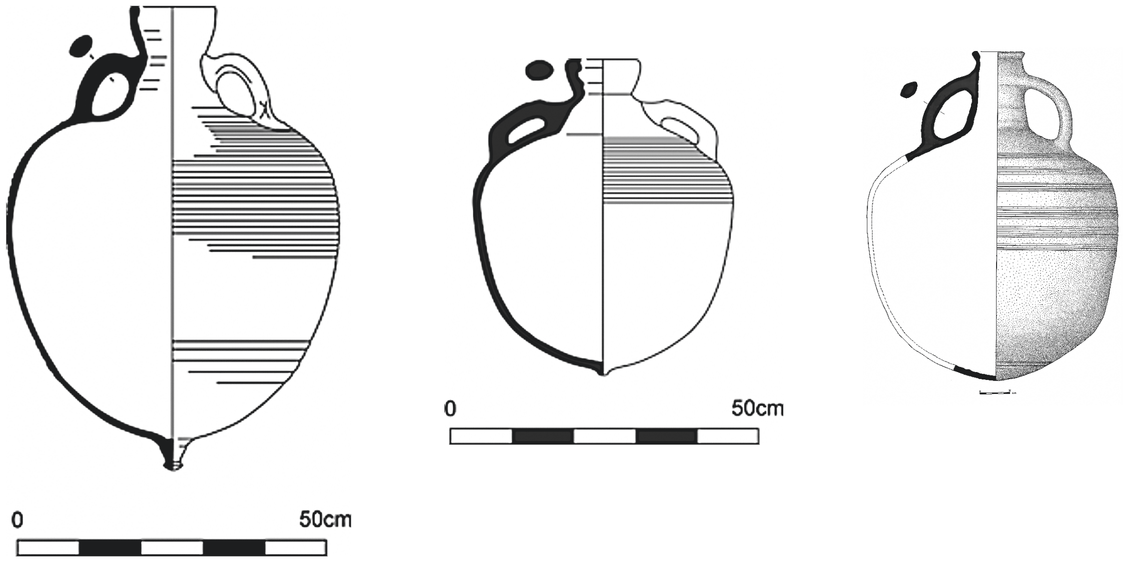
42 E.g., Pappus 5; see Cuomo 2000, 61.

43 Berni (forthcoming); see also infra, chap. 4.

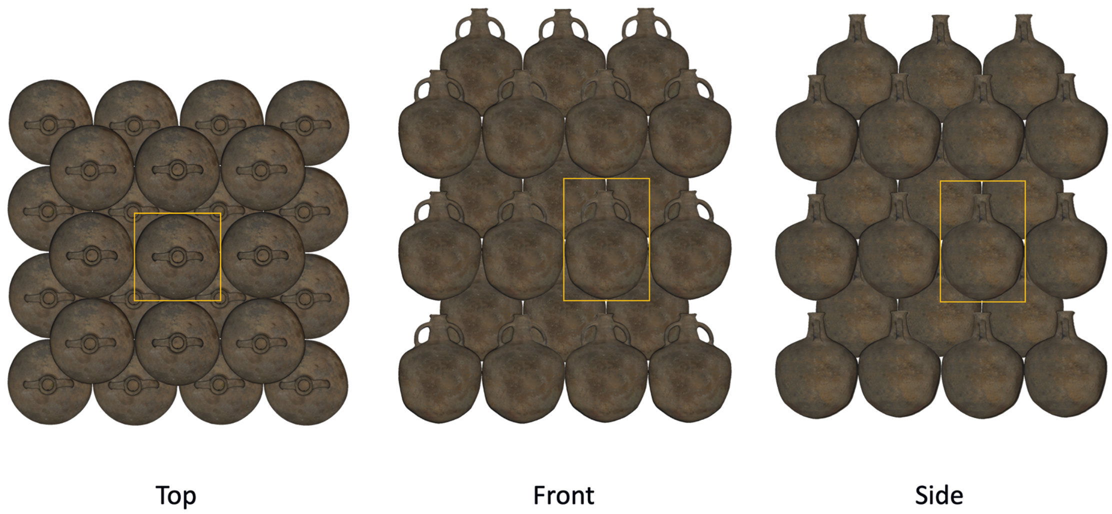
44 The two amphorae (DR155 and DR434) used for these calculations are drawn from the University of Southampton's database, »Roman Amphorae: a digital resource«; see <https://doi.org/10.5284/1028192> (28. 03. 2023).

45 Peacock – Williams 1986, 52.

46 See infra, chap. 1; chap. 2; Martin-Kilcher 1987, cover.



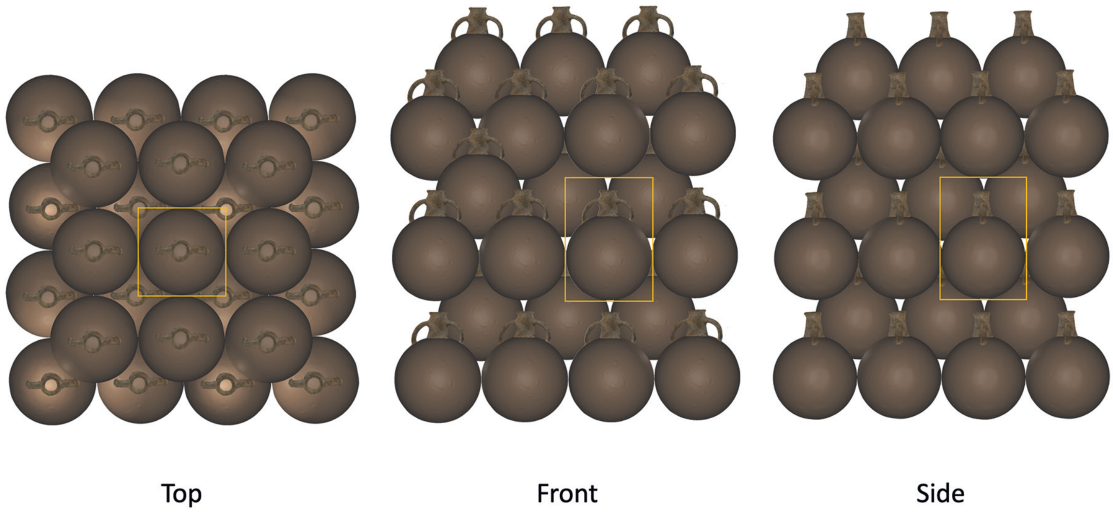
19 LR2 amphora development: shrinking sizes, lighter necks, and thinner walls; left and center: early (3rd–4th cent.) LR2 variant and amphora of LR2a subtype (University of Southampton/Archaeology Data Service 2005); right: 86/99 from the Yassıada shipwreck (© Institute of Nautical Archaeology)



20 Repeated iterations of a jar with a typical spiral-combed body (Y114), packed into a simple rectangular arrangement. The yellow box indicates the dimensions of one repeating unit within this simple cargo. Note that the box shifts location in different views so as to make clear the dimensions of the repeating unit with respect to the jars inside and around it (© by the authors)

the cargo where jars had no neighbors. A small amount of space would likewise have been taken up by the thorny burnet or other brush typically used to cushion the jars and prevent excessive wear. The packing efficiency of a real vessel would also necessarily depend on the specific hull shape and the configuration of the various different types brought together in the cargo (e.g., at Yassıada, with the LR1 jars noted above as packed on their sides between the necks of the top layer of LR2-related amphorae).

The efficient nesting of this shape is apparent in the illustrations: the slight narrowing of the body midsection from its maximum diameter – situated near the middle of the jar's overall height – allows it to rest against the necks of jars in the row beneath, while the tapering bottom section abuts their flattened shoulders. A spherical jar, by contrast, would lose use of some of this



21 Repeated iterations of a hypothetical jar with a perfectly spherical body (created using the maximum diameter of the same jar, Y114, and that jar's actual neck and handles) packed into a simple rectangular arrangement. The yellow box indicates the dimensions of one repeating unit within this simple cargo. For additional details see caption above (fig. 20) (© by the authors)

space. A similar packing arrangement of hypothetical jars with perfectly spherical bodies – here created using the maximum diameter of the same jar (Y114) and that jar's actual neck and handles – allows systematic comparison of efficiency (fig. 21). The spherical jars have a lower volume of product contained (66.34 l) for a considerably larger repeating rectangular unit (103.18 l), yielding a much lower packing efficiency of 64.3 %. The small amounts of lost space between jars add up to a major loss overall, a difference of 15 %, even though the spherical jar was by itself most efficient as a shape on an individual level, at least with respect to surface area. In other words, adapting the amphorae away from a perfect sphere resulted in a fuller shape and an increase of about 8 liters in content for each jar and allowed the group of jars to be more densely packed, rendering the overall assemblage vastly more efficient as a cargo. Viewed in this light, the specific subspherical shape may have been not only appreciated by those aiming to fill a cargo or warehouse but an intentional choice resulting from much experimentation, one that rendered immaterial the challenges noted above with manufacturing a more perfectly spherical jar.

MORE WORK AHEAD

The lens of state supply through which the Yassıada cargo should be viewed gives this strong drive toward standardization some much-needed context. The wine contained in the jars was assembled from Aegean sources, including perhaps church estates, and passed through many hands en route to provision soldiers on the march with Heraclius in the east. The comparatively easy calculation of total logistical supply – and even the distribution of rations – would therefore have been greatly facilitated by the employment of jars with predetermined and uniform capacities. One is therefore inclined to see an impetus behind this standardization trajectory in the state itself, but to what extent others engaged in the same practice remains an open question. Did the church likewise employ such a system to facilitate its own commercial trade or transfer among its major landholdings and communities[47], or did its involvement at Yassıada reflect merely an urgency that demanded it bend here toward state mechanisms?

These spiral-combed amphorae offer a particularly robust case study of a standardized set, yet analysis of the other components within the same cargo may help reveal how widespread such

47 See Monks 1953; Kingsley – Decker 2001, 9–11.

22 A fragmentary jar from Yassıada was stamped with an official seal and can be linked by fabric to Cos (© by the authors)

standardization and its production practices were. For example, another large group of LR2-related jars currently under study is differentiated by certain morphological features and a single wider band of combing[48]. Tying the fabrics of these different groups to more specific areas of manufacture could also help reveal not only the mechanisms behind the assembly of this one cargo but also the varied institutions driving these developments more broadly, whether state, church, or private commercial. The Yassıada shipwreck assemblage itself attests vividly to the importance of standardization studies of large cargoes of intact jars in circulation together, but it offers just one model that must be analyzed alongside other contexts of circulation, including on land. To that end, among the next steps analytically is the extension of these methods to embrace the more fragmentary amphorae typical of other archaeological assemblages. In short, a broader and comparative view is necessary to evaluate more fully the place of standardization within the Late Antique and early Byzantine economy of the eastern Mediterranean.

If additional context and comparison are key to understanding the origin of this system of standardization and its relationship to earlier Roman mass production, we might look to some clues from those jars that appear in singles or small groups at Yassıada. These jars – often older and sometimes reused – would seem to underscore the difficulty on this occasion of meeting necessary supply through only new production. To what extent, though, might these earlier amphorae also have been standardized in certain ways, even if we cannot detect as much from the few and sometimes poorly preserved examples that remain? Ch. Diamanti has linked abrupt shifts in Aegean amphora production to the reorganization of the provincial structure and imperial supply through Justinian's establishment of the *quaestura exercitus*, for which stamps bearing an official

[48] See analysis in van Alfen 2015.

seal appear occasionally on certain of these late types[49]. One jar from the Yassıada assemblage, unfortunately fragmentary, bears such stamps and can be linked by fabric to production at Halasarna on Cos (fig. 22). Was the sophisticated capacity standardization evident within the Yassıada cargo a product of this same reorganization? Whatever the case, once in place, the benefits of standardization could have been significant also for routine commerce, allowing this system to reach beyond state mechanisms toward market economies and a broader revolution in ›containerization‹[50].

TECHNICAL APPENDIX

Demonstrating ways to get a more aggregated diameter at the maximum cross section: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/circularity/diameter.ipynb> (31. 03. 2023).

Incorporating coordinates of two opposing points at the bottom of the neck and the coordinates of the bottom of the amphora and calculating amphora body height: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/body_height/body_height.ipynb> (31. 03. 2023).

Explaining and demonstrating the circularity calculation process: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/circularity/circularity_demo.ipynb> (31. 03. 2023).

Calculating and visualizing the circularity of vertical and horizontal view amphora sections for the Yassiada dataset: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/circularity/circularity.ipynb> (31. 03. 2023).

Explaining and demonstrating the sphericity calculation process: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/sphericity/sphericity_demo.ipynb> (31. 03. 2023).

Calculating and visualizing the sphericity for the Yassiada dataset: <https://nbviewer.jupyter.org/github/vophamhi/amphora/blob/master/yassiada2/sphericity/sphericity.ipynb> (31. 03. 2023).

BIBLIOGRAPHY

Bass 1982a	G. F. Bass, Conclusions, in: Bass – van Doorninck 1982, 311–319.
Bass 1982b	G. F. Bass, The Pottery, in: Bass – van Doorninck 1982, 155–188.
Bass – van Doorninck 1982	G. F. Bass – F. H. van Doorninck, Jr., Yassı Ada I. A Seventh-Century Byzantine Shipwreck (College Station 1982).
Berni (forthcoming)	P. Berni Millet, Las otras ánforas del Monte Testaccio. La producción de aceite y de ánforas oleícolas en la Cuenca del Guadalquivir en época romana, in: Mesa redonda internacional, 29–30 de octubre 2015 (Madrid, forthcoming).
Bevan 2014	A. Bevan, Mediterranean Containerization, Current Anthropology 55, 2014, 387–418.
Birch – Martinón-Torres 2019	T. Birch – M. Martinón-Torres, Shape as a Measure of Weapon Standardization. From Metric to Geometric Morphometric Analysis of the Iron Age ›Havor‹ lance from Southern Scandinavia, JASc 49, 2019, 249–254.
Bourgeon et al. 2016	O. Bourgeon – E. García Vargas – S. Mauné – S. Corbeel – C. Carrato – V. Pellegrino – J. Vázquez Paz, Investigación arqueológica en el alfar de ánforas Dressel 20 de Las Delicias (Écija, Sevilla) 2013–2015: un primer balance, in: R. Járrega Domínguez – P. Berni Millet (eds.), Amphorae ex Hispania: paisajes de producción y consumo. III Congreso Internacional de la Sociedad de Estudios de la Cerámica Antigua (SECAH), Ex Officina Hispana (Tarragona, 10–13 de diciembre de 2014) (Madrid 2016) 310–333.
Carlson et al. 2015	D. N. Carlson – J. Leidwanger – S. M. Kampbell (eds.), Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (College Station 2015).
Cuomo 2000	S. Cuomo, Pappus of Alexandria and the Mathematics of Late Antiquity (Cambridge 2000).

[49] Diamanti 2010; Diamanti 2012; Opaiţ – Diamanti 2014; Diamanti 2020.
[50] On containerization more broadly, see Bevan 2014.

Demesticha 1998 — S. Demesticha, Experimenting on Amphora Manufacture, in: E. Karpodini-Dimitriadi (ed.), Ethnography of European Traditional Cultures. Arts, Crafts, Techniques of Heritage, European Seminar 3 (Athens 1998) 139–148.

Demesticha 2002 — S. Demesticha, The Paphos Kiln. Manufacturing Techniques of LR1 Amphoras, ReiCretActa 36, 2002, 549–554.

Diamanti 2010 — Ch. Diamanti, Local Production and Import of Amphoras at Halasarna of Kos Island (5th–7th c.) (Athens 2010).

Diamanti 2012 — Ch. Diamanti, Byzantine Emperors on Stamped Late Roman/Early Byzantine Amphoras, ReiCretActa 42, 2012, 1–6.

Diamanti 2020 — Ch. Diamanti, *Quaestura exercitus*, the *Eparch of the islands* and the Late Roman/Early Byzantine Stamped Amphoras, in: C. Diamanti – A. Vassiliou (eds.), Ἐν Σοφίᾳ μαθητεύσαντες. Essays in Byzantine Material Culture and Society in Honour of Sophia Kalopissi-Verti (Oxford 2020) 205–216.

Eerkens –Bettinger 2021 — J. W. Eerkens – R. L. Bettinger, Techniques for Assessing Standardization in Artifact Assemblages: Can We Scale Material Variability?, American Antiquity 66, 3, 2001, 493–504.

Gerousi 2014 — E. Gerousi, A Late Roman Workshop at Dilesi in Boeotia, in: N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. The Mediterranean: A Market Without Frontiers, BARIntSer 2616 (1) (Oxford 2014) 193–202.

Greene – Lawall 2015 — E. S. Greene – M. L. Lawall. Amphora Standardization and Economic Activity, in: Carlson et al. 2015, 3–16.

Hassett – Lewis-Bale 2016 — B. R. Hassett – T. Lewis-Bale, Comparison of 3D Landmark and 3D Dense Cloud Approaches to Hominin Mandible Morphometrics Using Structure-from-Motion, Archaeometry 59, 2016, 191–203.

Karasik – Smilanksy 2011 — A. Karasik – U. Smilanksy, Computerized Morphological Classification of Ceramics, JASc 38, 2011, 2644–2657.

Kingsley – Decker 2001 — S. Kingsley – M. Decker, New Rome, New Theories on Inter- Regional Exchange: An Introduction to the East Mediterranean Economy in Late Antiquity, in: S. Kingsley – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity (Oxford 2001) 1–27.

Leidwanger 2014 — J. Leidwanger, A Preliminary Archaeometry Analysis of the Late Roman 1 Amphoras from the Cargo of the Seventh-Century Yassıada Shipwreck, Turkey, in: N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. The Mediterranean: A Market Without Frontiers, BARIntSer 2616, I (Oxford 2014) 897–906.

Martin-Kilcher 1987 — S. Martin-Kilcher, Die römischen Amphoren aus Augst und Kaiseraugst, I. Die südspanischen Ölamphoren (Gruppe I), FiA 7, 1 (Augst 1987).

Monks 1953 — G. R. Monks, The Church of Alexandria and the City's Economic Life in the Sixth Century, Speculum 38, 1953, 349–362.

Opaiţ – Diamanti 2014 — A. Opaiţ – C. Diamanti, Imperial Stamps on Early Byzantine Amphoras. The Athenian Agora Examples, ReiCretActa 43, 2014, 55–61.

Otsu 1979 — N. Otsu, A Threshold Selection Method from Gray-Level Histograms, IEEE Transactions on Systems, Man, and Cybernetics 9.1, 1979, 62–66; DOI:10.1109/TSMC.1979.4310076

Peacock – Williams 1986 — D. P. S. Peacock – D. F. Williams, Amphorae and the Roman Economy. An Introductory Guide (New York 1986).

Poulou-Papadimitriou – Didioumi 2010 N. Poulou-Papadimitriou – S. Didioumi, Nouvelles Données sur la Production de l'Atelier Céramique Protobyzantine à Kardamaina (Cos – Grèce), in: S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. Comparison between Western and Eastern Mediterranean, BARIntSer 2185, II (Oxford 2010) 741–749.

Riley 1979/1980 J. Riley, Industrial Standardisation in Cyrenaic During the Second and Third Centuries A.D. The Evidence from Locally Manufactured Pottery, LibSt 11, 1979/1980, 73–80.

Roux 2003 V. Roux, Ceramic Standardization and Intensity of Production. Quantifying Degrees of Specialization, American Antiquity 68, 4, 2003, 768–782.

Rye 1981 O. S. Rye, Forming, in: Pottery Technology: Principles and Reconstruction (Washington, DC 1981) 58–95.

Schilbach 1970a E. Schilbach, Byzantinische Metrologie (Munich 1970).

Schilbach 1970b E. Schilbach, Byzantinische metrologische Quellen (Düsseldorf 1970).

Steffy 1982 J. R. Steffy, Reconstructing the Hull, in: Bass – van Doorninck 1982, 65–86.

van Alfen 1996 P. G. van Alfen, New Light on the 7th-c. Yassi Ada Shipwreck. Capacities and Standard Sizes of LRA1 Amphoras, JRA 9, 1996, 189–213.

van Alfen 2015 P. G. van Alfen, The Restudy of the LR2 Amphoras from the Seventh-Century Yassıada Shipwreck. Preliminary Evidence for Standardization, in: Carlson et al. 2015, 17–32.

van der Walt et al. 2014 S. van der Walt – J. L. Schönberger – J. Nunez-Iglesias – F. Boulogne – J. D. Warner – N. Yager – E. Gouillart – T. Yu, Scikit-Image. Image Processing in Python, PeerJ 2.e453, 2014; DOI: 10.7717/peerj.453

van Doorninck 1982 F. H. van Doorninck, Jr., The Galley, in: Bass – van Doorninck 1982, 87–120.

van Doorninck 1989 F. H. van Doorninck, Jr., The Cargo Amphoras on the 7th Century Yassi Ada and 11th Century Serçe Limani Shipwrecks. Two Examples of a Reuse of Byzantine Amphoras as Transport Jars, in: V. Déroche – J.-M. Spieser, Recherches sur la Céramique Byzantine (Athens 1989) 247–257.

van Doorninck 2014 F. H. van Doorninck, Jr., Byzantine Amphoras Made for War?, INA Quarterly 41, 1, 2014, 21–27.

van Doorninck 2015 F. H. van Doorninck, Jr., The Seventh-Century Byzantine Ship at Yassıada and Her Final Voyage: Present Thoughts, in: Carlson et al. 2015, 205–216.

van Doorninck 2021 F. H. van Doorninck, Jr., The Cargo Amphoras on the 7th-Century Yassıada and the 11th-Century Serçe Limanı Shipwrecks: A Progress Report, TINA Maritime Archaeology Periodical 8, 2, 2021, 62–85.

Vo-Phamhi – Leidwanger 2020 J. Vo-Phamhi – J. Leidwanger, A New Computational Method to Quantify Morphological Standardization and Variation within Ceramic Assemblages, Archeologia e Calcolatori 31, 1, 2020, 55–76.

Williams et al. 2019 R. Williams – T. Thompson – C. Orr – A. Birley – G. Taylor, 3D Imaging as a Public Engagement Tool: Investigating an Ox Cranium Used in Target Practice at Vindolanda, Theoretical Roman Archaeology Journal 2.1, 2019, 1–16; DOI: 10.16995/traj.364

Xu et al. 2006 D. Xu – H. Zhang – Q. Want – H. Bao, Poisson Shape Interpolation, Graphical Models 68.3, 2006, 268–281; DOI: 10.1016/j.gmod.2006.03.001

Charikleia Diamanti

MASS PRODUCTION OF LATE ROMAN AND EARLY BYZANTINE AMPHORAE IN THE AEGEAN

CASES STUDIES FROM THE ISLANDS OF COS AND PAROS[1]

Abstract

This paper deals with the comparative presentation of the production of two coastal centers on the islands of Cos and Paros in the Aegean Sea: the amphora workshop(s) deposits discovered by the University of Athens at Kardamaina, Cos and the Parian amphora workshops at Laggeri in Paros, found by the Ephorate of Antiquities of the Cyclades.

More specifically, the following are discussed: the small-scale amphora production of Coan LR2 amphorae of the first half of the 6th century compared to the subsequent mass production of Coan LRA 13 at the end of the same century; the co-production and standardization of Coan LR1 and LR13 amphorae in the second half of the 6th–first quarter/half of the 7th century; the co-existence of the mass production and import of LR1 amphorae from the second half of the 6th century in Cos; the state-controlled stamping of Coan LR13 amphorae with the busts of emperors and titles of officials and the connection of the *eparch* of these stamps with the *quaestor Iustinianus exercitus*; the later-dated massive Parian production of types 1 and 2 (end of 6th–end of 7th/start of the 8th century [?]), accompanied by increasingly simplified morphological characteristics as a progressive evolution of earlier LR1 and LR13 amphorae co-productions in workshops like the one in Cos; the comparatively decreased standardization of the Parian amphorae as a result of the less direct supervision but the still urgent state demand for the amphorae's agricultural contents; and the life span of the Parian workshops of around 100 years, permitting the production of various late versions of LR1 and LR13 amphorae, derivatives of LRA 1 and LRA 13 amphorae, and finally some first examples of Byzantine globular/ovoid amphorae.

The location and, even more so, the quite rare excavations of massive Late Roman/Early Byzantine amphora production centers in the east Mediterranean can serve as a primary historical source for the early Byzantine economy. Moreover, this seems to apply particularly for amphora production that took place on the Aegean islands, situated on the maritime routes leading to the new capital of the state[2]. The main income of the latter, as has been noted, was the agricultural products of the provinces, while its major expenses were the administration and the army[3]. Transport amphorae, apart from free commercial trade, served exactly these two crucial areas of the State's economy: the massive shipment of provincial agricultural goods via Aegean routes to Constantinople and to the army within the framework of the *annona* and *quaestura exercitus*, which united administratively the Aegean islands, Caria, and Cyprus with Scythia Minor and Moesia Inferior[4].

Under these historical conditions, we suggest that the study of the massive local productions of each of the Aegean islands in the 6th and first quarter of 7th century A.D. should always include

[1] I would like to sincerely thank Justin Leidwanger and Horacio González Cesteros for the honor of inviting me to participate in the workshop »Regional Convergences: Mass Production and the Development of Roman and Byzantine Amphora Standardization«. Moreover, I thank them for their insightful agenda and coordination plan before and after it. All this work of theirs resulted in a brilliant level of brainstorming and productive discussions and provided the tools for creating a set of papers in a contextualized volume which can push the frontiers of the research.

[2] Abadie-Reynal 1989, 56.

[3] Oikonomides 2002, 979.

[4] Haldon 1990, 12; Haldon 1999, 235.

1 Aegean Sea islands of Paros and Cos (© Google Earth 2018 [10. 05. 2018])

2 Cos, Halasarna (modern Kardamaina) excavation site of Late Roman/Early Byzantine settlement (© Google Earth 2018 [10. 05. 2018])

a comparative examination of similar cases on an interregional level since most of the islands were administratively united under the service of the *quaestura* and for the purpose of serving the army's needs. This joint research on the standardization of massive amphora productions in the microcosm of each of the Aegean islands – at the same historical period, under the same administrative unit, and for serving the similar needs of a very centralized state[5] – would provide a unique opportunity to compare and interpret the degree of absolute as well as relative standardization among them. Differences between them could in particular add interesting information both

[5] Oikonomides 2002, 973 f.

archaeologically as chronological indicators of morphological evolution of specific types and historically for the different impact of events between the 530s and 630s. Of course, large-scale amphora manufacture does not necessarily involve standardization of the pottery produced, but this is more or less confirmed by the two examples presented here.

The study of new kilns and workshop deposits is becoming more difficult over time since construction activities in the heavily touristed Aegean islands have increased. The only optimistic facet of this development for archaeological research is the large numbers of rescue excavations and the few systematic ones, like the two cases examined in this paper (fig. 1). Both Cos and Paros are quite large islands, the third largest in the Dodecanese and Cyclades respectively. Already episcopal seats in the 4th century, they belonged to the *provincia insularum* and later to the *quaestura justiniani exercitus*, the needs of which were served by the mass production of amphorae presented here: the amphora workshop(s) deposits from systematic excavations by the University of Athens at Kardamaina (ancient Halasarna) on Cos and the Parian amphora workshops at Laggeri of Naoussa Bay on Paros, found by the Ephorate of Antiquities of Cyclades during rescue excavations[6].

THE WORKSHOPS AT HALASARNA ON COS

The Halasarna excavation on the island of Cos has been systematically carried out by the University of Athens for the last 35 years (fig. 2)[7]. This work has brought to light remains of houses, workshops, and a burial complex. For Halasarna, residential development and private commerce were central to the first phase of its life, from 400 to 550. It was a wealthy settlement with large two-level houses and enjoyed large-scale imports of fine wares, amphorae, and lamps. In addition, a small LR2 (variation LR2A according to D. Pieri's typology[8]) production was established during this early period (fig. 3). These spherical amphorae were up to 55 cm in height, featured continuous combed decoration, and often carried religious inscriptions; they could have served only local needs and probably the needs of a regional ›coasting trade‹[9]. Their reddish-orange fabric, with lime inclusions and mica, and a white-pink ›wash‹ on the outside surface, was similar to the later Coan LR1 and LR13 (Pieri's variation LR2C) amphorae[10]. Dated to the late 5th and early 6th century, they are found mainly in contexts with early African Red Slip (ARS) and LRC wares of up to the middle of the 6th century[11]. This lower-level production of spherical Coan LR2 (LR2A) amphorae in the first half of the 6th century contrasts with the mass production of Coan LR13 (LR2C) that follows from the second half of the 6th until the mid-7th century. Given the stratigraphic and contextual data and their ›linear typology‹ (to use Paul Reynolds' terminology), the rich Coan ›family history‹ of LR2 (LR2A) and LR13 (LR2C) production highlights the transition of production from a regional to an interregional character (figs. 3. 7–11)[12].

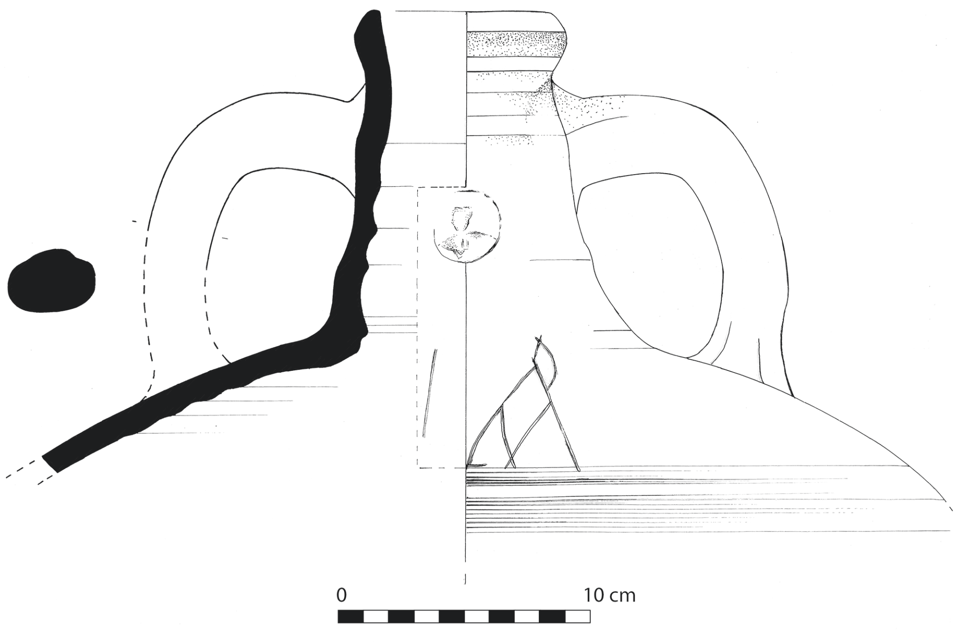
Indeed, after the catastrophic earthquake of 554 and the tsunami that followed[13], Halasarna developed into a production center for LR1 (fig. 4–6) and LR13 (LR2C) (fig. 7–11) amphorae on a massive scale. This is proved by the huge deposits of misfired and distorted amphorae dating from the third quarter of the 6th until the middle of the 7th century[14], around the time of the Arab

[6] Diamanti 2010a, 23–26. 193–195; Diamanti 2016, 693; Athanasoulis – Diamanti 2019; Diamanti et al. (forthcoming).
[7] Kokkorou-Alevras et al. 2006, 47–68; Kokkorou-Alevras et al. 2016, 185–187.
[8] Pieri 2005, 86.
[9] Diamanti (forthcoming).
[10] Diamanti 2010a, 137–152. 218 f.; Diamanti et al. 2014, 183 f.; Pieri 2005, 89 n. 121.
[11] Diamanti (forthcoming).
[12] Reynolds 2008, 62.
[13] Witnessed by the historian Agathias, s. Keydell 1967, Historiae B 16.
[14] Diamanti (forthcoming). To the same period contexts belong Asia Minor LR3 jars, ›Samos cistern type‹ amphorae, Spatheia Bonifay type 3.C, and Keay type 50 Spatheia. Another amphora kiln was located by the Archaeological Service nearby: Didioumi 2014, 170.

3 Coan L(ate) R(oman) A(mphora) 2, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: A. Drigopoulou)

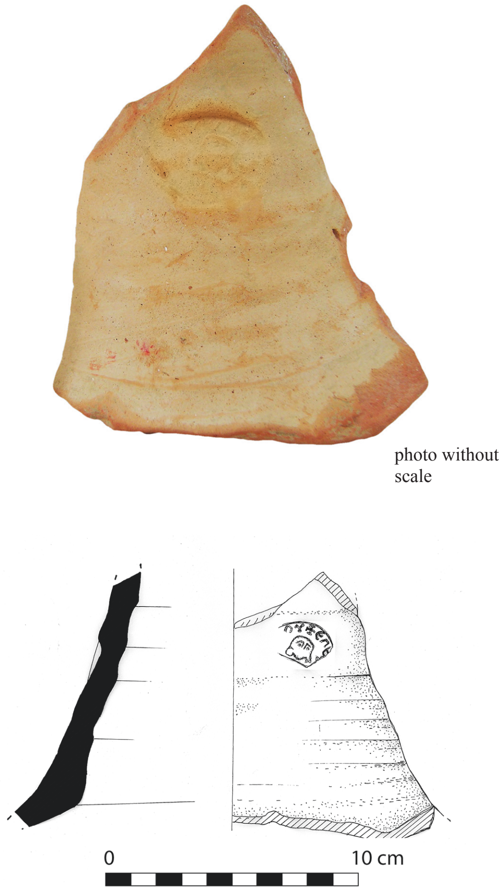
4–6 Coan LRAs 1, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: Ch. Diamanti)

7 Coan LRA 13, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: K. Mpairaktaris)



8 Coan Stamped LRAs 13, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: A. Drigopoulou)

9 Coan Stamped LRAs 13, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: A. Drigopoulou)



10 Coan Stamped LRAs 13, Halasarna, Cos

11 Coan Stamped LRAs 13, Halasarna, Cos

(© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: A. Drigopoulou)

invasions when the settlement was abandoned. We suggest this sharp shift to standardized mass production was the result of the participation of Cos in Justinian's *quaestura exercitus* of 536 and the urgent state need for agricultural supplies[15]. Moreover, the great plague of 541/542, which reached Constantinople via ships full of wheat from Alexandria, caused the death of thousands of taxpaying producers and provoked a crucial economic problem, which the state addressed through fast and strong measures pressing the available production centers to send their goods as a tax[16]. In the case of Cos, the simultaneous standardized production of two clearly different amphora types may suggest the exportation of two different products, most probably wine and olive oil[17].

The LR1 jars comprise about one third of the local Coan amphora production[18]. They are characterized by their finer fabric (with fewer inclusions) and shape (relatively oblong proportions and more careful production details) compared to the coarser shape and fabric (yellow-brown with many light and dark inclusions) of imported LR1 jars. They have a maximum height of ca. 45 cm and an external diameter of the rim of 7.5–8.5 cm (fig. 5), although some have smaller diameters of 6.5–7.5 cm (fig. 4) or larger diameters of 9–12 cm (fig. 6). The neck is cylindrical and oblong. One of the most characteristic features of these Halasarnian LR1s, though, is their deeply grooved vertical handles with a clearly different, more square-shaped section compared to the imported ones. The normally rounded base does not always bear a knob.

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15 Steckner 1989, 64 f.; Diamanti 2010b, 4 n. 28; Diamanti 2016, 693 n. 13.
16 Treadgold 1995, 16; Morrisson – Sodini 2002, 193–195; Sinakos 2006; Laiou – Morrisson 2007, 24. 38 f.
17 Steckner 1989, 64; Pieri 2012, 43.
18 Diamanti 2010a, 58–60. 203 f.; Pieri 2005, 75 f.; Pieri 2007, 615; Pieri 2012, 47 (LR1b).

It is important to examine the co-existence in late contexts of this mass production of Coan LR1s with the imported LR1s (fig. 13–14), which were present during the entire lifespan of the Halasarnian settlement in large quantities, bearing many *dipinti* and incised inscriptions of religious symbols, numerical indications, etc.[19]. If from Coan LR2 (LR2A) to Coan LR13 (LR2C) we saw the morphological evolution of a singular form across time, with imported LR1s and Coan LR1s, we see the free morphological imitation of products of different origins at the same time. It would be useful in the future to have a clearer picture of the proportion of Cilician and Cypriot fabrics in Halasarna through time so as to identify whether, following D. Pieri's suggestion, the incorporation of Cyprus into the *quaestura exercitus* may have affected distribution patterns: namely, could the earlier LR1 imports to Cos (found in contexts of the 5th–early 6th cent.) have come from production centers in Asia Minor, only later being replaced by the Cypriot LR1s that dominate during the latter 6th and 7th centuries[20]? In these late contexts, which include late ARS and LRD wares, the imports of LR1s co-exist with the Coan version of the same type, and the participation of both Cos and Cyprus in the *quaestura exercitus* could explain their co-existence.

Indeed, we suggest that the local production and imports of LR1s at Halasarna were two facets of the same *quaestura exercitus* redistribution (and reuse [?]) mechanism[21]. In other words, were it not for local production, some of the imported LR1 amphorae may never have reached Halasarna, Cilicia, and later Cyprus[22]. In this case, they would not have had a crucial role to play in these mechanisms of collection from taxpaying areas, the distribution and redistribution of amphorae and their contents, which resulted in their widespread circulation[23]. Here we should remember the early 7th-century Yassıada shipwreck amphorae, which were of different origins and probably also quite different dates[24]. Finally, as D. Pieri has noted, the production of LR1 amphorae in numerous provinces generally indicates common economic interests[25]. In our case, this common interest is supply for the army, so the local imitations of LR1 exist not because the state relaxed control[26] but quite the opposite. It is because state control increased in several different taxpaying areas within the *quaestura exercitus* that the appearance of these new imitative productions started in this particular period. This argument regarding the increase in state control is supported as well by the imperial stamps on Coan LR13 (LR2C) jars of the same period, as discussed below.

The LR13 (LR2C) type is the most common amphora find from the Halasarna excavations, representing almost two thirds of the local production (fig. 7). They have a maximum height up to 50–55 cm, and the diameter of the ovoid body is up to 35–38 cm. The rim has a maximum external diameter of 8.5 cm. The shoulder includes regular combed decoration of straight thin lines arranged in a few groups distinctly different from their Coan LR2 ancestors. In addition, they often bear traces of a kind of rope used for decorative or, most probably, technical reasons of production at the location of the connection between the shoulders and the main body.

Alongside the incised Greek inscriptions, usually of religious content (perhaps indicating the involvement of the church [?]), several Coan LR13 amphorae were recovered with stamps (fig. 8–11). Here the standardization – either of the whole production or of the distribution procedure –

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19 Diamanti 2010a, 52–58; Diamanti (forthcoming).

20 Pieri 2007, 614.

21 Peacock – Williams 1986, 57–60.

22 For the »extraordinarily high level of maritime trade around Cyprus during the early Byzantine centuries, a level of commerce that, at least for this part of the island, may not have been equaled in antiquity either before or after«, see Leidwanger 2015.

23 Decker 2005; Diamanti 2008, 20–23; Diamanti 2010a, 164 f. 221 f. In addition, I have suggested that especially the tax from Cos could be sent by *navicularii* like the Cilician ones mentioned in the Abydos inscription of 492, according to which Cilicians were traveling very often to Constantinople carrying *annona* goods.

24 van Doorninck 1989, 248–250; Leidwanger 2014, 899. 901; Diamanti 2008, 20–30. See also Waksman et al. 2014 for a similar situation for the LR1 amphorae of the Cape Plaka shipwreck (second quarter of the 6th–3rd quarter of the 7th cent.).

25 Pieri 2007, 613.

26 Pieri 2012, 48.

reached its highest level with the depiction of the emperor similar to his depiction on coins of the period[27]. The stamps appear mainly at the neck of the amphorae and are round in shape, bearing the busts of emperors or cross-like monograms, with solemn inscriptions around them often related to officials, especially eparchs. In the two instances where the neck is sufficiently preserved to detect them, there is one stamp on each side. We have suggested that this double stamping of the amphora necks, usually with both kinds of stamps, was normal practice, serving as a secure and fast way of checking the amphorae during some control procedure. The few similar published examples we know confirm this theory. One of these comes from the 7th-century Yassıada shipwreck, with monograms on both stamps. The interesting fact with these Yassıada stamps – one with an embossed border and one with an engraved border – is that they seem to imitate or preserve traces of the cords and the knot of a seal (fig. 12)[28].

The Coan workshop is the only one identified thus far that produced such stamped amphorae throughout the late Roman Mediterranean. There are more than 30 stamps at present, with new ones being revealed through conservation[29], and all belong to the LR13 (LR2C) type. Based on their stratigraphy and contexts, they are dated from the second half of the 6th to the mid-7th century. Similar stamps published from elsewhere are fewer in number. Outside Cos, they have been found at Constantinople[30], Athens[31], Yassıada[32], Rhodes[33], Knidos[34], Myndos[35], Limyra[36], Geronisos[37], Ras Abu Dahud (near Jaffa)[38], Kellia[39], Alexandria[40], and Brijuni castrum[41].

In general, we know that the busts of emperors in official seals were a usual way of referencing directly and underlining a strong connection to the emperor or state. This same practice occurs in two other late Roman state-controlled commercial stamping systems: those stamps on silver vessels made in state workshops and the lead seals of the state commercial inspectors, the *kommerkiarioi*[42]. As far as the iconographic details of the busts of the emperors are concerned, the most important and closest iconographic parallels can be found in the imperial coinage of this period. The emperors kept the *mappa* and cruciform scepter, former consular symbols which, after 541 and the abolition of the consulate by Justinian, were used by the emperors, as shown in the currency series of Tiberius II, Maurice, Phocas, and Leontius. The Coan examples have been identified with the emperors Tiberius II (578–582) or Maurice (582–602) and Phocas (602–610)[43]. Four stamped examples found in the Athenian Agora and one in Pnyca have about the same date as the Coan ones (up to the first quarter of the 7th cent.); two refer to the eparch Ptolemy and two to eparch Innocentius, and at least one may have originated from the Coan workshops[44].

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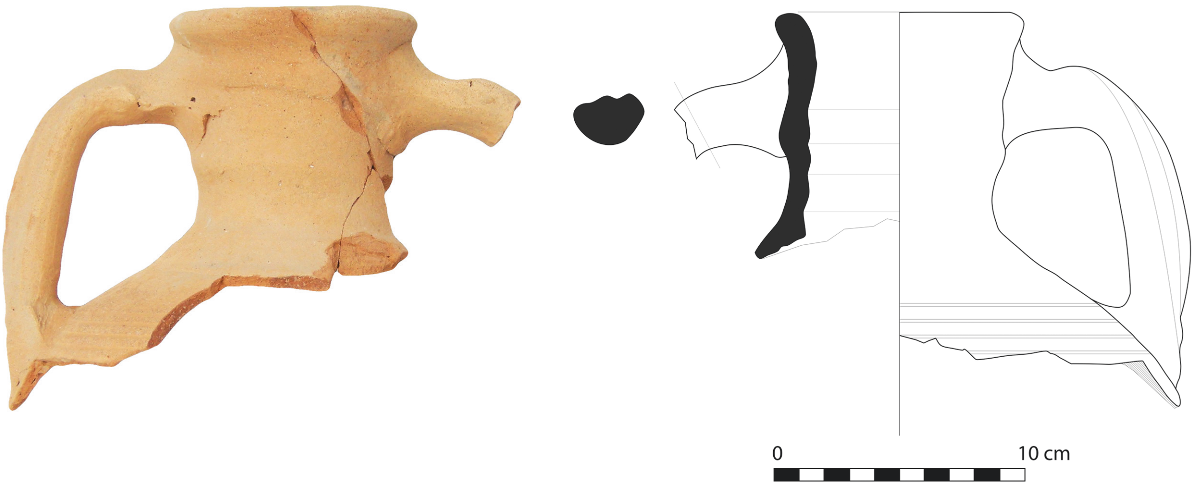
27 Diamanti 2010a, 92–107. 168–171. 209–215. 222–224; Diamanti 2010b, 1–6; Diamanti 2012; Diamanti 2015a; Diamanti (forthcoming).
28 van Doorninck 1989, 249 fig.1.2; 250. I would like to thank Justin Leidwanger and the Institute of Nautical Archaeology for information and kind permission to publish these photographs.
29 Diamanti (forthcoming).
30 Hayes 1992, 77; Kara 2015.
31 Grace 1949, 184. 188; Grace 1956, 171; Opaiţ – Diamanti 2014.
32 See above n. 24.
33 Papanikolaou 2014.
34 Doksanaltı et al. 2018, 46–48 fig. 62. Doksanaltı (forthcoming). I sincerely thank Ertekin M. Doksanaltı for this information.
35 Gülsefa 2016, 113.
36 I thank Banu Yener-Marksteiner and Horacio González Cesteros for this information.
37 Connelly – Wilson 2002, 274 f.
38 Gendelman 2010.
39 Bonnet – Cattin 1999, 538 f. no. 158 fig. 489.
40 Sztetyllo – Borkowski 1986.
41 González 2019.
42 Diamanti 2010b, 4.
43 Diamanti 2012, 2.
44 Opaiţ – Diamanti 2014.

12 Stamped LRA 13, Yassıada 7th-century shipwreck (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: J. Leidwanger)

13 Imported LRAs 1, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: A. Drigopoulou)



14 Imported LRAs 1, Halasarna, Cos (© University of Athens, Halasarna Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: K. Mpairaktaris)

We have recently suggested identifying these eparchs in the stamp inscriptions with the *quaestor exercitus* himself, who is known from the epitome of Novellae by Theodore Scholastikos as the »eparch of the islands«[45]. Both were directly responsible to the emperor as the stamp of the one and the title of the other reveal, and both served him in the same way the amphorae did: ensuring the transfer of agricultural goods from Cos and other production centers in the Aegean to the army. Of course, this politically and financially important but geographically and practically complicated effort would have benefitted greatly from the standardization of procedures as well as the assistance and know-how of the authorized *kommerkiarioi*[46]. Ongoing research into these stamped amphorae is expected to reveal additional information about their involvement.

Finally, John Lund's approach to analyzing pottery, especially the frequency of red slip wares, alongside historical economic cycles offers a model for consideration here[47]. Examining the historical period of the emperors depicted in the stamps in a similar way, we can observe the following: the chronologically and quantitatively limited phenomenon of Late Roman amphorae stamped by the *quaestor exercitus* and his authorized territorial assistants, using the busts of Tiberius II, Maurice, and Phocas in the same iconographic and propagandistic way as on imperial currencies, should be interpreted as material remains of these emperors' efforts to supply their armies in the Danubian provinces between at least 578 and 610[48]. We should add here that the relatively few finds thus far of stamped amphorae can be explained not only by the fact they were specifically serving state needs for only a few decades, and because they are generally worn and difficult to identify, but also because one stamped amphora could serve as a guarantee for the circulation of a number of unstamped ones of similar capacity. This system would have been more practical for the officer handling the seal, who could have stamped fewer amphorae before firing, and easier also for the ones responsible for checking the jars at port.

THE WORKSHOPS AT LAGGERI ON PAROS

The second case study concerns the Laggeri workshops on the large Cycladic island of Paros in the central Aegean. Like Cos, it belonged to the *Provincia Insularum* and during the Justinianic period to the *quaestura exercitus*. The comparatively little information available for the history of late Roman Paros can be enriched by the study of the pottery. A few years ago, a rescue excavation at Laggeri in Naoussa revealed vast wasters and debris as well as architectural remains of rough walls (fig. 15)[49]. Another rescue excavation in the adjacent field of the same site later revealed two well-preserved amphora kilns. Made of local schistolithic rock, the kilns had a rectangular plan and were almost identical in size, at ca. 7 × 4 m. Three square piers on either long wall supported the three arches and the *eschara* (perforated floor) of the upper chamber (fig. 16)[50].

Before the discovery of the kilns, study of the amphora wasters had suggested that the Parian workshops in this area produced two types of amphorae during the 6th and 7th centuries, ceasing only when the settlement was abandoned around the middle of the 7th century. We underlined that these local types of amphorae, if not identical, shared several features with the well-known types LR1 and LR13 (LR2C). With the discovery of the kilns, we confirmed that the area produced the Parian Type 1, a probable derivative of LR1, from the end of the 6th into the first half of the 7th century. It is worth noting that in the past J.-Y. Empeurer located kilns of different periods at other sites in the area of Naoussa, five of which produced a large quantity of LR1 amphoras[51]. The Laggeri Parian Type 1 amphorae seem to have a rim diameter of 7–8 cm, a cylindrical neck up to

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45 Diamanti 2015a; Diamanti 2019, 208; Theodore Scholastikos, Anekdota 3, 54 f.
46 Diamanti 2010b, 2. 4; Diamanti 2016, 693.
47 Lund 1996, 105.
48 Diamanti 2019, 209 f.; Dominique Pieri (2007, 614) has supported the *annona* amphora distribution for later, during Heraclius' reign.
49 Diamanti 2015b.
50 Diamanti 2016, 691.
51 Empereur – Picon 1986, 501–507.

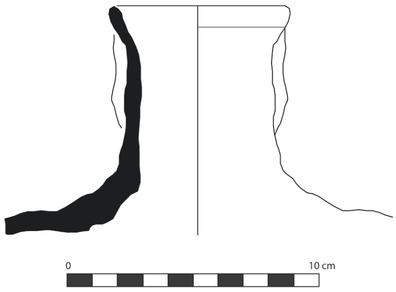
15 Paros, Laggeri excavation site of Late Roman/Early Byzantine amphora kilns (© Google Earth 2018 [10. 05. 2018])

16 Paros, Laggeri Late Roman/Early Byzantine amphora kiln (© Ephorate of Antiquities of Cyclades, Laggeri Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; plan: N. Tsouris)

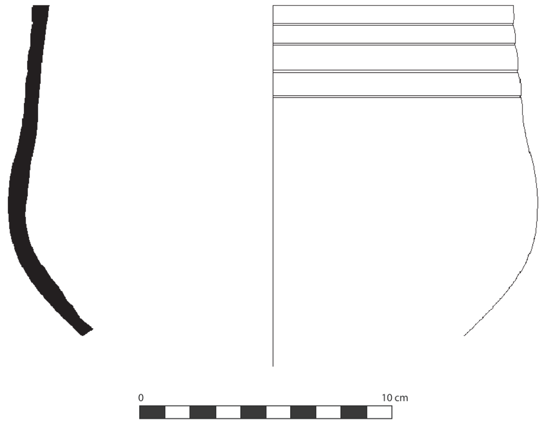
10 cm in height, not perfectly vertical but often grooved handles, a cylindrical and not so strongly ribbed body of ca. 20 cm diameter at its maximum, and a rounded base (fig. 17–18). Nevertheless, the hook-shaped interior of the rim is reminiscent of the Parian Type 2 examples, which we examine below. We await further study of this material to shed light on the distinctive characteristics of the morphology as well as the fabric of these late Roman Parian amphorae.

Indeed, our current systematic study of the pottery, the related finds, and the morphological details of the types, together with conservation and petrological study[52], gives further new information about the products of these kilns. It is quite clear by now that the kilns produced also, if not primarily, Parian Type 2 amphorae. This group comprises LR13 (LR2C) and LR13 derivative versions, suggesting production in these kilns until perhaps the end of the 7th century. In general, Parian Type 2 amphorae have an ovoid body, elongated conical neck up to 9–10 cm in height, a rim

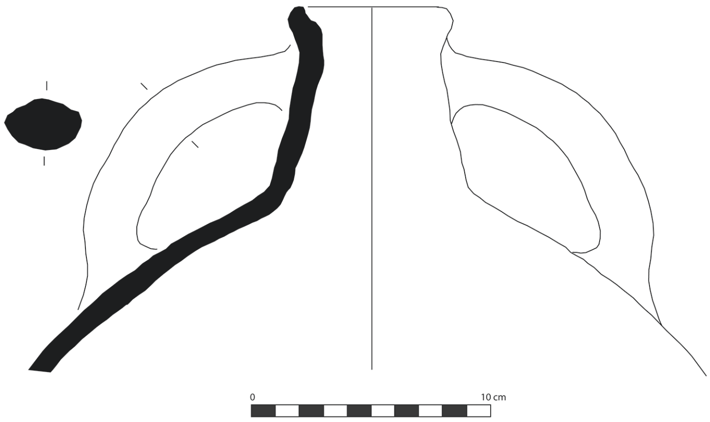
[52] Diamanti et al. (forthcoming).



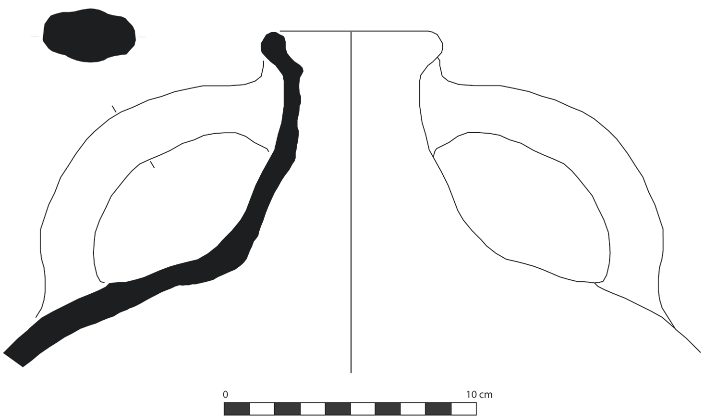
17 Parian type 1 Late Roman/Early Byzantine amphora, Laggeri, Paros



18 Parian type 1 Late Roman/Early Byzantine amphora, Laggeri, Paros



19 Parian type 2 Late Roman/Early Byzantine amphora, Laggeri, Paros



20 Parian type 2 Late Roman/Early Byzantine amphora, Laggeri, Paros

(© Ephorate of Antiquities of Cyclades, Laggeri Excavation Archive; drawings: fig. 17: Ch. Diamanti, fig. 18–20: N. Tsouris)

21 Parian type 2 Late Roman/Early Byzantine amphora, Laggeri, Paros (© Ephorate of Antiquities of Cyclades, Laggeri Excavation Archive, photo: Ch. Diamanti, A. Lamprakis; drawing: N. Tsouris)

with a maximum diameter of 7–8 cm and sometimes hook-shaped interior, and more horizontal and sometimes arched handles that are oval in section and often grooved (fig. 19–20). It is worth noting that preserved examples lack any kind of combed decoration. The fabric of both amphora types is brown in color (7YR 6/6), with several calcareous bits, mica, and other inclusions. Moreover, the good preservation of a context near one of the kilns offered the possibility to attempt reconstruction of the whole amphora shape (fig. 21). These results revealed an amphora that had a rim with a maximum external diameter of 7 cm, a body ca. 27 cm in diameter, a total height of up to 40 cm, and a rounded base of 16 cm at its maximum. Typologically, this amphora seems to reflect the last stages of LR13 (LR2C) or the first stages of the ›Byzantine globular amphorae‹ in the 7th or start of the 8th century[53]. The most similar examples to date come from Saraçhane: Types 36–38, from contexts of the 8th century, exhibit a quite narrow, almost vertical neck, and generally ribbed/grooved handles. Our example is undecorated, like Hayes Type 38[54].

These recent findings and published parallels can extend the life of the kilns on Paros probably until the end of the 7th or the beginning of the 8th century but no further. The imported diagnostic finds (particularly red slip wares) from these local contexts are dated mainly to the 6th and into the mid-7th century; none is later that ca. 660. The industrial character of the place continued for some time, but the archaeological data show that the site was abandoned after the 7th or the beginning of the 8th century and not reoccupied throughout the rest of the Byzantine period[55]. Nevertheless, the coastal circulation of Parian amphorae probably continued some few decades into the first

53 Hayes 1992, 71–73 (types 29, 35–43); Pieri 2005, 89 n. 121; Poulou-Papadimidriou – Nodarou 2014, 874.
54 Hayes 1992, 71.
55 Diamanti et al. (forthcoming).

half of the 8th century since Parian or similar examples are indicated in the pottery of this period at Naxos[56], Thira[57], and Despotiko[58].

COAN AND PARIAN AMPHORAS INTO THE 7TH CENTURY: FROM TYPOLOGICAL TO SYNCRETIC STANDARDIZATION

The two production centers presented here are characteristic examples of a quite clear chronological and typological standardization sequence that occurred in Aegean amphora forms into the 7th century. We suggest that production centers of the second half of the 6th century, such as the Coan one, passed the tradition on to production centers of the end of the 6th or start of the 7th century, such as the Parian one. This signals the development from standardized local reproduction of two well-established forms of the eastern Mediterranean (Coan LR1s and Coan LR13/LR2Cs), to a ›new‹ single type, the so-called Byzantine globular amphora, which predominates thereafter in the Aegean into the 8th century. Moreover, according to the Parian example, we suggest that the so-called Byzantine globular amphora type emerged as a syncretic form combining features of both the LR1 and LR13 (LR2C) types. Furthermore, this ›new‹ type should be named the ›Byzantine globular/ovoid amphora‹ type until a more detailed typology of this large morphological group of amphorae is established since its body is generally more ovoid than globular in shape[59].

The Coan production of the mid-6th to mid-7th century is characterized by a standardized reproduction of the well-known LR1s and the new trend of the period, the LR13s (LR2Cs), the material remains of a state policy, we propose, effected through the *quaestura exercitus* as reflected in their stamps. The two types kept their individual characteristics: the cylindrical versus the conical neck, the vertical handles with a square section versus the narrow handles with an oval section, the ridged decoration of the body versus the combed decoration of the shoulders. Nevertheless, when these different types started being produced alongside each other in the same workshops, as on Cos at the end 6th century, they gradually lost some of their distinguishing features over the 7th century and became similar not only in fabric but through standardized common morphological features, such as the common rounded base. It is true that the Coan LR1 and LR13 (LR2C) bases and body sherds often cannot be distinguished and the Coan LR13 (LR2C) walls of the body sometimes descend vertically, giving a more cylindrical shape to the amphora, similar to that of the LR1.

The development of these Aegean amphorae is followed in the Parian workshops of the end of the 6th to the end of the 7th or the beginning of the 8th century. Here, the two types of amphorae, late derivatives of LR1 and LR13 (LR2C) respectively, become even more similar and are distinguished, sometimes with difficulty, as Parian Type 1 and Type 2: the handles of the Parian Type 1 are not always so vertical as those of LR1, and its body not so strongly ribbed. In the same way, the ovoid Parian Type 2 examples lack the combed decoration of their LR13 (LR2C) ancestor, and the neck is not always strictly conical. This syncretic evolution moved toward the *unifying* ›globular/ovoid Byzantine amphora‹ form, which took over from the 8th century. There is much work still to be done and details to be revealed about the Aegean amphora production during the late Roman period, especially toward its end, and what particular needs were served by this development. But if in the Parian workshops, which seem to extend from the end of the 6th to the end of the 7th century (or even the beginning of 8th cent. [?]), we are looking forward to new clarity that the further study will bring on a typological level. On a broader level, the question centers on how we can cooperate to distinguish and categorize, under a widely accepted nomenclature, all

56 Personal observations on the pottery material of Kastro Apalirou site in the framework of a project of Ephorate of Antiquities of Cyclades with the Norwegian Institute at Athens and Newcastle University.

57 Perissa and Kamari sites: Sakellakou – Diamanti (forthcoming).

58 Diamanti et al. 2020.

59 Arthur 2007, 171. 173 for the drop in standards of manufacture after the 6th cent. (earlier in west Mediterranean and later in the east).

the known and future subtypes of the Late Roman series produced here: the globular (LR2) and later ovoid amphorae (LR13)[60], as well as the Byzantine ones[61], and also the late subtypes of LR1, its derivatives (7th cent.) and survivals (8th cent.)[62], in *linear typologies* which intersect in certain late forms[63].

The main historical context in which these developments of amphora standardization took place was the economic crisis that unfolded from the mid-6th century together with the state efforts to respond to it. The prudent reign of Maurice could not overcome the costs of Justinian's wars and the generous reign of Tiberius, but it did drive the military revolt which finally made Phocas emperor. In addition, the Avaro-Slavic wars and the demands of supply for the army were certainly affected by the great plague of 541/542 and its subsequent waves over the decades that followed together with famines. It had disastrous results for agricultural production in several regions, caused the loss of taxpayers and tax incomes and the inability to pay soldiers' salaries and army expenses[64]. Even if the available non-literary evidence for the serious demographic and financial problems caused by the plague and the following famines is still not rich compared to the literary evidence[65], we can suggest that the mass production of amphorae during these times reflects one archaeological indicator of this urgent situation alongside new relevant evidence from other specialties such as bioarchaeology[66].

Thus, through fast and strong measures, the state pressed the surviving population to send goods as a tax. The introduction of the LR13 (LR2C) type from the mid-6th century onward as well as the mass-produced standard LR1s in various places in the same period reflect state control and increased pressure on the less (?) affected taxpaying areas within the *quaestura exercitus*. The stamped Coan LR13s (LR2Cs) reached the highest level of standardization with the depiction of the emperors themselves since they were related to the *eparch of the islands*, the *quaestor exercitus*, whose service was crucial for Justinian and his successors to coordinate the transfer of amphorae with agricultural goods from Aegean production centers to the army from the 6th until the mid-7th century[67]. Thereafter, the coastal Late Roman settlements, such as the ones to which the Parian workshops belonged, gave way gradually to Byzantine fortified ones and a »very distinct diminution in the volume of the trade« can be noted[68], even if the dates or the degree differ from island to island with the different impacts of historical events (Arab invasions, earthquakes, etc.). Yet most of them, as has been pointed out, »accelerate the collapse of the system which has sustained the economy of the city«[69]. This does not mean that in the 8th and 9th centuries there were not active ports and commercial sea routes, but in this medieval phase, the security of the inland areas was preferred and life took on a more fortified character; the life of ports and coastal sites was not stopped since seaborne communication was the only means of supply for these fortified sites on the islands. Excavations in the future will shed more light on this subject for each Aegean island, and progress in petrographic analyses of Aegean production will also certainly help in this direction.

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60 Riley 1979, 217–219 (LR2); 231 f. (LR13); Hayes 1992, 66 (type 9); 66. 71 (type 10. 29); Pieri 2005, 85–88 (LR2a. b); 88 f. (LR2C).

61 Hayes 1992, 71.

62 Vroom 2004, 294; Pieri 2005, 77.

63 Reynolds 2008, 62.

64 Haldon 1990, 36; Haldon 1995, II 161. 178; IV 19; Treadgold 1995, 17–19. 205.

65 Durliat 1989; Sinakos 2006.

66 Quiroga 2016, 90.

67 Diamanti (forthcoming).

68 Arthur 2007, 181; Pieri 2012, 32. 49.

69 Portale 2014, 482; Haldon 1995, III 77 f. The case is similar for many coastal late Roman settlements of the Aegean Cyclades Islands as well; see above notes 55. 57. 58. For Cyprus, see Leidwanger 2015, 163.

BIBLIOGRAPHY

Abadie-Reynal 1989 C. Abadie-Reynal, Les Amphores Protobyzantines d'Argos (IV^{e}–VI^{e} siècles), in: V. Déroche – J.-M. Speiser (eds.), Recherches sur la Céramique Byzantine. Actes du colloque organisé par l'École française d'Athènes et l'Université de Strasbourg II. Centre de Recherches sur l'Europe centrale et Sud-Orientale Athènes 8–10 avril 1987, BCH Suppl. 18 (Paris 1989) 47–56.

Arthur 2007 P. Arthur, Form, Function and Technology in Pottery Production from Late Antiquity to the Early Middle Ages, in: L. Lavan – E. Zanini – A. Sarantis (eds.), Technology in Transition (AD 300–650) (Leiden 2007) 159–186.

Athanasoulis – Diamanti 2019 D. Athanasoulis – C. Diamanti, Το πρωτοβυζαντινό συγκρότημα της Παναγίας Καταπολιανής στην Πάρο- Αποτελέσματα από τις πρόσφατες έρευνες της Εφορείας Αρχαιοτήτων Κυκλάδων, in: D. Katsonopoulou (ed.), Ιερός Ναός Παναγίας Εκατονταπυλιανής Πάρου. 50 χρόνια από την αποκατάστασή του από τον Αναστάσιο Ορλάνδο (Athens 2019) 67–83.

Bonnet – Cattin 1999 F. Bonnet – M. I. Cattin, Le matériel archéologique. Catalogue systématique, in: R. Kasser (ed.), Explorations aux Qounçoûr el-Izeila: lors des campagnes 1981, 1982, 1984, 1985, 1986, 1989 et 1990, Mission Suisse Arch. Copte Univ. Genève (Leuven 1999) 519–573.

Connelly – Wilson 2002 J. Br. Connelly – A. I. Wilson, Hellenistic and Byzantine Cisterns on Geronisos Island, RDAC 2002, 269–292.

Decker 2005 M. Decker, The wine trade of Cilicia in Late Antiquity, Aram 17, 2005, 51–59.

Diamanti 2008 Ch. Diamanti, Η σημασία των παραλίων της Μικράς Ασίας στην παραγωγή και τη διακίνηση του υστερορωμαϊκού/πρωτοβυζαντινού αμφορέα 1 (= LRA 1). Αρχαιολογικές μαρτυρίες και επιγραφικές συμβολές, Deltio Kentrou Mikrasiatikon Spoudon 15, 2008, 11–37.

Diamanti 2010a Ch. Diamanti, Εντόπια Παραγωγή και Εισαγωγή Αμφορέων στην Αλάσαρνα της Κω (5^{ος}–7^{ος} αι.). Συμβολή στην Έρευνα της Παραγωγής και Διακίνησης των Υστερορωμαϊκών/ Πρωτοβυζαντινών Αμφορέων της Ανατολικής Μεσογείου, National and Kapodistrian University of Athens, School of Philosophy – S. Saripolos Library 115 (Athens 2010).

Diamanti 2010b Ch. Diamanti, Stamped Late Roman/Proto-Byzantine Amphoras from Halasarna of Kos, ReiCretActa 41, 2010, 1–8.

Diamanti 2012 Ch. Diamanti, Byzantine Emperors on Stamped Late Roman/Early Byzantine Amphoras, ReiCretActa 42, 2012, 1–5.

Diamanti 2015a Ch. Diamanti, Απεικονίσεις Αυτοκρατόρων και Επιγραφές Αξιωματούχων σε Ενσφράγιστους Πρωτοβυζαντινούς Αμφορείς, in: Τριακοστό πέμπτο Συμπόσιο Βυζαντινής και Μεταβυζαντινής Αρχαιολογίας και Τέχνης. Πρόγραμμα και Περιλήψεις Εισηγήσεων και Ανακοινώσεων, Αθήνα 23–26 Απριλίου 2015, The Christian Archaeological Society (Athens 2015) 47–48.

Diamanti 2015b Ch. Diamanti, Amphora Production at the Aegean Sea during the 5th–7th centuries. The Case of a Workshop at Paros Island: Preliminary Results, in: F. Thuillier – E. Louis (eds.), Tourner autour du pot … Les ateliers de potiers médiévaux du V^{e} au XII^{e} siècle dans l'espace européen. Actes du colloque international de Douai, 5–8 octobre 2010 (Caen 2015) 541–545.

Diamanti 2016 Ch. Diamanti, The Late Roman Amphora Workshops of Paros Island in the Aegean Sea. Recent Results, ReiCretActa 44, 2016, 691–697.

Diamanti 2019 Ch. Diamanti, *Quastura exercitus*, the *Eparch* of the islands and the Late Roman/ Early Byzantine Stamped Amphoras, in: Ch. Diamanti – A. Vassiliou (eds.), Essays in Byzantine Material Culture and Society in Honour of Sophia Kalopissi-Verti (Oxford 2019) 205–216.

Diamanti (forthcoming) Ch. Diamanti, Αμφορείς, in: S. Kalopissi-Verti – M. Panayiotidi Kesisoglou (eds.), Η κεραμική του οικισμού της Αλάσαρνας της πρώιμης βυζαντινής περιόδου (forthcoming).

Diamanti et al. 2014 Ch. Diamanti – K. Kouzeli – P. Petridis. Archaeology and Archaeometry in Late Roman Greece: the Case of Mainland and Insular Settlements, Workshops and Imports, in: Poulou-Papadimtriou et al. 2014, I, 181–192.

Diamanti et al. 2020 Ch. Diamanti – Y. Kourayos – A. Lamprakis, Late Roman Pottery Contexts from the excavations of the archaic sanctuary complex of Apollo in Despotiko island, Cyclades, ReiCretActa 46, 2020, 507–516.

Diamanti et al. (forthcoming) Ch. Diamanti – A. Lamprakis – J. Hilditch, Οι Πρωτοβυζαντινοί Αμφορείς της Πάρου – Μορφολογικά και Κεραμολογικά Χαρακτηριστικά, in: International Conference »Περί των Κυκλάδων νήσων. Το Αρχαιολογικό Έργο στις Κυκλάδες«. Ephorate of Antiquities of Cyclades, École française d'Athènes, Byzantine and Christian Museum of Athens, 22–26 November 2017 (forthcoming).

Didioumi 2014 S. Didioumi, Local pottery production in the island of Cos, Greece from the early Byzantine period. A preliminary report, in: Poulou-Papadimtriou et al. 2014, I, 169–180.

Doksanaltı et al. 2018 E. M. Doksanaltı – I. Karaoğlan – D. O. Tozluca, Knidos Denizlerin Buluştuğu Kent (Ankara 2018).

Doksanaltı (forthcoming) E. M. Doksanaltı, The Harbor Chapel and Its Complex in Knidos, Anodos 13 (forthcoming).

Durliat 1989 J. Durliat, La Peste du VI^{e} Siècle, in: C. Abadie-Reynal (ed.), Hommes et Richesses dans l'Empire Byzantin, I (Paris 1989) 107–119.

Empereur – Picon 1986 J.-Y. Empereur – M. Picon, Des ateliers d'amphores à Paros et à Naxos, BCH 110, 1986, 495–511.

Grace 1949 V. Grace, Standard Pottery Containers of the Ancient Greek World. Commemorative Studies in Honor of Theodore Leslie Shear, Hesperia Suppl. 8 (Princeton, NJ 1949) 175–189.

Grace 1956 V. Grace, The Canaanite Jar, in: S. Weinberg (ed.), The Aegean and the Near East. Studies presented to Hetty Goldman (New York 1956) 80–109.

Gendelman 2010 P. Gendelman, Stamped Amphora Handles in Buchennino, A., Ras Abu Dahud (North) – Final Report, Hadashot Arkheologiyot – ESI 122 [electronic edition <http://www.hadashot-esi.org.il/report_detail_eng.aspx?id=1495&mag_id=117> (13. 05. 2018)].

González 2019 H. González Cesteros, Eastern Mediterranean Amphorae, in: T. Bezeczky (ed.), Amphora research in the Castrum Villa on Brijuni Island, DenkschrWien 509 = AForsch 29 (Vienna 2019) 67–90.

Gülsefa 2016 G. Gülsefa, 2006–2013 Myndos Kazilarinda Bulunan Amphoralar ve Amphora MühürBuluntulari, in: D. Şahin (ed.), Myndos Kazi ve Araġtirmalari 2004–2013, Myndos Araġtirmalari, I (Ankara 2016) 35–160.

Haldon 1990 J. F. Haldon, Byzantium in the Seventh Century. The Transformation of a Culture (Cambridge 1990).

Haldon 1995 J. Haldon, State, Army and Society in Byzantium (Aldershot 1995).

Haldon 1999 J. Haldon, Warfare, State and Society in the Byzantine World – 565–1204 (London 1999).

Hayes 1992 J. W. Hayes 1992, Excavations at Saraçhane in Istanbul, II: The Pottery (Princeton, NJ 1992).

Kara 2015 Ü. Kara, Yenikapı Limanı'nda Ele Geçen Damgalı Amphoralar, in: A. Diler – K. Şenol – Ü. Aydınoğlu (eds.), Olive Oil and Wine Production in Eastern Mediterranean during Antiquity. International Symposium Urla-İzmir, Turkey, 17–19 November 2011 (Izmir 2015) 243–250.

Keydell 1967 R. Keydell (ed.), Agathias. Histories. Agathies Myrinaei Historiarum libri quinque, Corpus Fontium Historiae Byzantinae II (Berlin 1967).

Kokkorou-Alevras et al. 2006 G. Kokkorou-Alevras – S. Kalopissi-Verti – M. Panayotidi-Kesisoglou, The Sanctuary of Apollo and the Early Christian Settlement at Kardamaina (Ancient Halasarna) on the Island of Kos (Athens 2006).

Kokkorou-Alevras et al. 2016 — G. Kokkorou-Alevras – D. Grigoropoulos – Ch. Diamanti – M. Koutsoumpou, Maritime Connections of Halasarna on Cos from Prehistory to Late Antiquity. A View based on the Pottery and Other Finds, in: K. Höghammar – B. Alrothand – A. Lindhagen (eds.), Ancient Ports. The Geography of Connections, Boreas 34, 2016, 167–200.

Laiou – Morrisson 2007 — A. E. Laiou – C. Morrisson, The Byzantine Economy (Cambridge 2007).

Leidwanger 2014 — J. Leidwanger, A Preliminary Archaeometric Analysis of the Late Roman 1 Amphoras from the Cargo of the Seventh-century Yassıada Shipwreck, Turkey, in: Poulou-Papadimtriou et al. 2014, II, 897–906.

Leidwanger 2015 — J. Leidwanger, Early Byzantine Cyprus: A View from the Sea, in: D. N. Carlson – J. Leidwanger – S. M. Kampbell (eds.), Maritime studies in the wake of the Byzantine shipwreck at Yassiada, Turkey (College Station, TX 2015) 157–166.

Lund 1996 — J. Lund, From archaeology to history? Reflections on the chronological distribution of ceramic fine wares in South Western and Southern Asia Minor from the 1st to the 7th c. AD, in: M. Herfort-Koch – U. Mandel – U. Schädler (eds.), Hellenistische und kaiserzeitliche Keramik des östlichen Mittelmeergebietes. Kolloquium Frankfurt 24.–25. April 1995 (Frankfurt 1996) 105–126.

Morrisson – Sodini 2002 — C. Morrisson – J.-P. Sodini, The sixth-century economy, in: A. E. Laiou (ed.), The Economic History of Byzantium. From the Seventh through the Fifteenth Century, Dumbarton Oaks Studies 39, 3, 1 (Washington, DC 2002) 171–220.

Oikonomides 2002 — N. Oikonomides, The role of the Byzantine State in the Economy, in: A. E. Laiou (ed.), The Economic History of Byzantium. From the Seventh through the Fifteenth Century, Dumbarton Oaks Studies 39, 3, 3, 2002, 973–1058.

Opaiţ – Diamanti 2014 — A. Opaiţ – Ch. Diamanti, Imperial Stamps on Early Byzantine Amphoras. The Athenian Agora Examples, ReiCretActa 43, 2014, 55–61.

Papanikolaou 2014 — P. Papanikolaou, Αποτυπώσεις της εξουσίας. Εικονογραφία και προσωπογραφία επάρχων σε ενσφράγιστους πρωτοβυζαντινούς αμφορείς, in: P. Triantafyllidis (ed.), Σοφία άδολος. Τιμητικός τόμος για τον Ιωάννη Χρ. Παπαχριστοδούλου (Rhodes 2014) 171–188.

Peacock – Williams 1986 — D. P. S. Peacock – D. F. Williams, Amphorae and the Roman Economy. An Introductory Guide (New York 1986).

Pieri 2005 — D. Pieri, Le commerce du vin à l'époque Byzantine (IVe–VIIe siècles) (Beyrouth 2005).

Pieri 2007 — D. Pieri, Les centres de production d'amphores en Mediterranée orientale durant l'Antiquité tardive: quelques remarques, in: M. Bonifay – J.-C. Tréglia (eds.), LRCW 2. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and Archaeometry, BARIntSer 1662 (Oxford 2007) 611–625.

Pieri 2012 — D. Pieri, Regional and Interregional Exchanges in the Eastern Mediterranean during the Early Byzantine Period. The Evidence of Amphorae, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Byzantine Symposia and Colloquia (Washington, DC 2012) 27–49.

Portale 2014 — E. C. Portale, The sunset of Gortyn: Amphorae in 7th–8th centuries AD, in: Poulou-Papadimitriou et al. 2014, I, 477–489.

Poulou-Papadimidriou – Nodarou 2014 — N. Poulou-Papadimidriou – E. Nodarou, Transport Vessels and Maritime Trade Routes in the Aegean from the 5th to the 9th c. AD. Preliminary Results of the EU funded »Pythagoras II« project: the Cretan Case Study, in: Poulou-Papadimitriou et al. 2014, II, 873–883.

Poulou-Papadimidriou et al. 2014 — N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. The Mediterranean: A Market without Frontiers, BARIntSer 2616, I–II (Oxford 2014).

Quiroga 2016 — J. L. Quiroga, Early Byzantine Urban Landscapes in the Southwest and Southeast Mediterranean, in: Proceedings of the 23rd International Congress of Byzantine Studies (Belgrade 2016) 69–106.

Reynolds 2008 — P. Reynolds, Linear typologies and ceramic evolution, FACTA 2, 2008, 61–87.

Riley 1979 — J. A. Riley, The coarse pottery from Berenice, in: J. A. Lloyd (ed.), Excavations at Sidi Khrebish, Benghazi (Berenice), LibyaAnt Suppl. 5, 2, 2 (Tripoli 1979) 91–467.

Sakellakou – Diamanti (forthcoming) — Ch. Sakellakou – Ch. Diamanti, Κεραμική από πρωτοβυζαντινές εγκαταστάσεις στο Καμάρι και την Περίσσα της Θήρας, in: International Conference »Περί των Κυκλάδων νήσων. Το Αρχαιολογικό Έργο στις Κυκλάδες«, Ephorate of Antiquities of Cyclades – École française d’Athènes, Byzantine and Christian Museum of Athens, 22–26 November 2017 (Athens forthcoming).

Sinakos 2006 — A. Sinakos, Η επίδραση των λοιμών και των φυσικών καταστροφών του τέλους του 6ου και των αρχών του 7ου αι. στη διαμόρφωση της πολίτικης του αυτοκράτορα Μαυρικίου, Eoa kai Esperia 6, 2006, 97–121; DOI: http://dx.doi.org/10.12681/Eoaesperia.69

Steckner 1989 — C. Steckner, Les Amphores LR 1 et LR 2 en Relation avec le Pressoir du Complexe Ecclésiastique des Thermes de Samos. Relation entre Forme et Fonction d’un Vase en tant que Récipient d’un Contenu Spécifique. Examen par Ordinateur et Expérimentation, in: V. Déroche – J.-M. Speiser (eds.), Recherches sur la Céramique Byzantine. Actes du colloque organisé par l’École française d’Athènes et l’Université de Strasbourg II. Centre de Recherches sur l’Europe centrale et Sud-Orientale Athènes 8–10 avril 1987, BCH Suppl. 18 (Athens 1989) 57–71.

Sztetyllo – Borkowski 1986 — Z. Sztetyllo – Z. Borkowski, Un timbre céramique byzantin de l’Èparque de Constantinople, in: J.-Y. Empereur – Y. Garlan (eds.), Recherches sur les Amphores Grecques. Actes du Colloque International Organisé par le Centre National de la Recherche Scientifique, l’Université de Rennes II et l’École Française d’Athènes, Athènes, 10–12 Septembre 1984, BCH Suppl. 13 (Athens 1986) 649–654.

Treadgold 1995 — W. Treadgold, Byzantium and its Army (Stanford 1995) 284–1081.

van Doorninck 1989 — F. H. van Doorninck, Jr., The Cargo Amphoras on the 7th century Yassi Ada and 11th century Serçe Limani Shipwrecks. Two Examples of a Reuse of Byzantine Amphoras as Transport Jars, in: V. Déroche – J.-M. Speiser (eds.), Recherches sur la Céramique Byzantine. Actes du colloque organisé par l’École française d’Athènes et l’Université de Strasbourg II. Centre de Recherches sur l’Europe centrale et Sud-Orientale Athènes 8–10 avril 1987, BCH Suppl. 18 (Athens 1989) 247–257.

Vroom 2004 — J. Vroom, Late Antique pottery, settlement and trade in the east Mediterranean: A preliminary comparison of ceramics from Limyra (Lycia) and Boeotia, in: W. Bowden – L. Lavan – C. Machado (eds.), Recent Research on the Late Antique Countryside, Late Antique Archaeology 2 (Leiden 2004) 281–331.

Waksman et al. 2014 — S. Y. Waksman – Y. Morozova – S. Zelenko – M. Colac, Archaeological and Archaeometric Investigations of the Amphorae Cargo of a Late Roman Shipwreck sunk near the Cape of Plaka (Crimea, Ukraine), in: Poulou-Papadimitriou et al. 2014, II, 919–929.

Anastasia G. Yangaki

IN SEARCH OF STANDARDIZATION

THE CASE OF A GLOBULAR AMPHORA TYPE FROM CRETE

Abstract

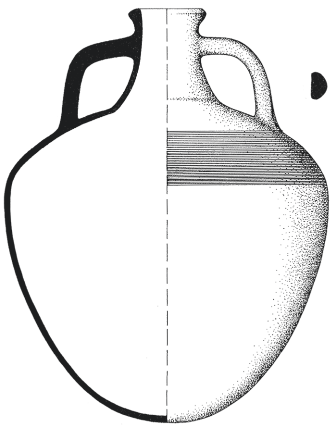
An important group of amphorae recognized by researchers in recent decades is the so-called globular amphorae characteristic of the 7th and the 8th–9th centuries A.D. and produced in various regions of the Mediterranean, including the Aegean. These share a globular – in some cases, globular/ovoid – body form but show several variations either in the form of their neck and rim or in the occurrence of a rounded or concave base with a knob. Although numerous publications provide examples of this group, no research has yet sought to address questions relating to the standardization of the various regional productions, their diffusion, and use.

The focus here is on a particular form of globular amphora. Initially identified through the study of the Yassıada globular series of amphorae, this form is also categorized under the label of Hayes's Type 29 from the Saraçhane material, and its Cretan version is tentatively identified and labelled »TRC12« based on material from Eleutherna. It is this Cretan version that I primarily address while making frequent reference to the type's other versions to provide some food for thought on its broader production and standardization. Examples of this Cretan type are found in layers of the 7th century, mostly dating later than its first decades, and seem still to have been in use in the very early 8th century at the site of Eleutherna. TRC12 can be clearly distinguished from its counterparts and ›prototypes‹ – namely, examples from the Yassıada shipwreck, Samos, and Constantinople – by its smaller dimensions. This seems also to be the case for the various other globular Cretan forms, which reveal a clear differentiation in size and volume in comparison to the far larger LR2 amphora, which must have served as an inspiration for their manufacture. The study of this Cretan version of globular amphora reveals a degree of standardization during the transitional period of the 7th and early 8th century, a period when other amphora types – well known and widely distributed during earlier centuries – were in decline. The Cretan case study, while offering an interesting picture of standardization, raises some questions about the production of such globular jars. It would appear that some coordination existed for this production during a certain period. However, the products do still reveal variation in both capacity and manufacturing details. Concrete evidence is still extremely limited both for the production centers of the globular amphorae of this form from other regions and for the Cretan counterpart. It has not yet been possible to trace in detail the variations of these amphorae from geographically dispersed workshops, and there is a need to study the capacities of many more examples in greater detail. However, the present study and the questions raised make it clear that the topic of standardization in the Late Roman and Byzantine periods offers considerable opportunities for interdisciplinary research. The ultimate aim is the generation of additional information on the material culture of the early medieval Mediterranean.

INTRODUCTION: IN SEARCH OF STANDARDIZATION WITHIN THE GLOBULAR AMPHORA GROUP

Given the topic of this volume on amphorae and their standardization during Roman, Late Roman and Byzantine times[1], it seemed most suitable to present some observations on the well-known group of so-called globular amphorae with a focus on Aegean examples. In particular, I con-

[1] I want to thank the organizers, Horacio González Cesteros and Justin Leidwanger, for inviting me to participate in the symposium that led to this publication. Given my previous involvement with the group of ›globular amphorae‹, and particularly with those of Cretan origin (e.g., see Yangaki 2005; Yangaki 2007, 767–774), the symposium gave me the opportunity to further reflect on the current evidence regarding the production and distribution of these amphorae. By posing questions on this particular theme, it will also hopefully allow a fresh view of an ever-growing set of related data.



1 Drawing of a Yassıada globular amphora (from: Bass 1982, 159 fig. 8–5 no. CA18; © Institute of Nautical Archaeology/S. Katzev)

centrate here on one form from Crete[2]. First, I would like to examine the term ›standardization‹ and its significance; after that, I test its applicability to the family of globular amphorae (fig. 1–3).

Regarding standardization, according to the most common interpretation – based on the verb »standardize«, or »to bring or to make of an established, standard size, weight, quality, strength or the like«[3] – the term means bringing together and comparing parts which share common (i.e., standard) characteristics. Although early discussions of standardization and its implications for archaeological ceramics already go back half a century, it was only very recently that research on the theme was afforded significance[4]. As the latest publications make clear, it is now an area of advanced research, given that the subject had been largely overlooked by scholars working on Mediterranean material from the Roman and later periods. However, in the context of this newly emerging interest in the subject, problems in terminology and conceptual issues do occur, with the conceptualization of standardization (and of variation too, since the two terms and concepts are tightly interconnected) not being fully explored and used systematically[5]. A. Kotsonas suggested »a conceptual scheme that emphasizes the relativity of standardization and of variation in the pre-modern world« and underlined »how modernity has profoundly transformed the understanding of this scheme«[6]. As he has remarked, it is not rare for some of us to assume – influenced by the modern notion as established by various organizations – that the term denotes objects (here ceramic vessels) that are exact copies of one another[7]. In fact, P. M. Rice has elaborated on the conceptualization of this term, noting that standardization should be understood as »the relative degree of homogeneity or reduction in variability in the characteristics of the pottery, or the process of achieving that relative homogeneity«[8]. In addition, Kotsonas, assembling Rice's as well as later researchers' observations and views, has remarked that standardization and variation should be seen as relative concepts, both encompassed by the overarching concept of variability, with the one related and referring to the other[9]. I hope what follows will add further nuance to this conception. Traditional modes of research are used in parallel to the application of statistics as well as materials science and other methods used to assess the standardization of different vessel attributes[10]. Regarding amphorae in particular, standardization could have facilitat-

2 For Crete and the various globular forms of amphorae: Belli-Pasqua – La Torre 1994/1995, 155 no. 631 fig. 36; Portale – Romeo 2001, 308–313; Poulou-Papadimitriou 2001, 245 f.; Yangaki 2005, 193–197; Yangaki 2007, 767–771; Poulou-Papadimitriou 2011, 398–403; Poulou-Papadimitriou – Nodarou 2014, 874 f.; Yangaki 2016, 217–219: Poulou 2017, 200–207. 214 f. fig. 6–8. For examples of globular/ovoid amphorae: Poulou-Papadimitriou 1995, 1122. 1129 fig. 6; Poulou-Papadimitriou 2014, 138–140; Poulou-Papadimitriou – Nodarou 2014, 874 f.; Poulou 2017, 200–207. 213 fig. 4; 214 fig. 5.

3 Standardization, in: Dictionary.com Unabridged. Random House, Inc. <http://www.dictionary.com/browse/standardization> (accessed 12. 04. 2018).

4 See also Kvamme et al. 1996, 117. For a summary and critical presentation of related research and references, see Kotsonas 2014a, 1 f.; Kotsonas 2014b, 7–23.

5 Kotsonas 2014a, 1.

6 Kotsonas 2014a, 2 f.; Kotsonas 2014b, 7–17.

7 For an elaboration: Kotsonas 2014b, 9.

8 Rice 1991, 268. For Rice's treatment of standardization in a passage on variability, see Rice 1987, 202–204; see also Kotsonas 2014b, 8.

9 Rice 1987, 201–204; Rice 1991, 273; Kotsonas 2014b, 8 f. For a synthesis of the notions of variation, diversity, and variability, see recently Kotsonas 2014b, 8.

10 For the various methods of analysis: Kvamme et al. 1996, 116–125; Kotsonas 2014b, 9–17 (with references). For various methods of calculating a vessel's capacity, see, in addition, Hüttig 1999, 317–324; Engels et al. 2009,

ed both their transportation in ships' holds, maximizing spatial efficiency, and their identification by consumers as packages for specific goods[11]. In addition, the degree of uniformity played a key role in transactions since it could ensure a specific quantity of a particular commodity[12]. Based on this approach, however, we must keep in mind, in regard to amphorae, the relative rather than absolute standardization of ancient ceramic containers; ›standardized‹ vessels were characterized by little absolute standardization of their capacities.

Dimensional standardization, through its focus on vessel form, has received the bulk of interest to date since it is suited to the assessment of specific ceramic shapes. Thus, for the amphorae in question, linear measurements defining the shape and size of the type are the main attribute used for assessing the presence and degree of standardization[13]. Dimensional standardization can yield information relating to organization behind the vessels' production (based on metrics such as rim diameter, vessel height, and circumference) without the need for analytical techniques[14].

The so-called globular amphorae (fig. 2–3) constitute an important group of containers that has been recognized by researchers in recent decades[15]. Characteristic mostly of the 7th and 8th centuries A.D., they were produced in various regions of the Mediterranean, including the Aegean. The main bulk of amphorae in this large group share a globular body form, but show several variations either in the form of their neck and rim, in the occurrence of a rounded or concave base with a knob or in the position and dimension of their maximum diameter, thus creating a rather heterogeneous group. To these can be added amphorae of globular/ovoid form. It has already been noted that these forms generally resemble one of the most widely circulating and studied amphorae of the Late Roman period: the LR2 amphorae in particular, but with some examples suggesting that in some cases LR1 constituted an additional source of inspiration[16]. Considering that globular amphorae have only been systematically explored during the 21st century, it is striking that a large amount of related evidence has so far been published. There are three main axes of this research. First, it seeks to acquire a better knowledge of the various types circulating during the 7th and 8th centuries. Consequently, most publications have persisted in presenting the basic characteristics of the forms from various sites. Secondly, research aims to identify the provenance of some of these forms given that most examples of globular amphorae – based on a macroscopic and, in a few cases, also microscopic and analytical investigation of their fabrics – are attributed to local productions at various sites. Thirdly, research attempts to date the amphorae, in particular since they usually figure among the main dating evidence for layers from this period given the scarcity or absence of fine wares. To our knowledge, by contrast, no research has yet focused on several key aspects: a) assembling this ample data with a view to identifying some basic traits as a precursor to drawing up a typological sequence; b) addressing questions regarding their modes of production, their diffusion, and use[17]; and c) determining whether some degree of standardization existed within the various regional productions. The lack of studies focused on the last area is surprising because, as has already been stressed by various researchers, they share a broad shape produced in numerous workshops in even distant regions of the central

129–133 (also consultable at <https://capacity.ulb.ac.be/index.php/en/home> [09. 04. 2018]).

11 Rice 1987, 202; Kotsonas 2014b, 15; Greene – Lawall 2015, 8.

12 Greene – Lawall 2015, 8.

13 For the use of linear measurements in assessing standardization, see Kotsonas 2014b, 10 f.; van Alfen 2015, 20–32.

14 For the combination of both attributes: Kotsonas 2014b, 11. 14.

15 The bibliography regarding this group of amphorae is rather large, and its enumeration lies beyond the scope of this study. For some studies which either focus on Aegean examples or have an introductive character, see Murialdo 2001, 289–291; Poulou-Papadimitriou 2001, 245–247; Demesticha 2002, 115–119; Yangaki 2005, 216–218; Leo Imperiale 2004, 331; Murialdo 2007, 18; Toniolo 2007, 101; Zanini 2010, 139–148; Poulou-Papadimitriou – Nodarou 2014, 874 f.; Poulou 2017, 200–207; Poulou – Leontini 2022, 104–108 (for a recent reappraisal).

16 For further details, see references in the previous note.

17 With the exception of cases such as the workshops excavated in the islands of Cos and Paros. For the respective references, see below, n. 49.

2 Globular amphora from Eleutherna (Yangaki 2005, 90 f. 481 pl. 23, 1; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

and eastern Mediterranean and therefore do not manifest the variety of forms and subforms in which workshops of the earlier Late Roman amphorae specialized. Are we to conclude that some degree of standardization existed in this group of containers? In the case of Late Roman amphorae, the term has mostly been used in relation to the well-known and well-diffused LR1 and LR2 amphora types[18]. In two additional studies, however, P. G. van Alfen and F. H. van Doorninck examined in detail the linear and volumetric measurements of the amphorae from the well-known Yassıada shipwreck, which have a general globular body[19]. But to my knowledge, standardization has never been examined in the context of globular amphorae. Various researchers have expressed the opinion that the forms of globular amphorae represent less standardized productions that distributed products on a local or regional scale[20]. In my opinion, this field of research has remained underexplored mostly due to the fact that, until a few decades ago, we knew very little about these amphorae. However, based on examples from the Aegean area, where this group of amphorae was dominant, a close examination of particular examples does seem to indicate that some subforms were also shared by various neighboring sites.

The situation outlined above shows that, apart from the various specialist publications on globular/ovoid amphorae, their detailed study is still in its infancy. Attempts to investigate examples of standardization within the group therefore inevitably run into various obstacles. First of all, although several researchers have insisted that the examples of this amphora group

[18] A representative study would be that of P. G. van Alfen: see van Alfen 1996, 189–216.
[19] van Alfen 2015, 17–34; van Doorninck 2015a, 35–62.
[20] For some of these views: Leo Imperiale 2004, 331; Murialdo 2007, 18.

3 Globular Cretan amphora from Eleutherna (Yangaki 2005, 91. 481 pl. 23, 3; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

are mostly smaller in comparison to the various types that preceded them[21], no specific detailed studies have been undertaken (with the exception of results from the Yassıada amphorae mentioned above) focusing on globular amphorae from various regional production zones with the aim of identifying similarities and differences. Thus, the lack of detailed studies of the capacities of these types and their variation is one significant factor that impedes deeper research into standardization within this group. Closely related to this point is the fact that, in those cases where amphorae of this large group are published, no specific effort is undertaken to study their dimensions in detail or to provide the exact measurements of various parts of specific examples, which would then permit insights into the form's characteristics and the possibility of standardization. These two obstacles also relate, of course, to the nature of the evidence since only rarely are numerous complete examples of a particular globular form brought to light: shipwrecks are the clear exception.

THE CASE OF THE CRETAN GLOBULAR AMPHORA, BASED ON EXAMPLES FROM ELEUTHERNA AND COMPARANDA

Having outlined the context for the state of evidence regarding globular amphorae and standardization and in order to provide grounds for further thought, the focus will now shift to a particular form of globular amphora. Initially identified through the study of the Yassıada globular series

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21 Leo Imperiale 2004, 331; Vroom 2017b, 182 f.; Papavassiliou et al. 2014, 161 fig. 9 a. b (however, this constitutes an example of an ovoid amphora).

of amphorae (fig. 1)[22], this form is also categorized under the label of Hayes's Type 29 from the Saraçhane material[23], and its Cretan version is tentatively identified and labeled ›TRC12‹ based on material from Eleutherna (figs. 4–6. 8)[24]. Hopefully the latter will serve as a case study to illustrate that standardization can be found in amphorae of the 7th and 8th century as well, in addition to numerous earlier forms, with all the issues of interpretation this raises.

This Cretan group offers evidence for standardization within the main forms of globular amphorae. The earlier globular jars from the Yassıada assemblage – also described by the authors as late forms related to Late Roman 2 and divided preliminarily into four major ›working types‹ (I–IV) of globular form but without a knob-like projection on their base – will be dealt with in more detail, in view of the important comparative evidence they provide for the Cretan form[25]. D. Pieri has classified the former type (of Yassıada amphorae) within LRA 2C, which he describes as transitional and which comprises several variations[26]. To cite just a few examples, the type occurs on the Greek islands (Cos, Paros)[27], in Anemurium[28], at various sites on Cyprus (Amathous, Ag. Philon, Soloi, Paphos)[29], in Italy (Rome, Comacchio, Naples, Bari, Castellana, Casignana Palazzi, Paleapoli, Ischia, Ustica)[30], along the Adriatic coast[31], as well as in Egypt[32], Tunisia (Carthage, Nabeul), and Libya (Sirte)[33]. However, to my knowledge, no effort has been made to collect the evidence for its diffusion in a detailed study of the various examples. An analytical effort of this sort could serve as a guide to the globular amphora's characteristics since, based on the examples above, it is clear that this particular form was one of the most widely distributed, especially in the eastern Mediterranean region during the 7th century (and in some cases also the 8th cent.). It appears together with other globular forms of local or nonlocal production and, judging by its ex-

22 Bass 1982, 161–165; van Doorninck 1989, 247–250; van Alfen 2015, 17–34.

23 Hayes 1992, 68 fig. 23, 2. 3. 8; 71 type 29 (Constantinople).

24 Yangaki 2005, 193 f. 197; Yangaki 2007, 768 f. In order to stress the continuation of the Cretan production over a long period starting from Hellenistic times and extending into the 8th cent. A.D. and comprising various then unclassified forms deriving from specific contexts in Gortyn, E. C. Portale and I. Romeo proposed in 2001 to designate a late series of Cretan amphorae the »Tardo Romana Cretese« (TRC) group (Portale – Romeo 2001, 261). This classification has been followed since then given that, besides the considerable evidence on later forms from the Gortyn and Eleutherna sites, only a limited number of relevant examples from other Cretan sites have so far been published, permitting a better understanding of the variety of the local production from the 7th cent. on and thus allowing a detailed and clear classification of these later forms (see also, on the same issue: Yangaki 2005, 182 with n. 888).

25 For the classification of the respective examples as ›LR2b‹ amphorae, see Karagiorgou 2001, 41–43 fig. 4.2; van Doorninck 2015b, 206 f. See also the initial division into LR2a and LR2b by G. F. Bass (Bass 1982, 157. 159). Regarding the confusion and the recognition of examples of ›globular amphorae‹ as forming part of the LRA 2 or the LRA 13 types, see the comments in Demesticha 2010, 137 n. 24; Diamanti 2010, 81–96; Poulou-Papadimitriou – Nodarou 2014, 874; Yangaki 2020, 170 f. 188 f. n. 60; Poulou – Leontini 2022, 107 f. For these four types (initially referred to as subtypes) within the general group of the globular amphorae of the Yassıada shipwreck: van Doorninck 1989, 247–249; and more recently, van Alfen 2015, 18–30 fig. 2, 1–4; 32 n. 7.

26 Pieri 2005, 88 f. fig. 49 pl. 27; reference is made here in particular to variation no. 3 in pl. 27.

27 Cos: Diamanti 2010, 81–84. 114. 155–156; Poulou-Papadimitriou – Didioumi 2010, 743 (type I); Diamanti 2012, 3 figs. 2. 5 a. b; Paros: Diamanti 2016, 692 fig. 2 c. d.

28 Williams 1989, 98 no. 575 fig. 60, 575.

29 Amathous: Touma 1989, 872 f. figs. 28. 29; Touma 2001, 269; Ag. Philon: Du Plat Taylor – Megaw 1981, 221 no. 372; 223 fig. 43, 372; Soloi: Des Gagniers – Tinh 1985, 98 no. 96 a–c fig. 230; Paphos: Megaw 1971, 131 no. 22; 132 fig. 5, 22.

30 Rome: Saguì et al. 1997, 43 fig. 6, 2. 3; 44; Ricci 1998, 371 fig. 13, 1. 2; Saguì 2001, 266 f. 287–289 nos. II.3.145; II.3.147; Comacchio: Negrelli 2007, 320. 322 fig. 18.5; Naples: Arthur 1993, 236 f. fig 3, 13; Bari: Radina 1984, 347 fig. 8, 4. 6; Castellana: Petrone et al. 1994, 276 f. fig. 6, 19. 20; Casignana Palazzi: Barello – Cardosa 1991, 679 f. 687 fig. 13, 1; Paleapoli: Lebole di Gangi 1991, 587 no. 4 fig. 10, 4; Ischia: Guarino et al. 1988, 455 fig. 12 a; Ustica: Mannino 1979, 22 f. fig. 23.

31 Butrint: Lako 1981, 134 f. pl. 3, 3.

32 Elephantine: Gempeler 1992, 199 form K765 fig. 129, 2 pl. 40, 4.

33 Carthage: Hayes 1978, 47 fig. 9 no. 25; Nabeul: Bonifay 2004, 152 type 66; Berenice: Riley 1979, 232 f. no. D 379 fig. 94, 379; Sirte: Preece 2000, 37 fig. 6, 23.

4 a. b Example of a TRC12 amphora from Eleutherna (Yangaki 2005, 95. 481 pl. 23, 6; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

5 a. b Example of a TRC12 amphora from Eleutherna (Yangaki 2005, 95. 481 pl. 23, 8; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

6 Examples of TRC10 and TRC12 amphorae from Eleutherna (Tsigonaki – Yangaki 2015, 437 fig. 10 c; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

tensive distribution, it must have been the main form to successfully replace the series of various Late Roman amphorae during the 7th century and later[34].

In an effort to offer detailed information on one of the type's production areas, emphasis here is placed on its Cretan version while making frequent reference to the type's other versions to provide some food for thought on its broader production and standardization. To date, ample evidence from several Cretan sites as well as sites beyond the island has enhanced our knowledge of the various types produced on the island from the Hellenistic to the Byzantine period, with the latest evidence dating to the 9th century[35]. This evidence has also demonstrated the existence of various production centers and offered researchers the opportunity to follow the morphological development of local forms. Although a detailed presentation of these forms is beyond the scope of this paper, it is worth noting that the longer and more cylindrical forms of the Roman era on Crete (ARC1, ARC2, ARC4, MRC1, MRC2, MRC3) gave way to the more ovoid, larger but shorter shapes that seem to have been dominant here during the first Byzantine period (MRC4, TRC1, TRC2). During the 7th and 8th centuries, amphorae with a globular/ovoid body seem most prevalent on the island (TRC7, TRC10, TRC12, TRC13, TRC14, TRC15, TRC16) (figs. 4–5. 10–12)[36]. Additional evidence has contributed further examples to the basic forms of this production[37].

Characteristics of the particular type in question here, TRC12 (figs. 4–5. 8), include, based on the examples from Eleutherna, a thick upright rim with a triangular lip, flattish on its upper part and with an angular edge; the neck is slightly conical, without ridges on its exterior. The Cretan amphora shows similarities to one example (CA18, fig. 1) from the Yassıada shipwreck[38], based most significantly on the formation of the rim[39]. Some variation exists in the form of the rim, which has a ridge on its interior in some examples, and in the formation of the neck, which is more cylindrical than conical in a few examples. The handles are uniformly oval in section and attached under the rim, almost at the midpoint between the neck and shoulder. They curve gently towards the shoulder, creating an angle of almost 90 degrees. Judging from the form of the shoulder, which curves toward the lower part of the body, and from the numerous sherds that could be attributed to the same form, the body was globular or slightly ovoid in shape. This is further corroborated by an almost complete in preservation example of this type from the neighboring area of Panormo[40]. Although no fragments from the base have so far been securely linked to this particular form, its resemblance to other Cretan amphorae suggests that it was probably rounded. The Cretan form has decoration consisting of parallel bands of fine, dense incisions on the shoulder between the handles and the mid-zone of the body (fig. 9), a characteristic found on some of the Yassıada amphorae.

Examples of this Cretan type are found in layers of the 7th century, mostly dating from after its first decades, and seem still to have been in use in the very early 8th century at the site of Eleutherna[41]. In addition to several examples already published from the central plateau at Pyrgi, more examples have been found and studied in detail among the material from a large cistern located on the hillside there (fig. 8)[42]. The combination of the earlier and later evidence may suggest that

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34 For this series of amphorae: Hayes 1976, 116 f.; Riley 1979, 115–124 fig. 10; Riley 1981, 85–124.

35 For the relative bibliography on the material of the first Byzantine period see above, n. 2 and also n. 24. On representative bibliography on Cretan amphorae, either in general or with an emphasis on earlier types: Marangou – Lerat 1995; Portale – Romeo 2001, 260–279; Yangaki 2007, 767–774; Gallimore 2016, 182–184; Yangaki 2016, 218–220; Gallimore 2018, 376–386; Mazzocchin 2019, 653–658; Francis et al. 2023, 147–164.

36 For an analytical presentation of this evolutionary scheme, see Yangaki 2007, 768–771.

37 For this evidence, mostly regarding globular/ovoid forms: Poulou-Papadimitriou 2011, 398–404 (with examples); Poulou-Papadimitriou – Nodarou 2014, 874–876.

38 Bass 1982, 159 fig. 8-5 no. CA18.

39 Yangaki 2005, 195; Yangaki 2007, 769.

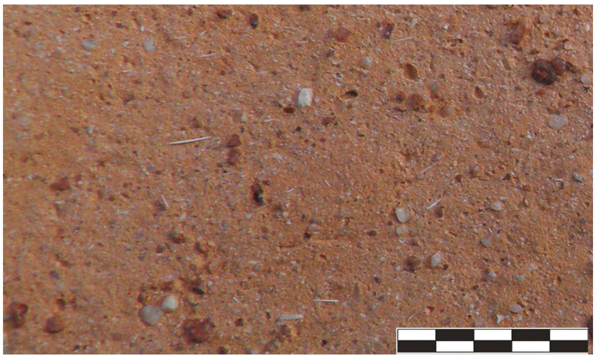
40 On this example: Fraidaki 2019, fig. 5 (bottom of the page).

41 For more details on the date of this type: Yangaki 2005, 195; Yangaki 2007, 768; Tsigonaki – Yangaki 2015, 438 f.

42 Tsigonaki – Yangaki 2015, 436–440. I would like to thank assistant professor Christina Tsigonaki, director of the excavation in sector II at Eleutherna, for the opportunity to continue studying the ceramic material and for her collaboration.

its production was characterized by some degree of standardization. Given the state of the evidence, which deprives us of complete examples, and since no sophisticated method of the sort presented in summary by A. Kotsonas has so far been applied to this particular material, the rather frequently used attributes of simple linear measurements must suffice here to demonstrate our argument for standardization[43]. Assembling the evidence, this type has an exterior rim diameter ranging from 6 to 8.7 cm, with a rim thickness ranging from 1.0 to 1.8 cm, a neck height ranging from 8.5 to 9.8 cm, and a body thickness ranging from 0.5 to 1.0 cm; the handles have a thickness of 2.5 to 3.0 cm and a width of 3.0 to 4.5 cm.

On Crete, examples of this form have been found at Gortyn (initially incorporated as variant ›g‹ within the TRC2 type) in various areas of the excavation, including the ›Praetorium‹ but also the Old Agora and the Early Byzantine Quarter[44]. Their rim diameter (7.5 cm) falls within the limits of the aforementioned group, although no additional remarks can so far be made given that they have not yet been documented sufficiently. In addition, judging from the main form of the body, which is almost completely preserved, and the characteristic decoration consisting of horizontal rows with fine incisions, an example from Knossos (tentatively attributed by Hayes to local production) probably should also be linked to the form[45]. It should be noted that this form is also characterized by small to medium dimensions since its height could not have surpassed 40 cm. The fabrics suggest that this type should be considered local production, at least in the cases of Gortyn and Eleutherna. Those from Gortyn are attributed to local production[46], while those from Eleutherna were manufactured in the same medium-coarse orange fabric typical of local production in that region (fig. 7)[47]. As was noted when the type was first recognized, it most closely resembles certain (Type I) globular amphorae of the Yassıada shipwreck in terms of the general body form, neck, and rim, and the way the handles are attached to the vessel. On the other hand, in terms of its handle section and horizontal rows of fine incised decoration, it most closely resembles others (Type II) within this globular amphora group[48]. Amphorae with similar features on their upper parts, particularly with regard to the rim, occur in numerous regions of the central and eastern Mediterranean, while the Cretan form has previously been compared with amphorae from Amathous, Anemurium, Carthage, Nabeul, and various sites of Italy, dated to between mainly the 7th and the 8th century[49]. In addition, the form finds exact parallels in specific examples from Samos, Cos, and Paros[50]. The numerous examples from the



7 Macroscopic view of the fabric of a TRC12 amphora from Eleutherna, attributed to the local production

43 Kotsonas 2014b, 10 f. For the importance of linear measurements in assessing standardization, see, as an example, Finkelstein et al. 2011, 249–258 tab. 2.

44 Portale – Romeo 2001, 304. 357 pl. 44 g; Zanini 2009, 56 f. 62 no. C9 fig. 11 to the right; Portale 2011, 128 fig. 36 c; 134 (placed under type TRC2); Portale 2014, 478. 481. 487 fig. 6.

45 Hayes 2001, fig. 4 no. A58.

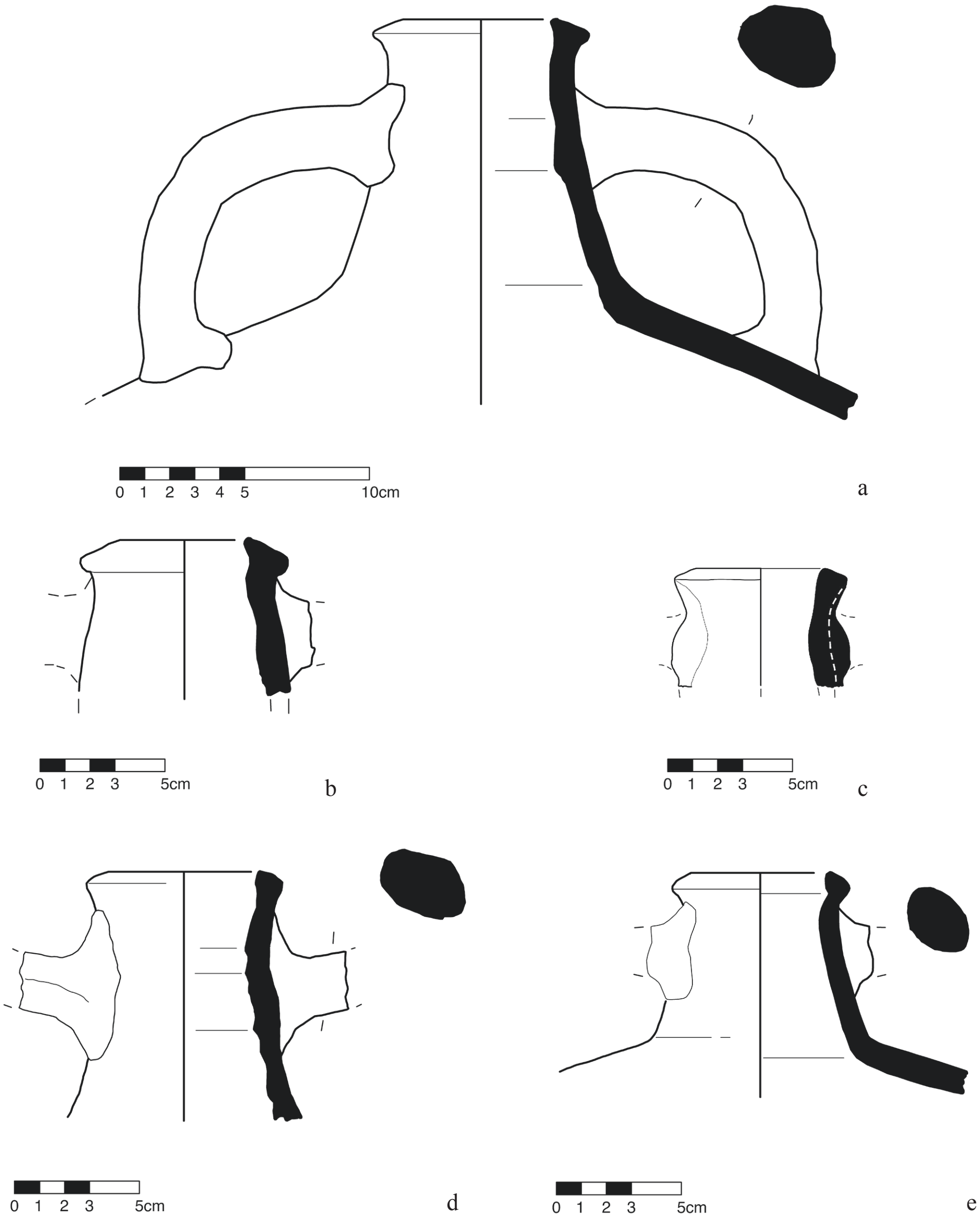
46 Portale – Romeo 2001, 304. 357; Portale 2011, 134; Portale 2014, 478. 481.

47 Yangaki 2005, 195; annexe I; tab. 2; Yangaki 2007, 769.

48 For these four types (initially referred to as subtypes) within the general form of the globular amphora of the Yassıada shipwreck, see above, n. 25.

49 For this comparison: Yangaki 2007, 769. See, respectively, Touma 2001, 269 fig. 6 (Amathous); Williams 1989, 98 no. 575 (Anemurium); Hayes 1978, 47 no. 25 (Carthage); Bonifay 2004, 152 f. »type globulaire 4« fig. 83, 3 (Nabeul); Lebole di Gangi 1991, 587 no. 4; Barello – Cardosa 1991, 687 fig. 13, 1 (for Italian sites).

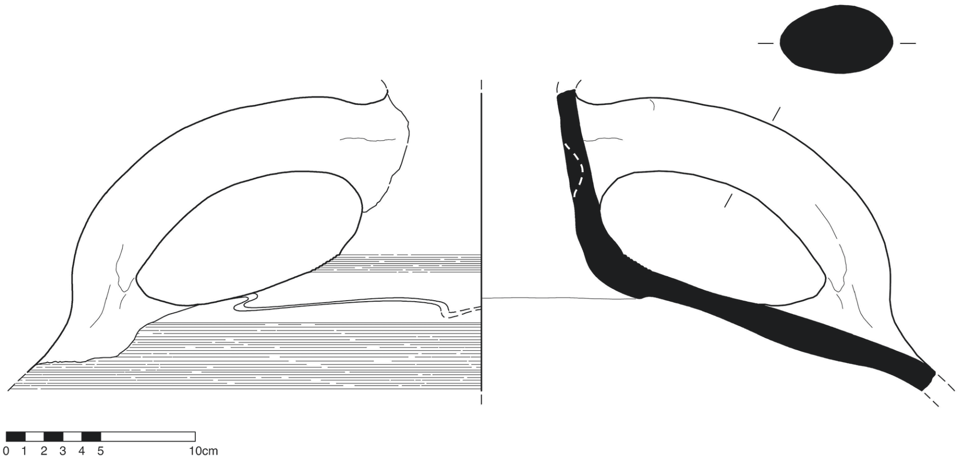
50 For Samos: Hautumm 2004, 294 no. 1736 pl. 101, 1736; Cos: Diamanti 2010, 81–84. 114. 155 f. and in particular examples on 335 no. 373; 495 fig. 91 no. 373–2320; 335 no. 375; 496 fig. 92 no. 375–2748; 338 no. 385; 498 fig. 94 no. 385–2474; 339 no. 392; 501 fig. 97 no. 392–1427; 340 no. 393; 501 fig. 97 no. 393–1425; 341 no. 398; 503 fig. 99 no. 398–72; Poulou-Papadimitriou – Didioumi 2010, 749 fig. 11 a; Diamanti 2012, 3 figs. 2. 5 a. b; Paros: Diamanti 2016, 692 fig. 2 c. d.



8 a–e Examples of TRC12 amphorae from Eleutherna (a. b. d. e: Yangaki 2005, fig. 52 g. h. j. l; c: Tsigonaki – Yangaki 2015, 437 fig. 10 b; drawings a. b. d. e: A. G. Yangaki; c: A. Ladianou)

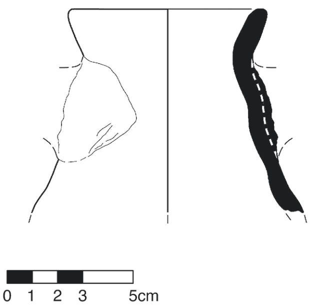
ecclesiastical complex, the Eupalinos tunnel, and two associated cisterns on Samos and on the Yassıada shipwreck are generally larger than the globular amphora of Crete[51]. In fact, although no complete example is preserved, this type does not differ in size from other Cretan types, such as TRC7 (fig. 10), mostly found in Gortyn, or TRC15, all of which have an average height of

[51] The amphorae of the latter three contexts have also been grouped together, given their similar morphological characteristics, by W. Hautumm (Hautumm 2004, 211), C. Steckner (Steckner 1989, 65; Steckner 1993, 156), and F. van Doorninck (van Doorninck 2015b, 209–211). For an earlier comparison of the amphorae of Yassıada with those from the Eupalinos tunnel: van Doorninck 1989, 248. For a critique of the connection of these assemblages to *annona militaris* linked with the *quaestura exercitus*, expressed by Steckner and van Doorninck: Steckner 1989, 65; van Doorninck 2015b, 209 f., see Moniaros 2009, 156 f.



9 Example of TRC12 amphora with characteristic incisions on its shoulder (Tsigonaki – Yangaki 2015, 438 fig. 11 b; drawing: A. Ladianou)

10 Example of a TRC7 amphora from Eleutherna (Yangaki 2005, 91. 193 f. 481 pl. 23, 2; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)



11 Example of a TRC10 amphora from Eleutherna (Tsigonaki – Yangaki 2015, 437 fig. 10 a; drawing: A. Ladianou)

12 Globular/ovoid amphora from Eleutherna with similarities to Cretan TRC13 amphorae (Tsigonaki – Yangaki 2015, 439 fig. 12 a; © University of Crete, excavation at Eleutherna, sector II/photo: Y. Papadakis-Ploumidis)

35–38 cm and an average maximum body diameter of 30–32 cm[52]. My earlier study has demonstrated that the globular Cretan forms exhibit low variability in terms of the basic elements of their morphology, with the rim diameter ranging 6–9 cm, body thickness not surpassing 0.9 cm, a neck height of 7.0–9.5 cm, a handle thickness of 2–3 cm, and a width of 3.4–4.5 cm[53].

The histograms (fig. 13–19) presenting the vessels' linear measurements reveal the potters' meticulousness and their interest in quality manufacture. The peak in each of the histograms indicates the potters' success in hitting a particular mark consistently. It is significant that these jars show little deviation regarding their rim diameters, which manifest an average of 7.59 cm for exterior rim diameter (tab. 1 fig. 14) and 6.08 cm for interior (tab. 1 fig. 13), another sign that the vessels were built to a predetermined size. It seems also that special care was taken in the formation of the neck and opening. The histograms and data in table 1 show that only a limited number of examples of this particular Cretan type from the site could be taken into consideration, at least in terms of sherds that can clearly be attributed to this form and measured[54]. Nevertheless, comparative evidence from other regions and periods has demonstrated that the coefficient of variation (CV) remains useful in assessing the existence and degree of standardization in vessels, even with a limited number of samples[55]. In particular, the specific amphorae constitute a closed group from two adjacent areas within a specific sector (II) of the site at Eleutherna and dating from the same time frame (which extends over some decades), thus constituting a coherent study assemblage. The use of CV values allows variability, a term inversely linked to standardization, to be reflected as a percentage[56]. The CV is a relative measurement and can be calculated by dividing the sample standard deviation (SD) by the sample mean, then multiplying the result by 100 to express it as a percentage[57].

[52] Gortyn: Portale – Romeo 2001, 308 f. pl. 46 a–d fig. 148; Portale 2014, 478. 480. 487 fig. 8; Eleutherna: Yangaki 2005, 193 f. 197; Yangaki 2007, 770.

[53] Yangaki 2007, 773 tab. 1.

[54] There were numerous sherds from the bodies of amphorae, but these cannot be convincingly linked to the particular TRC12 form.

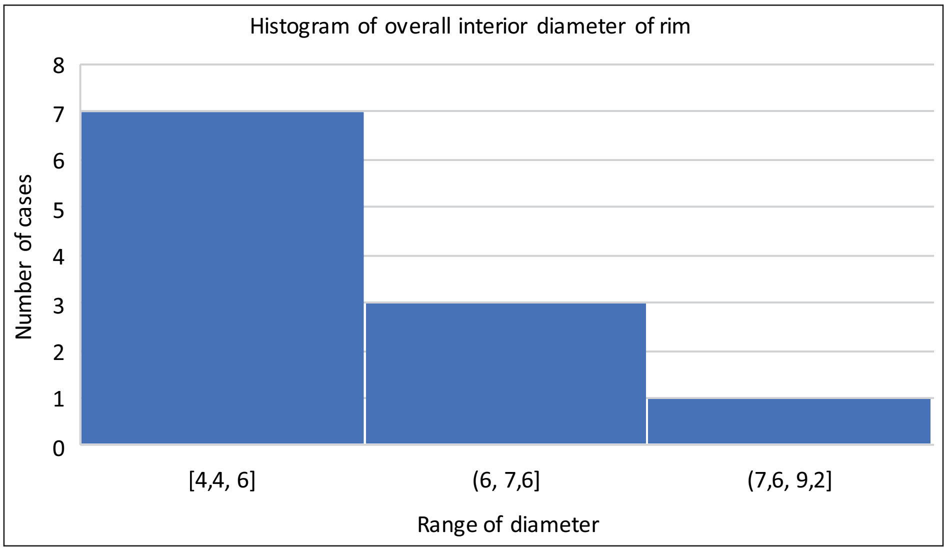
[55] On the coefficient of variation method and its use for assessing standardization in assemblages of artifacts: Eerkens – Bettinger 2001, 493–504. See also Costin 1991, 35; Rice 1991, 269; Roux 2003, 772; Masson – Rosenswig 2005, 357 f.; Kotsonas 2014a, 10. For a representative case study of this sort, see Blackman et al. 1993, 71–74 tab. 5.

[56] Blackman et al. 1993, 71; Roux 2003, 772. For variability and variation, see the approach taken by Kotsonas 2014b, 8 f. For the relation between variability and standardization, see also Eerkens – Bettinger 2001, 493.

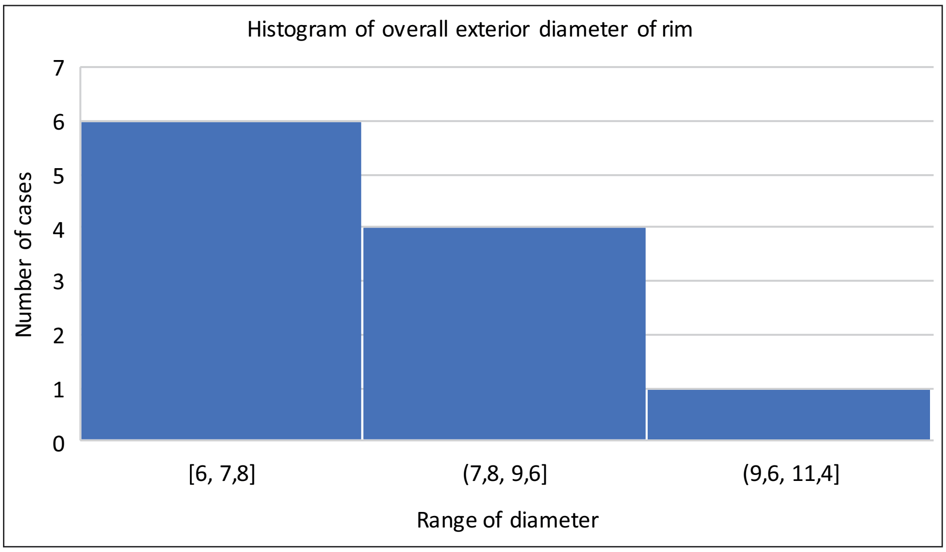
[57] Arnold – Nieves 1992, 106 f.; Eerkens – Bettinger 2001, 495; Roux 2003, 772; Masson – Rosenswig 2005, 357.

Measurement	n	Mean (Average)	SD	CV
Rim diameter (ext.)	11	7.59	1.15	15.23
Rim diameter (int.)	11	6.08	1.04	17
Rim thickness	13	1.23	0.2015	16.31
Maximum thickness	15	0.81	0.1642	20.27
Neck height	6	9.30	0.6132	6.59
Neck diameter	6	8.80	0.407	4.62
Handle width	8	3.65	0.40	10.95
Handle thickness	8	2.65	0.30	11.32

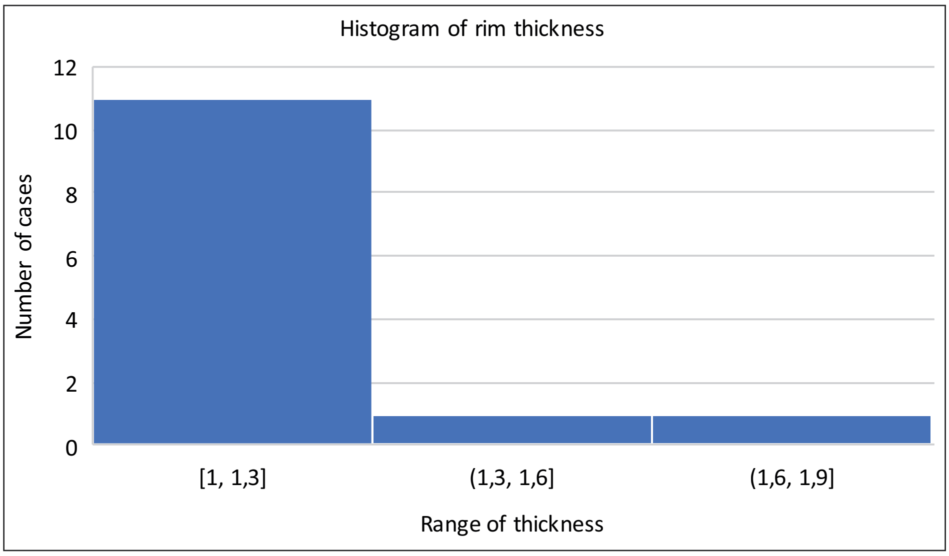
Table 1 Metric evidence for standardization using linear measurements of amphorae from Eleutherna (sector II) (n = total number of examples; SD = standard deviation; CV = coefficient of variation)



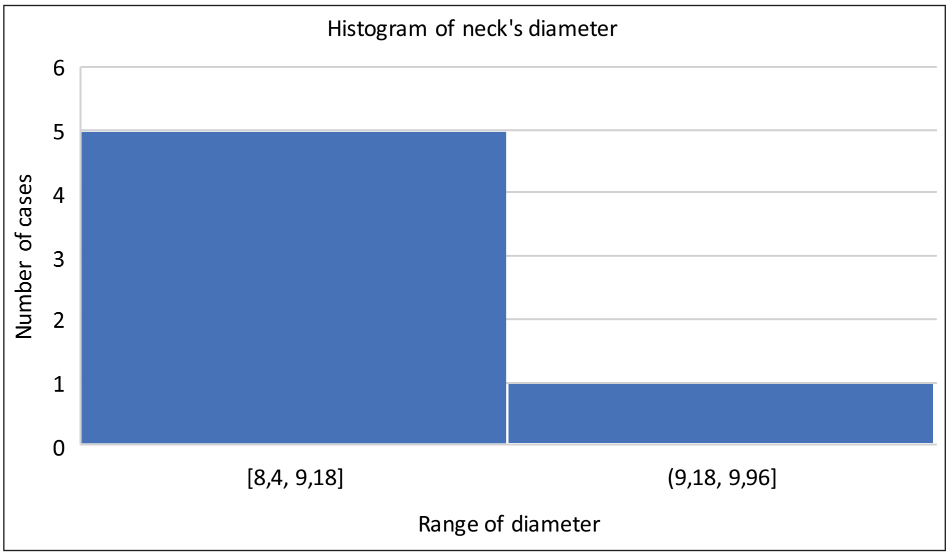
13 Histogram representing the overall interior rim diameters of the Eleutherna examples



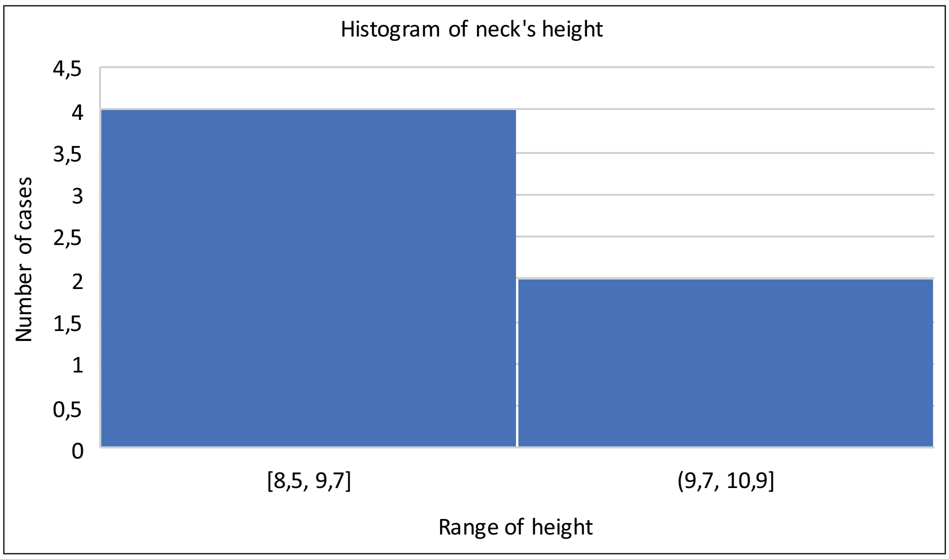
14 Histogram representing the overall exterior rim diameters of the Eleutherna examples



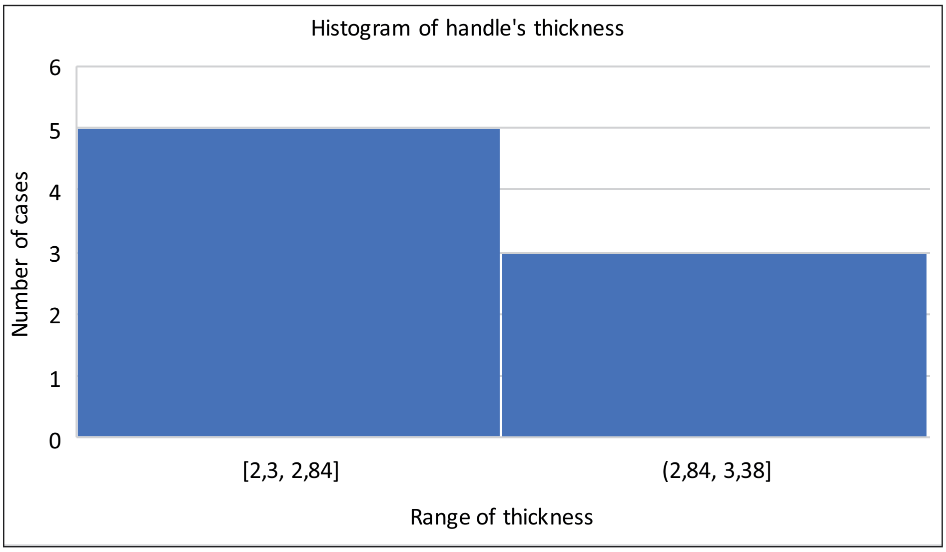
15 Histogram representing the overall rim thicknesses of the Eleutherna examples



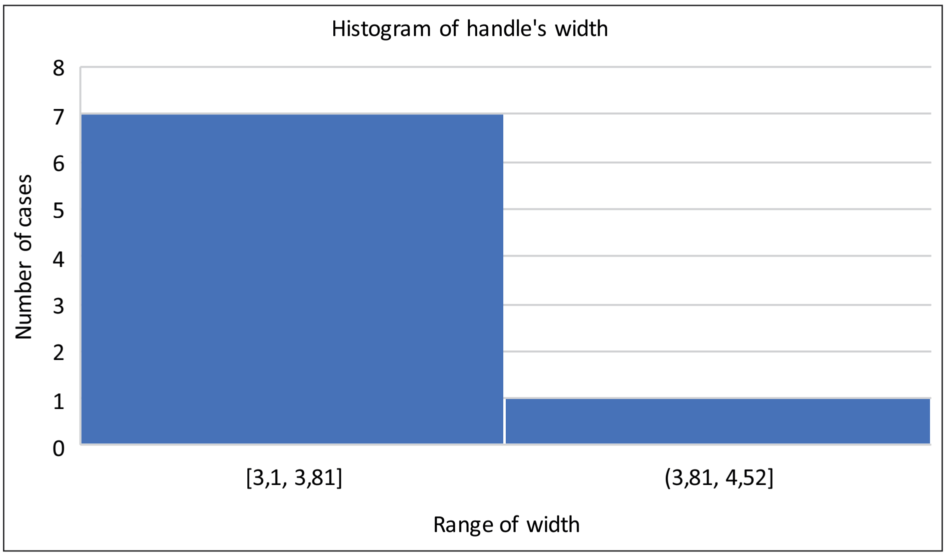
16 Histogram representing the overall neck diameters of the Eleutherna examples



17 Histogram representing the overall neck heights of the Eleutherna examples



18 Histogram representing the overall handle thicknesses of the Eleutherna examples



19 Histogram representing the overall handle widths of the Eleutherna examples

CV values for the recorded measurements of the Cretan amphorae range from below 10–17 % (tab. 1). As J. W. Eerkens and R. L. Bettinger have convincingly argued, a CV below 1.7 % suggests a very high degree of standardization while a value greater or equal to 57.7 % suggests high product differentiation and thus increased variation[58]. Although the values of the Cretan sample are not as low as the *minimum* represented by the 1.7 %, they clearly range between 4.6 % and 20 %. As table 1 demonstrates, given the nature of the sample, the rim diameter is the main measurement that could be calculated consistently, giving CV values of around 15.2 % (internal) and 17 % (external). According to V. Roux's work, while CV values below 3 % correspond to large-scale production, 3–6 % reflect moderate values and 6–9 % correspond to small or very small-scale production[59]. Other ethnographic evidence, such as the work of K. L. Kvamme et al.,

[58] Eerkens – Bettinger 2001, 493–502; 499 tab. 1 (with characteristic case studies that fall within these limits).
[59] See, in detail, Roux 2003, 775–780 fig. 8 in particular.

showed that pots produced by a community of less specialized potters (intended mainly for household use) present higher CV values[60]. Given that half of the eight recorded measurements are between 10 % and 15 %, but taking also into consideration that the CV value for neck diameter (for the limited number of examples that could be measured) is 4.62 % and the CV value for neck height is 6.59 %, the TRC12 products from Eleutherna have CV values that are not so high as to indicate increased variation, nor do they reflect a high degree of standardization[61]. They should therefore probably be seen as examples of a rather weakly standardized scheme resulting from a relatively small-scale production. Since the amphorae cannot be securely attributed to a single common production event – although they might belong to a common ›assemblage‹, the latter consists of different contexts – they may also reflect a relatively limited sequence of production spanning a period of few decades. This suggestion implies that although the manufacture of this specific type of amphora followed a general model, it was probably the result of a small-scale production over a long period[62]. This could help explain the specific CV values. It would be useful to test this suggestion by comparing the CV values on other categories of pots linked to the same local production since Roux showed that variations may exist along different categories of vessels and given that ethnographic evidence reveals that jars of larger dimensions exhibit lower levels of standardization compared to smaller-sized pots[63].

SOME SUGGESTIONS ON THE CRETAN TYPE'S STANDARDIZATION AND COMPARATIVE AEGEAN MATERIAL

TRC12 can be clearly distinguished from its counterparts and ›prototypes‹ – namely, examples from the Yassıada shipwreck, Samos, and Constantinople[64] – by its smaller dimensions. This seems to also be the case for the various globular Cretan forms, which reveal a clear differentiation in size and volume in comparison to the far larger LR2 amphora[65], which must have served as an inspiration for their manufacture. Although it is hypothesized that there is a range of distinct but closely grouped body sizes for globular amphorae Types I–IV from the Yassıada shipwreck, van Alfen's latest study of this material draws on data from the work of van Doorninck to isolate two main modules of linear dimensions for this type: the first, which comprises the majority of vessels, presents a significant clustering at 53–56 cm in height, with the highest concentration at 54–55 cm. This first group has the maximum clustering of body diameter around 41–45 cm, and especially around 42–43 cm. The second, which corresponds to Types II and III, shows a height ranging 43–45 cm and a maximum body diameter at 34–36 cm[66]. The interior rim diameter sits at 6.44–6.94 cm[67]. Van Doorninck has recently demonstrated using volume measurements that these Yassıada globular amphorae cluster into five weight capacity sizes with an interval of 6 pounds (at a pound value of 318.5 g), ranging from a smaller average of 33.166 liters to a larger of

60 Kvamme et al. 1996, 122 f. tab. 4.

61 Although it is a more distant parallel, one can note that ethnographic evidence from other cultures does seem to show that the height of the neck of water jars, for example, exhibits less variance in comparison with the dimensions of other parts of the vessel due to its particular significance in the way the vessel was used: see Arnold – Nieves 1992, 102.

62 For similar remarks deriving from the CV values of other ceramic assemblages: Kvamme et al. 1996, 122 f. tab. 4; Roux 2003, 780; Bikić 2017, 214 f.

63 Roux 2003, 775 f.

64 For related references, see n. 22. 23 and 50.

65 For this amphora and its main characteristics: Pieri 2005, 82–84. See also Ch. Diamanti, Chap. 11 this volume.

66 van Alfen 2015a, 21 fig. 2, 9; 22 fig. 2, 10; 23 fig. 2, 12; 24 fig. 2, 14; see also van Doorninck 1989, 247–252; for earlier general remarks on the dimensions of these jars: Bass 1982, 157. 159.

67 For additional details on the dimensions of the rims and the various types of amphorae: van Alfen 2015, 25. 29 fig. 2, 22. 23.

39.250 liters[68]. According to this research, the potters manifested a high degree of manufacturing control, as demonstrated by the precise dimensions of the jars, particularly their body measurements[69]. Van Alfen notes that these jars also seem to have standard-sized necks[70]. A comparison of the linear and volumetric evidence suggests that, although there is no clear capacity correlation between van Alfen's four main types and the amphorae recently studied by van Doorninck, even a small variance in body dimensions can lead to a different weight size[71]. Among the material from the Eupalinos tunnel on Samos, W. Hautumm had distinguished in the 1980s two main modules differentiated by dimensions and capacity[72].

A clarification must be made at this point: both assemblages, those from the Yassıada shipwreck and those from Samos, contain a variety of globular forms, most of which find exact parallels in one another. While an effort has been made to distinguish the main types in the first assemblage, no such clear differentiation has been attempted for the second. However, for the needs of this study, comparisons are only made with those published examples with which the Cretan type coincides best in terms of general form and decoration[73]. Thus, this comparison shows that vessels with the same characteristics can be separated into two main modules in terms of their dimensions but also and incontrovertibly in terms of their capacities: the first group comprises amphorae with a height of 55–60 cm, a maximum body diameter of 40–44 cm, and a capacity of 40–44 liters[74]. On the other hand, much smaller examples have a height not surpassing 46 cm, a maximum diameter of ca. 36 cm and a capacity of ca. 19–20 liters. These latter examples, of which amphora K1736 is the most characteristic, are considered by Hautumm to be »Halbgefäße« (i.e., half vessels)[75]. Comparing the linear dimensions of the two assemblages, we see clear analogies in the common occurrence of two main subsequent modules of globular amphorae, showing the success on the part of the various potters in achieving particular characteristics. A careful comparison of their linear measurements makes it clear that one can speak of two main modules, differing some 8–10 cm in height and maximum diameter. Although the Cretan examples from Eleutherna demonstrate the greatest consistency in formation of the rim, neck, and handles, and particularly in the slight ridge separating the neck from the shoulder with globular Type I at Yassıada, they reveal more common traits in their body form with Type III and in their decoration with Type II[76]. The differences in size between the Cretan form and those from the aforementioned assemblages lie not only in the linear dimensions of their height and maximum body diameter but also in the Cretan vessels' interior rim diameters, which are some 0.40–0.90 cm smaller on average than the Yassıada examples.

One could suggest that the local form adopts a combination of elements from other, well-circulated types while deviating from its prototypes and revealing a clear differentiation in terms of its smaller capacity. The Cretan amphorae from Eleutherna constitute a third and smaller module in addition to the two main modules analyzed above; they have yet to be better defined in light of additional and more complete examples. That smaller modules, in addition to the two larger mod-

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68 van Doorninck 2015a, 50–52 fig. 3, 4 (noting a 5-pound interval) and van Doorninck 2014, 25–27 (noting a 6-pound interval, the latter considered by the researcher as more appropriate; see also the postscript in van Doorninck 2015a, 52).

69 van Doorninck 2015a, 48. 49 tab. 3, 8. 51.

70 van Alfen 2015, 25. 26 fig. 2, 16.

71 For types I to IV, originally proposed by van Doorninck (van Doorninck 1989, 247–249), and their linear measurements: van Alfen 2015, 18–32.

72 Hautumm 1981, 23–30. 51–58. See also later Hautumm 2004, 210–213. 293–296.

73 This refers to the Samos amphorae nos. 6–9. 15. 18 (Hautumm 1981, 51–53. 183 f. 186 f.), respectively, nos. 1733–1736. 1741. 1743 (Hautumm 2004, 294–296).

74 Hautumm 1981, 51–53.

75 Hautumm 1981, 53. For these amphorae, see, in detail, Hautumm 2004, 212 f. no. 1329; 294 no. 1736 pl. 43, 1329; pl. 101, 1736.

76 For these four types (initially referred to as subtypes) within the general form of the globular amphora of the Yassıada shipwreck: van Doorninck 1989, 247–249; van Alfen 2015, 18–30 fig. 2, 1–4; 32 n. 7.

ules noted above, could occur and in some cases be produced within the same workshop is clear from the examples of the Mitello 1 Type from Otranto; there, in addition to the main and larger form, part of the production consisted of smaller versions of the amphora with a height of ca. 26.5 cm[77]. Further research is required into the role these smaller capacity modules and their place in the transport of foodstuffs and transactions. The general dimensions of other well-established productions of similar jars, like those produced in the workshops of Cos and Paros, seem to situate them alongside the amphorae from the Yassıada shipwreck and Samos[78]. The detailed publication of all the respective examples from known production centers, including a sophisticated range of measures (i.e., standard deviation, coefficient of variation) in addition to traditional measurements could help clarify the various dimensions – and possibly the different modules – that are characteristic of each production. Such work could help us both to assess standardization more effectively by comparing the values among different assemblages and to understand its implications regarding their production and circulation. This would furnish additional and necessary nuance to accompany the introductory references to the globular amphorae group that rely on only general measurements[79].

As shown by the series of MRC2a and b amphorae of the 4th and early 5th century, standardized amphorae were also produced earlier by local workshops on Crete[80]. Their detailed study reveals a clustering at around 52 cm in height, a rim diameter of 7.2–7.3 cm, and a neck height of 5.8–5.9 cm[81]. However, no effort has been made to bring to light late forms of local production that show some degree of standardization. It is here suggested, using the evidence from Eleutherna in the Mylopotamos region as an example, that the Cretan production of amphorae continued to feature a degree of standardization in later centuries too; products show standardization in some formal attributes – such as the shape and form of their handles, rim, and neck dimensions – but exhibit variation in others, such as small morphological details relating to the formation of the triangular rim. Given the period of the material and the CV values of 10–20 %, it can be suggested that the producers clearly tried to conform to a ›prototype‹, but there is some variability, and these variations could perhaps be seen as different production events. This suggests that the potters might not follow the same degree of standardization for all their products.

Uniform linear measurements were also potentially important for various uses beyond their role in trade activities and transportation[82]. For example, at a local level, they created vessels with an easily recognizable form and given capacity, which could have had, apart from their proper use as packaging containers, an additional domestic application. It has already been suggested that the numerous Cretan globular amphorae could have been used locally for a variety of such household uses[83]. Information provided by the interpretation of the amphora evidence from a large cistern at Eleutherna suggests that the amphorae were used to carry water from the cistern (as they were elsewhere and again in early modern Greece)[84]. Excavation inside the cistern mostly revealed body fragments of that amphora type, while evidence of handles, broken at or near the point where they join the neck and rim, are mostly found at a higher level, just outside the cistern. It is worth noting that the former CV values for the material from Eleutherna also include these amphorae from the cistern. These jars may of course be reused for this purpose, but in this context some of the variability in CV values may also simply reveal that potters followed different

77 Leo Imperiale 2004, 330 f. fig. 3, 1. 2.

78 For the dimensions of the products of Cos and Paros, see, respectively, Diamanti 2010, 86. 156; Diamanti 2016, 691.

79 For some examples: Leo Imperiale 2004, 331; Murialdo 2007, 18; Toniolo 2007, 101 (probably influenced by the general dimensions provided earlier on the Yassıada amphorae: Bass 1982, 157. 159).

80 For this type of amphora: Marangou-Lerat 1995, 73. 76; Portale – Romeo 2001, 276 f.; Yangaki 2005, 185–188.

81 Yangaki 2005, 186 pl. 9, 469; pl. 11, 4. 6–8.

82 Greene – Lawall 2015, 8.

83 Portale – Romeo 2001, 393; Yangaki 2005, 304.

84 See, in detail, Tsigonaki – Yangaki 2015, 439 f. figs. 12. 13 (with related examples from Eleutherna and information from other sites).

practices (and held to different levels of precision) when producing jars for different purposes: market-oriented containers versus general-purpose containers for household use[85]. Additional examples from other contexts should permit this hypothesis to be tested in the future in order to verify whether local products of the same form manufactured as packaging containers for external distribution and trade showed a greater degree of standardization than examples destined for various local domestic uses. This argument supports the notion of a complex relationship between standardization and specialization, a link suggested under the ›standardization hypothesis‹[86].

A clear distinction from earlier local production is that the newly standardized shape follows well-known and well-distributed examples, reproducing a form originating from other areas of the Aegean, such as the globular amphorae of the Yassıada shipwreck (Hayes Type 29)[87]. In earlier centuries, this standardization applied to local forms that were not imitations of types imported onto the island. To date, this is the only form of globular Cretan amphora of which many examples have been found at Eleutherna, while other globular forms occur only occasionally and are represented by a few examples[88]. In addition, it is the only globular form from the site that finds counterparts in amphorae circulating in the Aegean and other Mediterranean regions[89]. In contrast, other local globular forms like the TRC7 amphora (fig. 10), while very common in Gortyn, rarely occur in Eleutherna or other sites[90]; given its morphology and self-supporting concave base, it has been linked to domestic storage or even table use[91]. Other Cretan forms belonging to the globular/ovoid series of amphorae seem not to have so clearly followed a well-distributed globular ›prototype‹[92].

Unfortunately, the study of the globular/ovoid amphorae of Crete is still in its infancy given that the evidence from Cretan sites is limited and that data on the possible distribution of such types outside the island is lacking. S. Gallimore presented maps illustrating the distribution of earlier types of Cretan amphorae from the 4th through to the first half of the 7th century across the Mediterranean, following A. Marangou's evidence on the Roman period[93]. Although A. Sazanov drew attention to Cretan amphorae found at sites on the northern coast of the Black Sea from the second quarter of the 6th century up to 650–670, there is no data from the later part of the 7th century onward[94]. We therefore cannot include in our discussion an exploration of the possibility that this Cretan type could also have had an extraregional distribution like the earlier, more cylindrical types TRC2 and TRC4[95]. Nevertheless, this seems possible given the positive evidence for standardization in the case of production attributed to the Mylopotamos region and the current

[85] It should be noted that ethnographic evidence from Mexico shows that the difference in the market orientation of pottery products is reflected by differences in each group's variability: see Arnold – Nieves 1992, 109–112. In this case, though, each group comprised a different shape of vessel.

[86] For these views, see Kvamme et al. 1996, 125; Esposito – Zurbach 2014, 39 f.; Kotsonas 2014a, 3; Kotsonas 2014b, 12 f. (with related references); for the ›standardization hypothesis‹, see Rice 1991, 261; Kotsonas 2014a, 3; Blackman et al. 1993, 73–78.

[87] For details on this form, see above.

[88] For related examples, see Yangaki 2005, 193–197; Yangaki 2007, 768–771; and more recently: Tsigonaki – Yangaki 2015, 436–439.

[89] For related examples, see, Yangaki 2005, 217 n. 1245 (with references).

[90] For examples from Gortyn: Portale – Romeo 2001, 308 f. pl. 46 a–d fig. 148; Portale 2014, 479–481. 487 fig. 8; from Eleutherna: Yangaki 2005, 193 f.; Yangaki 2007, 770.

[91] Portale – Romeo 2001, 390. 393; Yangaki 2005, 303 f.; Yangaki 2007, 770; Fabrini – Perna 2009, 132; Portale 2010, 932; Portale 2014, 478. 480.

[92] A characteristic example is provided by one of the amphorae published from Pseira and probably attributed to a Cretan production on the island's southern coast: see Poulou-Papadimitriou – Nodarou 2014, 875. 881 fig. 5 a. b.

[93] Gallimore 2015, 288 fig. 10, 6; 313 fig. 11, 5. For additional evidence on the 5th cent., Reynolds 2002, fig. 21, 910; Reynolds – Pavlidis 2017, 658. 659 fig. 8, 4. For the distribution of Cretan amphorae during the Roman period: Marangou-Lerat 1995, pls. 41. 43. 45. 47. 49.

[94] Sazanov 2007, 807; Sazanov 2014, 404. 406 fig. 1, 7.

[95] For additional characteristics of these forms: Portale – Romeo 2001, 303–305 fig. 146 pl. 44 a–h; 52 a–k; 55 c–e; Yangaki 2005, 190 f. For their diffusion, see n. 93 f. On the suggestion, however, that some amphorae of globular form located in areas outside Crete are of Cretan provenance, see Gallimore 2016, 183.

lack of evidence for a high degree of standardization in other contemporaneous Cretan globular types. Examples sharing the same form found at the site of Panormo reveal that this type enjoyed a regional distribution throughout neighboring Cretan sites[96].

CONCLUDING REMARKS

The study of this particular form of widely distributed amphora reveals a degree of standardization during the transitional period of the 7th and early 8th century, a period when amphora types that were well known and distributed during earlier centuries were in decline. The Cretan case study here, while offering an interesting picture of standardization, raises some questions about the production of such globular jars. It would appear that some coordination existed within this production in the region during a certain period. However, given the previous analysis, the material from Eleutherna seems to represent a rather small scale of production. Despite remarkable similarities in the various examples and the previous observations regarding their morphological standardization, when this regional evidence is situated alongside vessels of this form from different areas, it reveals variation in both capacity and manufacturing details. Concrete evidence is still extremely limited for the production centers of the Cretan counterpart; it has not yet been possible to trace variations in the final products of geographically dispersed workshops on the island and thus to test if all workshops on the island followed the same ›prototype‹. The situation does not differ from that of the globular amphorae of this type from other regions given the generally limited information on specific production centers and their distribution and the need to study the capacities of many more examples in greater detail[97]. Looking outside Crete, relatively comparable amphorae have been published from various sites in the Aegean and the eastern Mediterranean besides those from Yassıada or the islands of Samos, Cos, and Paros, which include numerous examples of amphorae with similar morphology though of different modules[98]. Although no studies have yet offered details on the specific distribution of amphorae of known provenance, it is clear from the general circulation of this form that it was for regional and also extraregional transport. As a container, it stands apart from other globular transport vessels, which seem to have been mostly limited to local or intraregional distribution. Hopefully the present study, by comparing the existing evidence from various assemblages and adding information on this Cretan globular amphora, demonstrates the complexity of the type's production and the need for more comprehensive study of its numerous examples.

In addition to standardization centered on production – the homogeneity and regularity of the production process reflected in the final products, like these Cretan globular amphorae – a second notion of standardization was recently proposed by A. Esposito and J. Zurbach, which refers to a reduction in the number of vessel types used for a purpose, here as packaging containers[99]. Indeed, when one first approaches the large group of ›globular amphorae‹, one can appreciate the variation within existing amphora forms. However, when one examines the evidence more closely, it becomes clear – based on the analysis above – that within this general picture, globular amphorae,

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96 Fraidaki 2019, 7 f. fig. 5 (particularly the globular in form amphora at the bottom of the page). I would like to thank Mrs Fraidaki for providing me with the necessary information at a time when the material was still unpublished.

97 For these issues, see Pieri 2005, 89. In the case of the Aegean, for example, the productions on the islands of Cos and Paros are known so far (Cos: Diamanti 2010, 81–84. 114. 155 f.; Poulou-Papadimitriou – Didioumi 2010, 743 (Type I); Diamanti 2012, 3 fig. 2; fig. 5 a. b; Paros: Diamanti 2016, 692 fig. 2 c. d).

98 See above, n. 27–33.

99 Esposito – Zurbach 2014, 41. In order to discuss the two notions of standardization, A. Esposito and J. Zurbach engaged with case studies on Mycenean pottery from Anatolia and southern Italy: see Esposito – Zurbach 2014, 39–45. The material discussed here fits well within the general framework of standardization as a restricted number of forms within one functional category, in this case transport jars. On the view of these researchers, see also Kotsonas 2014a, 2 f.

such as those from the Yassıada shipwreck, do indicate convergence, with the type manifesting considerable regional production and distribution.

It has been suggested that under the military office of the *Quaestura Iustiniana Exercitus*, a state control mechanism for the provision of commodities from the southern provinces to the northern regions, a directed distribution of LRA 2 and other amphorae of this general shape seems to have been in place during the 6th century and possibly during part of the 7th century as well[100]. In addition, during the 7th and mostly the 8th century, there was a gradual decline in the production and circulation of the numerous earlier amphora varieties. Considering these two developments, the workshops which started to produce imitations of this type in several regions, including on Crete, adopted this form to circulate their products between areas, making this originally Aegean product the ›globular amphora‹ par excellence[101]. The linear measurements of the globular amphorae suggest coordination in the manufacture of this well-distributed type. In fact, van Alfen has suggested that Types I and II of the globular jars from the Yassıada wreck »are representative of a system of precisely formed, standardized capacities«[102]. The need to communicate certain information – to reference a widely circulating and standardized form with specific sizes – must have been an important factor behind the introduction of this container into Crete's local production alongside other amphora forms. The particular amphora from Eleutherna dates somewhat later than ›prototypes‹, such as the Yassıada jars and others. Perhaps the form's specific connotations promoted and facilitated the spread of its production. Let us not forget that during the 7th century the Byzantine Empire suffered important territorial losses. Within this transitional context came the regional adoption of this amphora production. This may have been undertaken to fill the gap, at least partially, left by the previous – and much more diverse – earlier forms derived primarily from areas that were no longer included in the empire. But among the other factors that may have played a role in this adoption was the identification in this form of a direct succession to the earlier long production of Aegean LRA 2 and the official state mechanism that controlled the distribution and consumption of certain globular amphorae and their contents[103]; that is, the form referenced a packaging container that was widely circulated and used for official Byzantine purposes. It would be useful to shed light on the specific modules that characterized this form since this could further reveal its standardization. Based on the previous analysis, the module of the amphorae from Eleutherna is the smallest of the three main modules identified thus far.

The meticulous study of this form of amphora from other sites of production and consumption mentioned above will contribute considerably to our understanding of the conditions that led to the dissemination of such practices, offering a missing link between earlier and later amphora forms. Characteristic of the latter is the ›YK12‹ or ›Bozburun 1‹ type of cylindrical amphora of the 9th century[104], which has come to light in both the YK12 shipwreck at Yenikapı site, the Theodosian Harbor of Constantinople and the Bozburun shipwreck off southwest Turkey, and which

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100 Steckner 1989, 65; van Alfen 1996, 211 f.; Karagiorgou 2001, 145. 154 f.; Demesticha 2002, 119; Moniaros 2009, 145–158; Diamanti 2010, 166–168; Poulou-Papadimitriou – Didioumi 2010, 744; van Doorninck 2015b, 209 f.; Diamanti 2016, 691. 693. See also, however, n. 51.

101 For the use of the term ›Byzantine Globular Amphorae‹ (BGA) to designate the various types of globular amphorae produced from the mid-7th to the 9th century in various regions of the eastern Mediterranean (and consequently the term ›Byzantine Cretan Amphorae‹ [BCA] for the Cretan amphorae produced within the same period), see Poulou-Papadimitriou 2001, 245–247; Poulou-Papadimitriou 2014, 138–140; Poulou-Papadimitriou – Nodarou 2014, 874; Poulou-Papadimitriou 2011, 404 f., respectively.

102 van Alfen 2015, 30.

103 For these factors, among which a change in the ship's size and tonnage is also included, see, indicatively, Gurt i Esparraguera 2007, 847; Poulou-Papadimitriou 2014, 140; Poulou-Papadimitriou – Nodarou 2014, 874; van Alfen 2015, 30–32. For the ship's size and tonnage relations, see recently Kampbell 2015, 98 f.; Ginalis 2017, 201 f. pl. 1.

104 For the examples from the Yenikapı (YK12), see Denker et al. 2013, 204 no. 237 (A. Denker – T. Akbaytogan); for the amphora from Bozburun, see Hocker 1995, 12–14 fig. 4; Hocker 1998, fig. 3.

was recently presented in more detail by J. Vroom[105]. Judging from the published examples, variation seems to have occurred in details of the morphology, possibly also as a result of different production centers, but they still seem to manifest a shared primary form.

Until recently, the concept of standardization has been tackled in various studies and particularly in relation to antiquity[106], yet it has been largely neglected in the archaeological literature of the Late Antique and Byzantine periods. However, the present study and questions raised above make it clear that the subject offers considerable opportunities for interdisciplinary research with the aim of generating additional information on the material culture of the early medieval Mediterranean.

BIBLIOGRAPHY

Arnold – Nieves 1992 D. E. Arnold – A. L. Nieves, Factors Affecting Ceramic Standardization, in: G. J. Bey, III – C. A. Pool, Ceramic Production and Distribution: An Integrated Approach (Boulder, CO 1992).

Arthur 1993 P. Arthur, Early Medieval Amphorae, the Duchy of Naples and the Food Supply of Rome, BSR 61, 1993, 231–244.

Barello – Cardosa 1991 F. Barello – M. Cardosa, Casignana Palazzi, MEFRA 103, 2, 1991, 669–687.

Bass 1982 G. F. Bass, The Pottery, in: G. F. Bass – F. H. van Doorninck, Jr. (eds.), Yassi Ada 1. A Seventh-Century Byzantine Shipwreck (Texas 1982) 155–188.

Belli-Pasqua – La Torre 1994/1995 R. Belli-Pasqua – G. F. La Torre, La Strada Ovest del Pretorio di Gortina, ASAtene 72/73, 1994/1995, 135–224.

Bikić 2017 V. Bikić, Ottoman Glazed Pottery Standardisation: The Belgrade Fortress Evidence for Production Trends, in: S. Bocharov – V. François – A. Sitdikov (eds.), Glazed Pottery of the Mediterranean and the Black Sea Region, 10th–18th Centuries, II (Kazan 2017) 207–216.

Blackman et al. 1993 M. J. Blackman – G. J. Stein – P. B. Vandiver, The Standardization Hypothesis and Ceramic Mass Production: Technological, Compositional, and Metric Indexes of Craft Specialization at Tell Leilan, Syria, American Antiquity 58, 1, 1993, 60–80.

Bonifay 2004 M. Bonifay, Étude sur la céramique romaine tardive d'Afrique, BARIntSer 1301 (Oxford 2004).

Carlson et al. 2015 D. N. Carlson – J. Leidwanger – S. M. Kampbell (eds.), Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey (College Station 2015).

Costin 1991 C. L. Costin, Craft specialization: Issues in defining, documenting, and explaining the organization of production, in: M. B. Schiffer (ed.), Archaeological Method and Theory III (Tuscon 1991) 1–56.

Demesticha 2002 S. Demesticha, Οι σφαιρικοί αμφορείς της ύστερης ρωμαϊκής περιόδου (4ος–7ος αι. μ.Χ.), Enalia 6, 2002, 115–121.

Demesticha 2010 S. Demesticha, Το φορτίο του Ναυαγίου 7 στον Παγασητικό κόλπο. Πρώτη ερμηνευτική προσέγγιση, in: D. Papanikola-Bakirtzi – D. Kousoulakou (eds.), Κεραμική της ύστερης αρχαιότητας από τον ελλαδικό χώρο (3ος–7ος αι. μ.Χ.). Επιστημονική Συνάντηση, Θεσσαλονίκη, 12–16 Νοεμβρίου 2006 I, Δημοσιεύματα Αρχαιολογικού Ινστιτούτου Μακεδονικών και Θρακικών Σπουδών 8 (Athens 2010) 131–142.

Denker et al. 2013 A. Denker – F. Demirkök – G. Kongaz – M. Kiraz – Ö. Korkmaz Kömürcü – T. Akbaytogan, YK12, in: Stories from the hidden harbor: The Shipwrecks of Yenikapı, Istanbul Archaeological Museums 2013 (Istanbul 2013) 197–209.

[105] Vroom 2017a, 292–296; Vroom 2017b, 183 f.

[106] Rice 1987, 201–204. For representative examples, see, selectively, the studies presented in Kotsonas 2014c; Kotsonas 2014a, 1–5 (with additional, earlier bibliography).

Des Gagniers – Tinh 1985 J. Des Gagniers – T. T. Tinh, Soloi, dix campagnes de fouilles (1964–1974), I. Introduction historique, La Basilique (Sainte-Foy 1985).

Diamanti 2010 Ch. Diamanti, Εντόπια παραγωγή και εισαγωγή αμφορέων στην Αλάσαρνα της Κω ($5^{ος}$–$7^{ος}$ αι.). Συμβολή στην Έρευνα της Παραγωγής και Διακίνησης των Υστερορωμαϊκών/Πρωτοβυζαντινών Αμφορέων της Ανατολικής Μεσογείου, Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών, Φιλοσοφική Σχολή. Βιβλιοθήκη Σοφίας Ν. Σαριπόλου 115 (Athens 2010).

Diamanti 2012 Ch. Diamanti, Byzantine Emperors on Stamped Late Romane/Early Byzantine Amphoras, ReiCretActa 42, 2012, 1–5.

Diamanti 2016 Ch. Diamanti, The Late Roman Amphora Workshops of Paros island in the Aegean Sea. Recent Results, ReiCretActa 42, 2016, 691–697.

Du Plat Taylor – Megaw 1981 J. Du Plat Taylor – A. H. S. Megaw, Excavations at Ayios Philon, the Ancient Karpasia, part II. The Early Christian Building, RDAC 1981, 209–250.

Eerkens – Bettinger 2001 J. W. Eerkens – R. L. Bettinger, Techniques for Assessing Standardization in Artifact Assemblages: Can We Scale Material Variability?, American Antiquity 66, 2001, 493–504.

Engels et al. 2009 L. Engels – L. Bavay – A. Tsingarida, Calculating vessel capacities: A new web-based solution, in: A. Tsingarida (ed.), Shapes and Uses of Greek Vases (7^{th}–4^{th} centuries B.C.), Proceedings of the Symposium held at the Université libre de Bruxelles 27–29 April 2006 (Bruxelles 2009) 129–133.

Esposito – Zurbach 2014 A. Esposito – J. Zurbach, Technological standardization and cultural contact: some methodological considerations and two case studies, in: A. Kotsonas (ed.), Understanding standardization and variation in Mediterranean ceramics. Mid 2^{nd} to late 1^{st} Millennium BC, BABesch Suppl. 25 (Leuven 2014) 39–47.

Fabrini – Perna 2009 G. M. Fabrini – R. Perna, Lo scavo dell'Edificio Sud e delle Case bizantine a Gortina di Creta, in: G. Bejor – E. Panero (eds.), La ceramica di Gortina (Creta), Atti del Convegno, Milano 17 giugno 2009, Lanx. Rivista della Scuola di Specializzazione in Archeologia dell'Università degli Studi di Milano 4, 2009, 121–138.

Finkelstein et al. 2011 I. Finkelstein – E. Zapassky – Y. Gadot – D. M. Master – L. E. Stager – I. Benenson, Phoenician ›Torpedo‹ Amphoras and Egypt: Standardization of Volume based on Linear Dimensions, AegLev 21, 2011, 249–259.

Fraidaki 2019 A. Fraidaki, Σωστική ανασκαφική έρευνα κτηρίου της πρώτης βυζαντινής περιόδου στο Πάνορμο Ρεθύμνου: Παρουσίαση της κεραμικής, in: Proceedings of the 12^{th} International Congress of Cretan Studies. Heraklion, 21–25. 9. 2016 (Herakleion 2019) 1–13.

Francis et al. 2023 J. Francis – E. Nodarou – J. Moody, The Fabrics of Roman to Early Byzantine Cretan Amphorae from the Sphakia Survey, in: J. E. Francis – M. J. Courtis (eds.), Change and Transition on Crete: Interpreting the Evidence from the Hellenistic through to the Early Byzantine Period. Papers Presented in Honour of G. W. M. Harrison (Oxford 2023) 147–167.

Gallimore 2015 S. C. Gallimore, An Island Economy. Hellenistic and Roman Pottery from Hierapytna, Crete, LANG Classical Stud-ies 18 (New York 2015).

Gallimore 2016 S. Gallimore, Crete's Economic Transformation in the Late Roman Empire, in: J. A. Francis – A. Kouremenos (eds.), Roman Crete. New Pespectives (Oxford 2016) 175–188.

Gallimore 2018 S. Gallimore, The Relationship Between Agricultural Production and Amphora Manufacture on Roman Crete, JRA 31, 2018, 373–386.

Gempeler 1992 R. D. Gempeler, Elephantine 10. Die Keramik römischer bis früharabischer Zeit, Archäologische Veröffentlichungen 43 (Mainz 1992).

Ginalis 2017 A. Ginalis, The Impact of Byzantium's Political and Economic History on Mediterranean Seafaring, in: H. Frielinghaus – T. Schmidts – V. Tsamakda (eds.), Schiffe und ihr Kontext. Darstellungen, Modelle, Bestandteile – von der Bronzezeit bis zum Ende des Byzantinischen Reiches, Byzanz zwischen Orient und Okzident 5 (Mainz 2017) 199–208.

Greene – Lawall 2015	E. S. Greene – M. L. Lawall, Amphora Standardization and Economic Activity, in: Carlson et al. 2015, 3–16.
Guarino et al. 1988	V. Guarino – D. Mauro – P. Peduto, Un tentantivo di recupero di una stratigrafia e materiali vari da collezione: il caso del complesso ecclesiastico di S. Restituta a Lacco Ameno di Ischia, AMediev 15, 1988, 439–469.
Gurt i Esparraguera 2007	J. M. Gurt i Esparraguera, Bilan: de Barcelone à Aix, in: M. Bonifay – J.-Ch. Tréglia (eds.), LRCW 2. Late Roman coarse wares, cooking wares and amphorae in the Mediterranean. Archaeology and Archaeometry 2, BARIntSer 1662 (Oxford 2007) 845–848.
Hautumm 1981	W. Hautumm, Studien zu Amphoren des spätrömischen und frühbyzantinischen Zeit (Bonn 1981).
Hautumm 2004	W. Hautumm, XVII. Die Keramik aus dem Tunnel des Eupalinos auf Samos sowie aus zwei benachbarten Zisternen, in: U. Jantzen (ed.), Die Wasserleitung des Eupalinos. Die Funde, Samos 20 (Bonn 2004) 198–345.
Hayes 1976	J. W. Hayes, Pottery: Stratified Groups and Typology, in: J. H. Humphrey (ed.), Excavations at Carthage 1975 Conducted by the University of Michigan 1 (Tunisia 1976) 47–123.
Hayes 1978	J. W. Hayes, Pottery Report 1976, in: J. H. Humphrey (ed.), Excavations at Carthage 1976, Conducted by the University of Michigan 4 (Ann Arbor, MI 1978) 23–98.
Hayes 1992	J. W. Hayes, Excavations at Saraçhane in Istanbul 2, The Pottery (Princeton, NJ 1992).
Hayes 2001	J. W. Hayes, Early Christian Pottery from Knossos: the 1978–1981 Finds from the Knossos Medical Faculty Site, BSA 96, 2001, 431–454.
Hocker 1995	F. M. Hocker, A Ninth-century Shipwreck near Bozburun, Turkey, InstNautAQ 22, 1, 1995, 12–14.
Hocker 1998	F. M. Hocker, The Byzantine Shipwreck at Bozburun, Turkey: the 1997 Field Season, InstNautAQ 25, 2, 1998, 12–17.
Hüttig 1999	M. Hüttig, Methoden der Volumenbestimmung für antike Gefäße am Beispiel griechischer Transportamphoren, AM 114, 1999, 317–324.
Kampbell 2015	S. M. Kampbell, Reconstructing the Pantano Longarini Ship, in: Carlson et al. 2015, 91–101.
Karagiorgou 2001	O. Karagiorgou, LR 2: a Container for the Military annona on the Danubian Border?, in: S. Kingsley – M. Decker (eds.), Economy and Exchange in the East Mediterranean during Late Antiquity. Proceedings of a Conference at Somerville College, Oxford, 29th May 1999 (Oxford 2001) 129–166.
Kotsonas 2014a	A. Kotsonas, Introduction: why standardization and variation?, in: Kotsonas 2014c, 1–5.
Kotsonas 2014b	A. Kotsonas, Standardization, variation, and the study of ceramics in the Mediterranean and beyond, in: Kotsonas 2014c, 7–23.
Kotsonas 2014c	A. Kotsonas (ed.), Understanding standardization and variation in Mediterranean ceramics. Mid 2nd to late 1st Millenium BC (Leuven 2014).
Kvamme et al. 1996	K. L. Kvamme – M. T. Stark – W. A. Longacre, Alternative Procedures for Assessing Standardization in Ceramic Assemblages, American Antiquity 61, 1996, 116–126.
Lako 1981	K. Lako, Fouilles archéologiques 1971–1976 dans la cité de Butrint, Iliria 1, 1981, 93–154.
Lebole di Gangi 1991	M. C. Lebole di Gangi, Saggi nell'abitato altomedievale di Paleapoli, MEFRA 103, 2, 1991, 575–598.
Leo Imperiale 2004	M. Leo Imperiale, Otranto, cantiere Mitello: un centro produttivo nel Mediterraneo bizantino. Note attorno ad alcune forme ceramiche di fabbricazione locale, in: S. Patitucci-Uggeri (ed.), La ceramica altomedievale in Italia. Atti del V Congresso di Archeologia Medievale, Roma, CNR, 26–27 Novembre 2001, Quaderni di archeologia medieval 6 (Florence 2004) 327–342.
Mannino 1979	G. Mannino, Ustica. Risultati di esplorazioni archeologiche, SicA 12, 1979, 7–40.

Marangou-Lerat 1995 A. Marangou-Lerat, Le vin et les amphores de Crète de l'époque classique à l'époque impériale, Études crétoises 30 (Paris 1995).

Masson – Rosenswig 2005 M. A. Masson – R. M. Rosenswig, Production characteristics of Postclassic Maya pottery from Caye Coco, Northern Belize, Latin American Antiquity 16, 2005, 355–384.

Mazzocchin 2019 S. Mazzocchin, I contenitori da trasporto, in: J. Bonetto – D. Francisci – S. Mazzocchin et al., Gortina 9, 2. Il Teatro del Pythion. Scavi e Ricerche 2001–2013, MSAtene 28 (Athens 2019) 633–660.

Megaw 1971 A. H. S. Megaw, Excavations at Saranda Kolones, Paphos. Preliminary Report on the 1966–67 and 1970–71 Seasons, RDAC, 1971, 117–145.

Menchelli 2010 S. Menchelli – S. Santoro – M. Pasquinucci – G. Guiducci (eds.), LRCW 3. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. Comparison between Western and Eastern Mediterranean, BARIntSer 2185 (Oxford 2010).

Moniaros 2009 X. Moniaros, Η μεταφορά της annona militaris στο πλαίσιο της quaestura exercitus, in: A. E. Goutzioukostas – X. M. Moniaros (eds.), Η περιφερειακή διοικητική αναδιοργάνωση της Βυζαντινής αυτοκρατορίας από τον Ιουστινιανό Α΄ (527–565): Η περίπτωση της Quaestura Iustiniana Exercitus (Thessaloniki 2009) 145–158.

Murialdo 2001 G. Murialdo, Le anfore da trasporto, in: T. Mannoni – G. Murialdo (eds.), S. Antonino: un insediamento fortificato nella Liguria Bizantina (Bordighera 2001) 255–296.

Murialdo 2007 G. Murialdo, Alto-adriatico e alto-tirreno nel mondo mediterraneo: due mari a confronto tra VI e X secolo, in: S. Gelichi – C. Negrelli (eds.), La circolazione delle ceramiche nell'Adriatico tra tarda antichità e altomedioevo. III incontro di studio CER.AM.IS., Documenti di archeologia 43 (Mantua 2007) 9–29.

Negrelli 2007 C. Negrelli, Vasellame e contenitori da trasporto tra tarda antichità ed altomedioevo: l'Emilia Romagna e l'area medio-adriatica, in: S. Gelichi – C. Negrelli (eds.), La circolazione delle ceramiche nell'Adriatico tra tarda antichità e altomedioevo. III incontro di studio CER.AM.IS., Documenti di archeologia 43 (Mantova 2007) 297–330.

Papavassiliou et al. 2014 E. Papavassiliou – K. Sarantidis – E. Papanikolaou, A Ceramic Workshop of the Early Byzantine Period on the Island of Lipsi in the Dodecanese (Greece): A Preliminary Approach, in: Poulou-Papadimitriou et al. 2014, II 159–168.

Petrone et al. 1994 D. Petrone – E. Siena – D. Troiano – V. Verrocchio, Una fornace di età bizantina a Castellana di Pianella, AMediev 21, 1994, 269–286.

Pieri 2005 D. Pieri, Le commerce du vin oriental à l'époque byzantine (V[e]–VII[e] siècles). Le témoignage des amphores en Gaule, Institut Français du Proche-Orient, Bibliothèque Archéologique et Historique 174 (Beyrouth 2005).

Portale 2010 E. Ch. Portale, Nuovi dati sulla circolazione anforica a Gortina, in: Menchelli et al. 2010, II 931–939.

Portale 2011 E. Ch. Portale, Contenitori da trasporto, in: Antonino Di Vita – M. A. Rizzo (eds.), Gortina Agorà. Scavi 1996–1997, Studi di archeologia cretese 9 (Padua 2011) 123–182.

Portale 2014 E. C. Portale, The sunset of Gortyn: amphorae in the 7[th]–8[th] centuries AD, in: Poulou-Papadimitriou et al. 2014, II 477–489.

Portale – Romeo 2001 E. Ch. Portale – I. Romeo, Contenitori da trasporto, in: A. Di Vita (ed.), Gortina 5, 3. Lo scavo del Pretorio (1989–1995), I Materiali, MSAtene 12 (Padua 2001) 260–410.

Poulou 2017 N. Poulou, Transport Amphoras and Trade in the Aegean from the 7th to the 9th Century AD: Containers for Wine or Olive Oil?, Byzantina 35, 2017 [2018] 195–216.

Poulou – Leontsini 2022 N. Poulou – M. Leontsini, Δίκτυα, συνδετικότητα και υποδομές ανεφοδιασμού στο Αιγαίο και το Ιόνιο πέλαγος (7ος–9ος αιώνας), in: N. Poulou (ed.), Δίκτυα και Επικοινωνία στο Βυζάντιο (Thessaloniki 2022) 73–135.

Poulou-Papadimitriou 1995 N. Poulou-Papadimitriou, Le monastère byzantin à Pseira-Crète: la céramique, in: Akten des XII Internationalen Kongresses für Christliche Archäologie, Bonn 22–28 September 1991, Teil 2, JbAC 202, 1995, 1119–1131.

Poulou-Papadimitriou 2001 — N. Poulou-Papadimitriou, Βυζαντινή κεραμική από τον ελληνικό νησιωτικό χώρο και από την Πελοπόννησο (7ος–9ος αι.): μία πρώτη προσέγγιση, in: E. Kountoura-Galaki (ed.), Οι σκοτεινοί αιώνες του Βυζαντίου (7ος–9ος αι.) (Athens 2001) 231–266.

Poulou-Papadimitriou 2011 — N. Poulou-Papadimitriou, Τεκμήρια υλικού πολιτισμού στη βυζαντινή Κρήτη: από τον 7ο έως το τέλος του 12ου αιώνα, in: E. G. Kapsomenos – M. Andreadaki-Vlazaki – M. Andrianakis (eds.), Πεπραγμένα του Ι΄ Διεθνούς Κρητολογικού Συνεδρίου (Χανιά, 1–8 Οκτωβρίου 2006), Α, Πανηγυρικές Συνεδρίες - Ολομέλειες - Στρογγυλές Τράπεζες - Οι Διοργανωτές και το Πρόγραμμα του Συνεδρίου (Chania 2011) 381–447.

Poulou-Papadimitriou 2014 — N. Poulou-Papadimitriou, Θαλάσσιοι δρόμοι στο Αιγαίο κατά την πρωτοβυζαντινή περίοδο: η μαρτυρία της κεραμικής, in: N. Zarras – M. I. Stefanakis (eds.), Αρχαιολογία και Τέχνη στα Δωδεκάνησα κατά την Ύστερη Αρχαιότητα. Πρακτικά ημερίδας στη μνήμη του Ηλία Κόλλια, Ρόδος 19 Νοεμβρίου 2011, Ευλιμένη. Σειρά Αυτοτελών Εκδόσεων 2 (Rethymnon 2014) 127–152.

Poulou-Papadimitriou – Didioumi 2010 — N. Poulou-Papadimitriou – S. Didioumi, Nouvelles données sur la production de l'atelier céramique protobyzantin à Kardamaina (Cos - Grèce), in: Menchelli et al. 2010, I 741–749.

Poulou-Papadimitriou – Nodarou 2014 — N. Poulou-Papadimitriou – E. Nodarou, Transport Vessels and Maritime Routes in the Aegean from the 5th to the 9th c. AD. Preliminary Results of the EU funded »Pythagoras II« Project: The Cretan Case Study, in: Poulou-Papadimitriou et al. 2014, II 873–883.

Poulou-Papadimitriou et al. 2014 — N. Poulou-Papadimitriou – E. Nodarou – V. Kilikoglou (eds.), LRCW 4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry. The Mediterranean: A Market without Frontiers, BARIntSer 2616 (Oxford 2014).

Preece 2000 — C. Preece, Marsa-el-Brega: A Fatal Port of Call. Evidence for Shipwreck, Anchorage and Trade in Antiquity in the Gulf of Sirte, LibSt 31, 2000, 29–57.

Radina 1984 — F. Radina, Ricognizioni e saggi di scavo in via Camillo Rosalba-Bari, AMediev 11, 1984, 339–351.

Reynolds 2002 — P. Reynolds, The Pottery, in: W. Bowden – R. Hodges – K. Lako (eds.), Roman and Late-antique Butrint: Excavations and Survey 2000–2001, JRA 15, 2002, 199–229.

Reynolds – Pavlidis 2017 — P. Reynolds – E. Pavlidis, An early 5th AD pottery deposit from a cloaca cleaning shaft of the cardo next to Basilica A, Nicopolis, Greece, in: Σπείρα. Επιστημονική συνάντηση προς τιμήν της Αγγέλικας Ντούζουγλη και του Κωνσταντίνου Ζάχου (Athens 2017) 651–666.

Rice 1987 — P. M. Rice, Pottery Analysis. A Sourcebook (Chicago 1987).

Rice 1991 — P. M. Rice, Specialization, standardization, and diversity: A retrospective, in: R. Bishop – F. W. Lange (eds.), The ceramic legacy of Anna O. Shepard (Colorado 1991) 257–279.

Ricci 1998 — M. Ricci, La ceramica commune dal contesto di VII secolo della Crypta Balbi, in: L. Saguì (ed.), Ceramica in Italia: VI–VII secolo. Atti del Convegno in onore di John W. Hayes. Roma, 11–13 maggio 1995 (Florence 1998) 351–382.

Riley 1979 — J. A. Riley, The Coarse Pottery from Berenice, in: J. A. Lloyd (ed.), Excavations at Sidi Khrebish Benghazi (Berenice), II, LibyaA Suppl. 5, 2 (Tripoli 1979) 91–467.

Riley 1981 — J. A. Riley, The Pottery from the Cisterns 1977.1, 1977.2 and 1977.3, in: J. H. Humphrey (ed.), Excavations at Carthage Conducted by the University of Michigan 6 (Ann Arbor, MI 1981) 85–124.

Roux 2003 — V. Roux, Ceramic Standardization and Intensity of Production: Quantifying Degrees of Specialization, American Antiquity 68.4, 2003, 768–782.

Saguì 2001 — L. Saguì, La circolazione delle merci: il deposito della fine del VII secolo nell'esedra della Crypta Balbi, in: M. S. Arena – P. Delogu – L. Paroli – M. Ricci – L. Saguì – L. Vendittelli (eds.), Roma. Dall'antichità al medioevo. Archeologia e Storia. Nel Museo Nazionale Romano Crypta Balbi (Milan 2001) 266–330.

Saguì – Ricci – Romei 1997 L. Saguì – M. Ricci – D. Romei, Nuovi dati ceramologici per la storia economica di Roma tra VII e VIII secolo, in: G. Démians d'Archimbaud (ed.), La céramique médiévale en Méditerranée. Actes du VIe congrès de l'AIECM2, Aix-en-Provence (13–18 novembre 1995) (Aix-en-Provence 1997) 35–48.

Sazanov 2007 A. Sazanov, Les amphores orientales d'époque protobyzantine au Nord de la Mer Noire: chronologie et typologie, in: M. Bonifay – J.-C. Tréglia (eds.), LRCW 2. Late Roman coarse wares, cooking wares and amphorae in the Mediterranean. Archaeology and Archaeometry II, BARIntSer 1662 (Oxford 2007) 803–815.

Sazanov 2014 A. Sazanov, Cretan Amphorae from the Northern Black Sea Region: Contexts, Chronology, Typology, in: Poulou-Papadimitriou et al. 2014, I 399–409.

Steckner 1989 C. Steckner, Les amphores LR1 et LR2 en relation avec le pressoir du complexe ecclésiastique des thermes de Samos. Relation entre forme et fonction d'un vase en tant que récipient d'un contenu spécifique. Examen par ordinateur et expérimentation, in: V. Déroche – J.-M. Spieser (eds.), Recherches sur la céramique Byzantine, BCH Suppl. 18 (Athens 1989) 57–71.

Steckner 1993 C. Steckner, Baurekonstruktion der Hauptbauphase, in: W. Martini – C. Steckner (eds.), Das Gymnasium von Samos. Das frühbyzantinische Klostergut, Samos 17 (Bonn 1993) 47–166.

Toniolo 2007 A. Toniolo, Anfore dall'area lagunare, in: S. Gelichi – C. Negrelli (eds.), La circolazione delle ceramiche nell'Adriatico tra tarda antichità e altomedioevo. III incontro di studio CER.AM.IS., Documenti di archeologia 43 (Mantua 2007) 91–106.

Touma 1989 M. Touma, La céramique protobyzantine d'Amathonte: remarques sur le matériel trouvé en 1988, BCH 113, 1989, 871–875.

Touma 2001 M. Touma, Chypre: céramiques et problèmes, in: E. Kountoura-Galaki (ed.), Οι σκοτεινοί αιώνες του Βυζαντίου (7ος–9ος αι.) (Athens 2001) 267–291.

Tsigonaki – Yangaki 2015 Ch. Tsigonaki – A. G. Yangaki, Οι αρχαιολογικές έρευνες του Τομέα II στις Δεξαμενές της Ελεύθερνας και η μαρτυρία της κεραμικής, in: P. Karanastasi – A. Tzigounaki – Ch. Tsigonaki (eds.), Αρχαιολογικό Έργο Κρήτης. Πρακτικά 3ης Συνάντησης, Ρέθυμνο, 5–8 Δεκεμβρίου 2013, 2, Χανιά – Ρέθυμνο – Λασίθι (Rethymnon 2015) 429–448.

van Alfen 1996 P. G. van Alfen, New Light on the 7th-century Yassi Ada Shipwreck: Capacities and Standard Sizes of LRA 1 Amphoras, JRA 9, 1996, 189–213.

van Alfen 2015 P. G. van Alfen, The Restudy of the LR2 Amphoras from the Seventh-Century Yassıada Shipwreck, in: Carlson et al. 2015, 17–34.

van Doorninck 1989 F. H. van Doorninck, Jr. 1989, The Cargo Amphoras on the 7th Century Yassi Ada and 11th Century Serçe Limanı Shipwrecks: Two Examples of a Reuse of Byzantine Amphoras as Transport Jars, in: V. Déroche – J.-M. Spieser (eds.), Recherches sur la céramique Byzantine, BCH Suppl. 18 (Athens 1989) 247–257.

van Doorninck 2014 F. H. van Doorninck, Byzantine Amphoras Made for War?, IntJNautA 41.1, 2014, 21–27.

van Doorninck 2015a F. H. van Doorninck, Jr., The Metrology of the Piriform Amphoras from the Eleventh-Century Byzantine Ship at Serçe Limanı. New Designs but an Old System, in: Carlson et al. 2015, 35–62.

van Doorninck 2015b F. H. van Doorninck, Jr., The Seventh-Century Byzantine Ship at Yassıada and Her Final Voyage: Present Thoughts, in: Carlson et al. 2015, 205–216.

Vroom 2017a J. Vroom, The Byzantine Web. Pottery and Connectivity Between the Southern Adriatic and the Eastern Mediterranean, in: S. Gelichi – C. Negrelli (eds.), Adriatico Altomedievale (VI–XI secolo). Scambi, porti, produzioni, Studi e ricerche 4 (Venice 2017) 285–310.

Vroom 2017b J. Vroom, Ceramics, in: P. Niewöhner (ed.), The Archaeology of Byzantine Anatolia. From the End of Late Antiquity until the coming of the Turks (Oxford 2017) 176–193.

Williams 1989 C. Williams, Anemurium: The Roman and Early Byzantine Pottery (Toronto 1989).

Yangaki 2005 A. G. Yangaki, La céramique des IV[e]–VIII[e] siècles ap. J.-C. d'Eleutherna: sa place en Crète et dans le basin égéen (Athens 2005).

Yangaki 2007 A. G. Yangaki, Amphores crétoises de forme globulaire: remarques preliminaries, in: M. Bonifay – J.-Ch. Tréglia (eds.), LRCW 2. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry II, BARIntSer 1662 (Oxford 2007) 767–774.

Yangaki 2016 A. G. Yangaki, Pottery of the 4th–early 9th century AD on Crete: The Current State of Research and Evidence, New Directions, in: J. A. Francis – A. Kouremenos (eds.), Roman Crete. New Pespectives (Oxford 2016) 199–234.

Yangaki 2020 A. G. Yangaki, Πτυχές της έρευνας γύρω από τους βυζαντινούς αμφορείς (επισκόπηση και προοπτικές): αμφορείς για λάδι ή για κρασί, in: I. Anagnostakis – E. Balta (eds.), Ελιά και λάδι στην ανατολική Μεσόγειο από την αρχαιότητα στην προβιομηχανική εποχή (Athens 2020) 167–202.

Zanini 2009 E. Zanini, Uomini e cocci: i contesti ceramologici del Quartiere Bizantino del Pythion in una prospettiva antropologica, in: G. Bejor – E. Panero (eds.), La ceramica di Gortina (Creta), Atti del Convegno: Milano 17 giugno 2009, Lanx. Rivista della Scuola di Specializzazione in Archeologia dell'Università degli Studi di Milano 4, 2009, 44–72.

Zanini 2010 E. Zanini, Forma delle anfore e forme del commercio tardoantico: spunti per una riflessione, in: Menchelli et al. 2010, I 139–148.

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THE LAST BYZANTINE AMPHORA

SHERDS, SITES, AND SHIPWRECKS IN LATE BYZANTINE TIMES

Abstract
In this paper, we discuss the production, circulation, and function of one of the final amphora types in the Byzantine world, which can be generally dated to the 13th and 14th centuries. During this period, a vast and lively maritime medieval Mediterranean trade network existed that connected remote places and generated a diverse exchange of foodstuffs.

The ›Last Byzantine Amphora‹ was distributed to regional and more distant markets over mostly coastal areas. Certain urban centers played important roles in this network, either as producers or consumers/redistributors. Merchant ships carrying these ceramic containers often had to sail dangerous waters, and consequently many shipwrecks have been discovered in the eastern Mediterranean. Newly documented shipwrecks from the Adriatic, Aegean, and Black Sea regions can thus provide information on exchange patterns and maritime routes.

The ship sizes as well as their cargo volume and the amphora shapes and sizes are interesting parameters in studying the scale and overall organization of the amphora trade in late Byzantine times. Furthermore, we need to keep in mind that by then ceramic transport jars started to be replaced by wooden barrels. Changes in amphora shapes, fabrics, sizes, and manufacturing techniques may therefore have been adaptations to these new ways of storing and transporting bulk goods.

INTRODUCTION

It is well known that starting in the late 12th century and during the Late Byzantine period (ca. 13th–14th cent.) the production of amphorae, the traditional Mediterranean ceramic containers and transport vessels, rapidly declined[1]. There seems to be not much archaeological evidence for the production and circulation of Byzantine amphorae after 1350. The reduced use of ceramic transport containers is not only amply documented at excavations, but it is also corroborated by the findings of underwater archaeology: the cargo quantities of amphorae on Late Byzantine shipwrecks clearly diminished, while those of glazed tablewares increased[2]. During this period, ceramic transport vessels were steadily replaced throughout the Byzantine Empire by wooden barrels and leather sacks, containers already familiar both in the east and in northwestern Europe[3]. It is likely, though not certain, that the notable changes in size, shape, and volumes of Late Byzantine Amphorae were adaptations to new ways of storing and transporting commodities.

Recent excavations of several shipwrecks from the Adriatic, Aegean, and Black seas shed new light on this conjecture and on other important questions surrounding the final amphora types in the Byzantine world. The findings of these underwater excavations provide new and unique information not only concerning exchange patterns and maritime routes in the 13th and 14th centuries but also regarding the distribution and function of one lesser-known amphora type of Late Byzantine times[4].

In this chapter we discuss the production and circulation of this specific transport vessel, which seems to have been a quite exceptional relic of the omnipresent amphorae of the previous era. After a detailed description of the amphora type, a full survey of the sites where the vessel has been

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1 All dates in this article are A.D., unless otherwise stated.
2 Vroom 2016, tabs. 2 f.
3 Bakirtzis 1989, 81. 84–87 pls. 22, 5 and 53 b; Vroom 2003, 155; Jacoby 2010.
4 See also van Doorninck 2002, 903; Manolova-Voykova 2018, 104.

identified at excavations and other archaeological projects, and an inventory of the various names that have been suggested for the type, we will try to gain a better understanding of its dating and history of use, in other words the still largely unknown function, distribution and provenance of this ceramic container. Also, we will explore the question of how to understand this mobile container and its standardized features in a broader socioeconomic context, including its competition with the increased use of wooden barrels as a means of transport in the 13th and 14th centuries.

Little is known about this specific type of ceramic container, and although various names have been suggested for the type, none of them seem very satisfying, let alone have found general use. For the sake of clarity and brevity, we use here the designation ›Last Byzantine Amphora‹[5].

THE AMPHORA IN BYZANTINE TIMES

Since prehistoric times ceramic containers were used in the Mediterranean in vast numbers for the storage and transport of common staple goods, both liquid and dry, such as wine, grain, and olive oil[6]. This did not stop with the demise of the Roman Empire. It is well known that during the Early and Middle Byzantine periods, specifically during the 11th and 12th centuries, new pottery production sites emerged throughout the eastern Mediterranean region, where new generations of amphorae (known in Byzantine sources as *magarika*) were manufactured in considerable quantities[7]. Compared to the production of the previous centuries, these sites manufactured different, often somewhat smaller-sized ceramic transport containers[8]. At the same time, a lively maritime trade network continued to operate in the eastern Mediterranean, connecting remote places with larger economic centers and ultimately with the capital of the Empire, Constantinople. Thus, a diverse and intricate linkage of networks existed for all sort of products transported in all sorts of amphorae[9]. Several urban centers played important roles in this exchange system, either as producers or as redistributors and consumers[10].

Middle Byzantine amphora types were distributed over large areas and were found in many, specifically coastal, parts of the eastern Mediterranean and the Black Sea[11]. During the Byzantine period, the amphorae were transported mostly by small ships, which sailed from harbor to harbor, keeping, as much as they could, close to the shore or at least not losing sight of land. However, not all made it to a safe port, and as a result, various shipwrecks from Byzantine times carrying amphorae have been discovered in the eastern Mediterranean and beyond[12]. Recently, some of these shipwrecks dating to the Late Byzantine period have been excavated in the Adriatic, Aegean, and Black seas. Although by this time the production and use of ceramic containers had diminished sharply, the ships yielded a wealth of information on exchange patterns and maritime routes, including the distribution of the Last Byzantine Amphora.

MEDIEVAL TRAFFIC AND EXCHANGE IN THE EASTERN MEDITERRANEAN

We would like to address first the issue of the scale and the mode of late medieval shipping in the Aegean and Adriatic seas. Factors influencing maritime trade and seafaring in the eastern Medi-

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5 We consider the type described in this paper to be the last Byzantine amphora form circulating in the eastern Mediterranean, at least for the moment and until proven otherwise.

6 Bevan 2014, 387.

7 Vroom 2017; Vroom 2018.

8 Vroom 2014, 94–103.

9 See Vroom 2016, figs. 2. 6.

10 Maniatis 2003, 144; Vroom 2018.

11 Periodization in the present article is as follows: ›Middle Byzantine‹ designates the period from the 10th to the late 12th/early 13th cent.; ›Late Byzantine‹ or ›Frankish‹ from the 13th–15th cent. See also Vroom 2003, 25–29 and tab. 1.1 for the chronological division of post-Roman ceramics in the Aegean.

12 Vroom 2016, tabs. 1. 2.

terranean were geographical, social, and technological in nature[13]. They limited and, at the same time, empowered human action in these regions. In order to clarify by which dynamics the Last Byzantine Amphora might have been moving, these issues are important to address here briefly[14].

The eastern Mediterranean during the later Middle Ages was in some ways distinct regarding maritime interaction and connectivity. This area should not be judged as a mere cross-cultural transit zone along supraregional routes between Europe, the Black Sea, and the Near East, of which the commercial foci were located far away on the western and eastern extremities[15]. This long-persisting Eurocentric view does not take into consideration the ›ownness‹ of the area itself. Hence, the Aegean and the Adriatic seas should be judged as physiographic as well as sociohistorical entities in their own right, rendering special conditions for seafaring and trade[16].

Since ancient times, the sea was central as the main medium of communication throughout the whole Mediterranean[17]. The Aegean and the Adriatic seas were distinct subregions within this large and diverse basin[18], with both beneficial and hazardous factors[19]. The overall proximity to coastal locations and the patchwork of islands provided ample opportunities for reliable and safe communication and exchange over considerable distances[20]. Nevertheless, capricious and rocky coastlines, frequent storms, heavy winds, and strong currents were serious menaces to seaborne activities. This environment was well-suited for small to medium-sized ships sailing relatively short distances with limited carrying capacities, stopping at various transit points during a journey[21]. This was a more indirect manner of transportation rather than direct large-scale, long-distance shipments between the point of departure and the final destination. In this complex web of sea lanes, the importance of islands and peninsulas can hardly be overstated[22]. Island-hopping and cabotage characterized Medieval seafaring, as it often had in the Aegean, and this situation was not different in Late Byzantine/Frankish Greece[23]. Thus, shipments of goods and people were mainly carried out with small and medium-sized vessels tramping and hugging the long coastlines[24]. Furthermore, direct open-sea shipment of large amounts of bulk products (mainly raw industrial goods or rural surpluses, such as grain) did occur in some instances as well, yet much less frequently.

Although the Byzantine market became gradually more integrated in wider Italian-controlled exchange systems, many maritime trading activities remained confined within the boundaries of the Aegean and were rather limited in scale and restricted in geographical range, with, again, small and medium-sized ships as the principal craft[25]. Of course, interregional commerce was important as well; however, significant quantities of goods circulated between various eastern Mediterranean ports rather than being directed outward toward European or Islamic consumer markets[26]. The late medieval Aegean lacked the overarching dominance of once-mighty Byzantium and was a hotbed of geopolitical struggle (most notably the naval wars between the Ottomans and the western powers) and economic competition (between the Italian mercantile pow-

13 Braudel 1998, 58 f. 243.
14 The authors do not claim to be experts on this topic, and most of the interpretations are based on published archaeological and historical research.
15 Jacoby 2012, 100 f.; Jacoby 2014, 208.
16 Jacoby 2016, 194.
17 Horden – Purcell 2000, 11; Avramea 2002, 77.
18 Horden – Purcell 2000, 13.
19 Avramea 2002, 77–79; Papayannis – Sorotou 2008, 83.
20 Braudel 1998, 162.
21 Makris 2002, 95.
22 Jacoby 2012, 95 f.
23 Jacoby 2017, 5 f. 8.
24 Avramea 2002, 78; Jacoby 2014, 208 f.
25 Lock 1995, 251; Jacoby 2012, 106.
26 Jacoby 2017, 8 f.

ers), thereby generating serious problems for commercial traffic[27]. Likewise, in the Adriatic area, growing tensions between Venetian and Ottoman territorial interests and rivalry among the Italian city-states created unpredictable and threating conditions for economic exploration and trade[28]. Despite the dangers of corsairs, the presence of other hostile entities (increased due to the lack of an effective authority to police the sea), and the omnipresence of treacherous waters, maritime trade could flourish, albeit hampered by episodes of crisis. Moreover, economic conditions were greatly fostered by the involvement of Italian merchants in the wake of the Crusades.

In these settings, the long-distance shipment of bulk goods on the open sea was a risky and costly enterprise and thus not easily achieved or maintained[29]. Hence, such shipping was probably not as appealing to the investors and authorities concerned. After 1204, local and regional retail trade and small to medium-sized transportation were of considerable importance[30]. In this manner, native Greek sailors and merchants remained vital actors, operating in a Latin-dominated network. State policies and regulations of the Republic of Venice were of great importance in shaping these socioeconomic configurations[31]. Discriminatory rules, for instance, strictly dictated in which kinds of trading their Italian citizens, colonial subjects, and other foreigners could participate. Venice also invested in the construction of harbors and ports across its maritime empire[32]. These strategically located posts provided safe havens for seamen and their ships *en route*. During these stops, crew members could take shelter from storms and enemies. They could repair their ships, resupply, and involve themselves in small-scale trade in local markets. Additionally, in several Venetian territories, commercial fleets were created, which played a significant role in eastern Mediterranean trade. They typically consisted of small ships, often sailing in mandatory convoys for security reasons, and were run by companies with generally limited financial capabilities. For these reasons, it seems likely that large-scale and long-distance bulk trade was not always a feasible or desired option.

The exact ship types involved in these maritime activities are not clear, and historical information about commercial voyage regimes (such as times, distances, and routes traveled or tonnages) is equally ambiguous[33]. Byzantines had long possessed a strong navy and developed outstanding nautical technologies[34], and unsurprisingly the Venetians made use of Greek shipbuilding traditions. Rowed galleys were probably important as well as small round sailing vessels[35]. Some graffiti depicting ships on Greek pottery and church walls seems to indicate the presence of the former type in waters surrounding the island of Euboea in later medieval times[36]. It is therefore most likely that the Last Byzantine Amphora was mainly transported in smaller ships and over local and regional distances. Its size and shape as well as the fact that it has never been recorded in large quantities at a shipwreck site support this suggestion[37].

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27 Carr 2015, 120; Kolditz 2017, 62. The centralized Byzantine state had long given protection and stability to the region and had been a major player in the large-scale shipment of bulk goods and foodstuffs: see Mango 2009, 3; Necıpoğlu 2017, 440. In the Late Byzantine period, however, the empire was no longer in the position to exercise this role.

28 Muhaj 2019.

29 Braudel 1992, 369.

30 Lock 1995, 260; Jacoby 2012, 101; Necıpoğlu 2017, 444 f.; Pagratis 2017, 431 f.

31 Makris 2002, 92; Gertwagen 2016, 147; Pagratis 2017, 433.

32 Gertwagen 2004, 179 f.

33 Avramea 2002, 78; Makris 2002, 91.

34 Makris 2002, 99.

35 Epstein 2009, 163; see also Cunliffe 2017, 485–489. According to George Makris (2002, 96), however, rowing was not economical for commercial sailing and merely played a secondary role. During the Yenikapı excavations of 37 Byzantine shipwrecks of the 5th–late 10th cent. at Istanbul, both ship types were indeed recognized: six galleys with a long, narrow hull as well as various round merchant ships: Kocabaş et al. 2016, 365–371.

36 See Nakas – Krapf 2017.

37 Several other well-known Byzantine amphorae have been found in sometimes extremely high numbers at underwater wreck sites: see Vroom 2016, 158–165.

THE LAST BYZANTINE AMPHORA: SHAPE AND FABRIC

The amphora type under discussion here was first documented in detail by G. Sanders, who not only described two small complete examples found in the 1930s at Mystras in Laconia but also published a drawing of two other specimens from Agios Stephanos in southern Laconia[38]. Although his documentation of the vessels is exhaustive, he did not suggest a specific new name for the amphora type. Ch. Bakirtzis, on the other hand, mentioned this amphora from Mystras as his »7th amphora type«[39]. The description below largely follows the description of Sanders but is also based on fragments and other more or less complete examples of the amphora found since his publications (see tab. 1).

The Last Byzantine Amphora comes in some variations, but the general shape is clear: a small ovoid-bodied vessel ca. 34–43 cm tall, with quite thick walls, a maximum body diameter of ca. 15–17 cm, and an opening with a maximum width of ca. 6.2–8.5 cm (fig. 1)[40]. The amphora has an everted rim with an oval-shaped mouth, a very short (almost nonexistent) neck, convex sloping shoulders, a pointed base, and two broad flat strap handles, which slightly rise above the rim and then descend to the upper shoulder. The elongated ovoid-shaped body of the type has distinctive wheel-ridging on the interior and pronounced horizontal ribbing regularly on the exterior. The surfaces of the upper shoulder and the bottom section are smoothed on the outside.

1 One example of the Last Byzantine Amphora found at Mystras, southern Peloponnese; unscaled (from: City of Mystras 2001, 89)

On one of the complete vessels described by Sanders, a painted motif seems vaguely discernible. It includes a large Greek letter *theta* (Θ), running from the shoulder almost all the way down to the bottom[41].

The fabric is generally medium fine, and medium hard to hard fired. The color is largely pinkish to dull orange (7.5 YR 8/4–6, 7.5 YR 6/6–5 YR 8–7/4)[42]. The clay is mixed with many tiny to large, rounded orange-brown to red-brown grog/shale, tiny (silt-sized) to large dark reddish brown stone inclusions (or monocrystalline quartz grains), some medium limestone/calcite particles, and it contains a fair amount of tiny to small voids (probably of disappeared limestone). All in all, the fabric is quite similar, if not identical, to the so-called fabric type 2 described by Sanders for the two specimens from Agios Stephanos[43]. According to him, the general appearance of the fabric suggests that the examples were made from a ›marl clay‹, that is to say a lime-rich mudstone containing silt-sized inclusions[44]. The use of this clay was common for pottery throughout the Peloponnese, and apart from the Last Byzantine Amphora and fabric type 2, the fabric is known from large, unglazed closed vessels found in Early Modern Laconia (known in Greek as *stamnoi*), which were mainly used for the storage and transport of liquids (in particular wine, water, and olive oil)[45].

Due to the large quantity of limestone inclusions, it has been suggested by D. Williams that these amphorae were produced in a ›calcareous sedimentary region‹, which would suggest a southern Peloponnesian origin[46]. In addition, the laminated fabric of the Last Byzantine Amphora

38 Sanders 1989, 196–199 fig. 5 a. b; see also Sanders 1993, 255; Sanders 2008, 398 f. 404. 408 cat. 4017. 4073.
39 Bakirtzis 1989, figs. 22.1; 39 a.
40 We would like to thank Peter Buis for his help with the illustrations.
41 Sanders 2008, 404; see fig. 2 left.
42 Fabric colors are classified using the Munsell Color System.
43 Sanders 1993, 255; Sanders 2008, 398 f.
44 Sanders 2008, 398.
45 Sanders 2008, 397; for a discussion on north Peloponnesian clays, see also Whitbread 2003.
46 See Zmaić 2013, 86. However, other parts of the Peloponnese also have important limestone and calcareous clay sediments: Whitbread 2003, 2 f.

THE LAST BYZANTINE AMPHORA FOUND AT:	PROJECT	PUBLICATIONS
Acrocorinth	Excavation	Tzavella (forthcoming)
Aipeia	Excavation	Konstantinidou 2018
Agios Stephanos	Excavation	Sanders 1989; Sanders 2008
Agios Vasilios	Survey (?)	Personal observation
Corinth	Excavation	Snyder – Williams 1997; Williams – Zervos 1988; Williams – Zervos 1992; Williams – Zervos 1994; Sanders 2008, 294
Kalydon	Excavation	Bollen 2011
Kastri	Excavation	Jonston – Slane – Vroom 2015
Krapanj Island	Shipwreck (?)	Zmaić 2013; Zmaić – Miholjek 2012
Loutraki	Restoration	Tzavella (forthcoming)
Lucnjak Island	Shipwreck	Zmaić 2013; Zmaić – Miholjek 2012
Merara Islet	Shipwreck	Zmaić 2013; Zmaić – Miholjek 2012
Mystras	Restoration	Orlandos 1935; Sotiriou 1956 in: Sanders 2008
Nemea	Survey	Athanasssopoulos 2016
Sikyon	Survey	Tzavella (forthcoming)
Stymfalia	Excavation	MacKay 2018

Table 1 Alphabetical list of find-spots of the Last Byzantine Amphora in the Aegean and in the Adriatic Sea region

looks very similar to fabrics typical of the southern coasts of the Peloponnese (Messenia and Laconia). In fact, some twenty percent of the locally manufactured pottery in this area has a fabric similar to that of the Last Byzantine Amphora[47].

FINDS OF THE LAST BYZANTINE AMPHORA AT GREEK SITES

Southern Peloponnese

The first archaeological documentation of the Last Byzantine Amphora dates from the 1930s, when A. Orlandos published a photograph of two small examples found at the Aphendiko Church of the Brontochion Monastery at Mystras in Laconia[48]. Both had been built into the pendentives of the main church dome, where they were discovered during a restoration (fig. 1). The original construction of the Aphendiko Church had perhaps started around 1310 and was probably finished around 1320. Thus, these two examples of the Last Byzantine Amphora (both ca. 35 cm tall) found here as fill material can be dated securely within the first half of the 14th century[49]. Reusing amphorae as fill material for architectural structures was not uncommon in the Byzantine world. The vessels were not only used for dome- or arch-building but also as an element improving acoustics in churches or other large buildings[50]. This tradition of reuse can be a helpful tool for both establishing the chronology of architectural structures or for dating the pottery found within them.

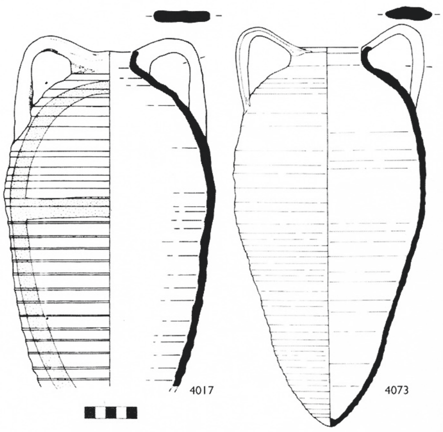
A full description of these two vessels from Mystras had to wait until Sanders mentioned them some sixty years later, together with drawings of two more specimens of the Last Byzantine Am-

47 D. Williams in: Zmaić 2013, 87.

48 See Orlandos 1935, 197. 204 pl. 6; Sotiriou 1956, 33 in: Sanders 1989, 196 n. 26; Bakirtzis 1989, pl. 39 a. They now appear on display in the Archaeological Museum of Mystras (see also City of Mystras 2001, 89).

49 Sanders 1989, 196; Sanders 2008, 408.

50 See, e.g., Demangel – Mamboury 1939, 148 f.; Vroom 2003, 155; Bakirtzis 2009.



2 Two examples of the Last Byzantine amphora found at Agios Stephanos, southern Peloponnese (from: Sanders 1989, fig. 5)

phora found at the site of Agios Stephanos in southern Laconia[51]. The excavation of this last site not only yielded an almost complete example (cat. 4017) found at the top of a pit in ›Area Zeta‹ but also a complete specimen (cat. 4073) as well as a large body sherd (cat. 4075) from a tumble layer in ›Area Lambda‹, both of which had apparently been used as fill material in the superstructure of a rural house[52]. The two specimens of the Last Byzantine Amphora found at the Agios Stephanos site were recovered with associated coins (among which was one of Charles I of Anjou, Prince of Achaia from 1278 to 1285) as well as glazed decorated pottery and an imported Archaic Maiolica jug from central or northern Italy, which could date them approximately between the late 13th and early 14th century (see tab. 2).

In 2011 the Ephorate of Antiquities of Messenia conducted an excavation at the Saint Nicholas church in Aipeia some 10 km north of Kalamata in southern Messenia[53]. Small amounts of late 13th- and early 14th-century pottery were recovered, among which were fragments of presumably the Last Byzantine Amphora[54]. A. Konstantinidou recognized a level of technological standardization and speculated on a presumed Messenian origin for these vessels. Oddly enough, no pieces of Italian Maiolica were found; this observation deviates slightly from the general pattern of finds.

Furthermore, we have noticed a few fragments (mostly ribbed body sherds) presumably of the Last Byzantine Amphora during an archaeological survey at Agios Vasilios in southern Laconia[55], as well as a painted handle fragment of this type at the site of Kastri on the island of Kythera, south of the Peloponnese[56].

Northern Peloponnese

Several specimens of the Last Byzantine Amphora have also been found in the northern Peloponnese, most of them in the American excavations at Corinth[57]. Five ›almost identical examples‹ were recovered here in a pit dating from the second decade of the 14th century (pit 1991-2),

[51] Sanders 1989, 196–199 fig. 5 a. b; Sanders 2008, 402.
[52] Sanders 2008, 404. 408 fig. 7.10; see fig. 2.
[53] Konstantinidou 2018, 825. 828.
[54] Konstantinidou 2018, 828 f. 832 fig. 3 cat. 17.
[55] Personal observations of the authors.
[56] Johnston et al. 2014, 58 fig. 30 e M 42.
[57] Sanders 1989, 190; Sanders 2008, 294. Another ›typologically similar amphora‹ mentioned by Sanders (2008, 394) and by Williams – Zervos (1988, 106), which was found in a well in the Athenian Agora and probably dates to the mid-12th cent. (see Shear 1984, pl. 16 d), turned out to be not a Last Byzantine Amphora as discussed here but another Byzantine amphora type with a different shape and different fabric (personal observation).

FIND-SPOTS OF THE LAST BYZANTINE AMPHORA	FOUND WITH: LATE BYZANTINE COINS AND OTHER NON-CERAMIC ARTEFACTS	FOUND WITH: LATE BYZANTINE GLAZED DECORATED POTTERY
Agios Stephanos	One billon denier of Charles I of Anjou (1278–1285); three billon deniers of Isabella de Villehardouin (1297–1285), Philip of Taranto (1307–1313), Maud of Hainault (1313–1321).	Archaic Maiolica jug; Zeuxippus Ware Family bowl (late 13th–early 14th cent.); fragments of Late Green and Brown Painted Ware (ca. late 13th–14th cent.); one sherd of Olive-Brown Ware; small pieces of Metallic Ware; Late Slip-painted Ware.
Corinth	Two coins of William Villehardouin (Clarenza, issue, 1250–1278); one coin of Charles I of Anjou (1278–1285).	Proto-Maiolica vessels; Archaic Maiolica vessels.
Corinth (Williams – Zervos 1992)		Fragments of an Archaic Maiolica bowl; fragments of a Metallic Ware jug and bowl.
Kalydon		Fragments of Archaic Maiolica or RMR Ware from Italy.
Island of Krapanj; likely from a shipwreck	Possibly associated with a large bronze bell with inscription (stating it was cast by Jakob from Messane and Andreaot from Pisa at Akko), dated to 1266. Other associated finds include a lead anchor and marble tiles.	
Sikyon		Sherds of Archaic Maiolica, RMR Ware and Veneto/Roulette Ware from Italy; sherds of Champlevé Ware and Zeuxippus Ware Family.

Table 2 List of find-spots of the Last Byzantine Amphora in combination with find circumstances

ca. 13 m east of the Frankish *plateia*[58]. The best preserved of these is decorated with four broad vertical strokes in red wash on the handles as well as on each side of the wheel-ridged body, and with another broad horizontal red band just below the handle attachment to the body[59]. It was found together with fragments of an Archaic Maiolica bowl, a Metallic Ware jug and a Metallic Ware bowl[60]. Also in Corinth, a similar-looking ribbed jar with a missing toe was recovered in a mid- or late-13th-century pit, although its body shape seems rounder than that of the average Last Byzantine Amphora[61].

Another example, but from an undated context, was excavated by the 25th Ephorate of Byzantine Antiquities on the Acrocorinth, and yet another specimen was found during a restoration project by the same ephorate at the Church of Agios Andreas in nearby Loutraki[62]. During the Sikyon Survey Project (SSP), six fragments[63] of the Last Byzantine Amphora were found in a single area of the Sikyonian Plateau[64]. Three of these fragments were covered with a yellowish beige slip.

58 Williams – Zervos 1992, 163 f.

59 Williams – Zervos 1992, 164 cat. 36 pl. 40; see fig. 3 left. Theodora Stillwell MacKay (2003, 410) mentions another piece of a red-bodied transport amphora (C-1977-276) »with scoring around the body for grip«, dated to the late 13th or early 14th cent., which might be a fragment of the Last Byzantine Amphora. She also refers (n. 44) to a complete unpublished specimen of this type in storage at Corinth as C-37-2007. See also Sanders 1989, 196 n. 27.

60 Williams – Zervos 1992, pl. 39 cat. 33; pl. 40 nos. 34. 35.

61 Williams – Zervos 1988, 106 f. cat. 19 fig. 12 pl. 36; Sanders 2008, 294; see fig. 3 right. One may wonder whether this is a variant or subtype of the Late Byzantine Amphora.

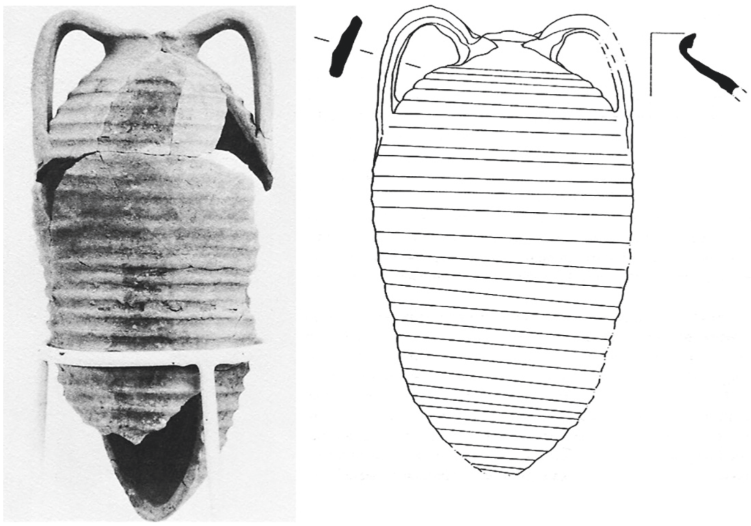
62 Tzavella (forthcoming). We would like to thank Elli Tzavella for sharing her upcoming manuscript with us.

63 Of which two fragments were uncatalogued.

64 Tzavella (forthcoming).

Late Byzantine ceramic evidence from the plateau also included glazed decorated tablewares, among which were imported sherds of Archaic Maiolica, RMR (Ramina, Manganese, Rosso) Ware, and Veneto/Roulette Ware from Italy, all datable to the late 13th and first half of the 14th century[65].

Among other survey material found on the Peloponnese, we have spotted a wide strap handle fragment on site 704 (›Tourkilias‹) in the surveyed area of the Nemea Valley Archaeological Project (NVSAP), which could be a fragment of a Last Byzantine Amphora[66]. Its fabric and shape look at least similar to the vessel type under discussion here. Lastly, fragments of another example of the Late Byzantine Amphora were found at the Cistercian Monastery of Zaraka, near the village of Stymfalia in the Corinthia region, although not recognised yet in its description[67].



3 Two examples of the Last Byzantine Amphora found at Corinth, northern Peloponnese (from: Williams – Zervos 1988, fig. 12, no. 19; Williams – Zervos 1992, pl. 40, no. 36)

North of the Peloponnese

At Kalydon in Aetolia, the large site facing the Peloponnese from the northern shore of the Corinthian Gulf, six fragments of the Last Byzantine Amphora have been recovered, although they have not been recognized as such[68]. A Greek-Danish team under the auspices of the Danish Institute at Athens and the Ephorate of Patras has excavated these fragments together with painted glazed wares, unglazed jugs, and cooking pots, in a series of pits on the acropolis of the site and in a single pit in the lower town of Kalydon. The amphorae were described as having »broad ridging on exterior«, and a »thick black substance coating part of interior and patches on wall« [*sic*][69].

Unfortunately, these fragments from Kalydon have erroneously been diagnosed as ›Günsenin 3 amphorae‹[70]. Considering the shape, fabric, and surface treatment of these fragments, this is certainly a misidentification. Furthermore, the sherds were also – together with the rest of the pottery assemblage – incor-

4 One example of the Last Byzantine Amphora found at Kalydon, Aetolia (from: Bollen 2011, fig. 179)

65 See in general, Vroom 2014, 128 f. 132 f.
66 Athanassopoulos 2016, 123 fig. 69 cat. 238.
67 MacKay 2018, 129 fig. 5.47 cat. 28.
68 Bollen 2011, 253 f. 258 f. 263 fig. 179 pls. 4. 5 cat. 12. 13; see fig. 4.
69 Bollen 2011, 259 cat. 12.
70 Bollen 2011, 253 f. 259.

rectly dated to the »11th to 12th century BC«[71]. It is, however, clear from all the glazed ceramics, cooking pots, and amphorae that these Byzantine finds at Kalydon should rather be dated from the mid-/late 13th to the mid-14th century[72]. In fact, the Last Byzantine Amphora sherds were clearly found in a context with, among others, fragments of Archaic Maiolica jugs of the mid-/late 13th to the first half of the 14th century[73].

This is, in fact, not surprising, as this was the period in which Frankish rulers were active on the northern shore of the Gulf of Corinth. The fortified town of Salona (modern Amfissa) was, for instance, in the hands of the Aurtemencourt and Fadrique families, while Naupactus (an important Byzantine naval station near Kalydon that controlled access to the Corinthian Gulf) became a major Angevin base and eventually a Venetian stronghold on the Greek mainland[74]. In short, during the late Middle Ages the Gulf functioned not only as a physical separation between the Peloponnese and mainland Greece but certainly also as a link for traffic between both shores, in this case for the Frankish rulers of southern Greece.

FINDS OF THE LAST BYZANTINE AMPHORA ON DALMATIAN SITES AND SHIPWRECKS

The Last Byzantine Amphora has been found not only at Greek sites but also in Croatia and on shipwrecks along the Dalmatian coast. The recent excavations of these shipwrecks yielded valuable new information. To date, this type has been retrieved from wrecks off the Islet of Merara, the Island of Vela Arta close to Murter, and in the Shallow of Lučnjak, all located in the eastern Adriatic Sea (fig. 5).

The Last Byzantine Amphora was already known in Croatia. That is to say, it has now become clear that a specimen has long been part of the archaeological collection of a Franciscan monastery on the island of Krapanj before it was recognized as such[75]. The shape of this vessel is almost complete: only its bottom is missing (see fig. 5, right). Apparently, this amphora from Krapanj was incorrectly included earlier by Z. Brusić in his »amphorae group 5B«, together with various amphora types of quite different shapes and dates[76]. In addition, he published without typological diagnoses a half-preserved ceramic container that looks similar to the Last Byzantine Amphora[77]. This fragment was recovered together with ballast stones off the eastern coast of the island of Vela Arta, but it is too heavily overgrown and distorted to judge[78].

During an underwater survey in 2006 near the Islet of Merara off the Croatian coast, large quantities of amphora fragments and medieval kitchenware were recovered within an area of some 80 m², which led archaeologists to conclude that the site was the location of a shipwreck[79]. No complete specimens of the Last Byzantine Amphora were found here, and unfortunately little information is given about the total sum of sherds recovered, but several published fragments can

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71 Bollen 2011, 251.

72 Unfortunately, the identification by the Danish team of some white slipped and painted fragments as »Early Miletus Ware« of Ottoman times (Bollen 2011, 255) is also wrong; these are clearly imported Late Byzantine sherds from southern Italy; cf. Vroom 2014, 128 f.

73 Bollen 2011, 258 fig. 183–184.

74 Koder – Hild 1976, 254; Bommeljé 2009, 6 f.

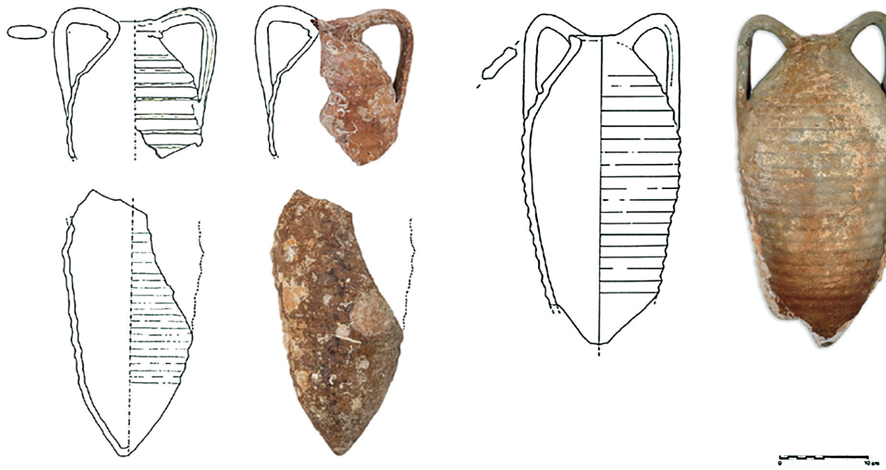
75 Brusić 1976, 42 pls. 5.3; 11.3; Brusić 2010, fig. 8 cat. 5; Zmaić – Miholjek 2011, 98 fig. 8.2; Zmaić 2013, 83 fig. 7; Zmaić Kralj 2017, 57 f. fig. 16 cat. 1–3. This last example on Krapanj Island was brought by sponge divers from an unknown underwater site on the eastern Adriatic coast. It was presumably found in association with a bronze bell, which has been dated with great certainty between 1266 and 1291: see Zmaić Kralj 2017, 58.

76 Brusić 1976, 42 f. pl. 5 cat. 3. The nearly complete amphora from Durrës Museum (Albania) published by Fatos Tartari (1982, fig. 29) could be a Late Byzantine Amphora, but this is difficult to see in the photograph. So far, there have been no fragments of the Last Byzantine Amphora found at Butrint (personal observation).

77 Brusić 1976, pl. 6 cat. 4.

78 Brusić 1976, 42 pl. 10 cat. 6.

79 Zmaić – Miholjek 2011, 97 f. fig. 8.1; Zmaić 2013, 83.



5 Examples of the Last Byzantine Amphora found on Croatian sites and shipwrecks (from: Zmaić 2013, fig. 5–7)

still be diagnosed as originating from the vessel type under discussion here[80]. A new survey in 2009 and an excavation in 2012 at the Merara underwater site yielded more easily identifiable examples of the Last Byzantine Amphora. To date, at least nine upper halves (rims, necks, handles) have been published from these campaigns[81]. Based on variations in width, shape, and horizontal ribbing, these pieces were initially divided into three subtypes, although the excavators realized later that the differences were probably rather imperfections in potting techniques and not indications of regular subtypes (see fig. 5, left).

South from the Merara Islet, near the Shallows of Lučnjak in southern Croatia, an underwater site with amphorae was discovered on the seabed, probably from shipwrecks that were unfortunately mixed as one sank on top of the other. Three large fragments belonging to the Last Byzantine Amphora, similar to the Merara ones, were brought on land here[82]. At first, the Croatian excavators of the Merara shipwreck dated the amphora type to the 12th and 13th centuries[83], but later they changed this to the late 13th and beginning of the 14th century[84].

THE LAST BYZANTINE AMPHORA: DATING

Considering all the known specimens of the Last Byzantine Amphora from Greece (mainly the Peloponnese) and from Croatia, as well as the contexts in which they were found or excavated, it strongly suggests that the Last Byzantine Amphora had a rather limited history of use. All the archaeological evidence indicates a dating of the vessel type between roughly the second half of the 13th and the first half of the 14th century (tab. 2).

The information available at present is consistent: two specimens from Mystras built into a church dating between ca. 1310 and 1320; two specimens found at Agios Stephanos recovered with coins dating between 1278 and 1285; five examples found at Corinth together with Archaic Maiolica and Metallic Ware (ca. mid-13th–early 14th cent.); fragments found at Sikyon in a context with Archaic Maiolica, RMR Ware, and Veneto/Roulette Ware (all datable from the mid-/late

80 Vesna Zmaić (2013, 86 fig. 12) mentions another specimen of similar shape to the Last Byzantine Amphora that was found at Torre dell'Orso off the Apulian coast, but this appears to be another type with a different shape for the body and handles.
81 Zmaić 2013, 83 f. fig. 6.
82 Zmaič 2013, fig. 10.
83 Zmaić – Miholjek 2011, 94. 97; Zmaić 2013, 81. 86.
84 Zmaić 2013, 81. 86.

13th–early/mid-14th cent.); fragments from Kalydon excavated in a context again with Archaic Maiolica; fragments from the Lučnjak shipwreck found with an almost complete Günsenin 3 amphora (ca. late 12th–13th cent.). The Krapanj example was probably from the same wreck carrying a large bronze bell, which was safely dated between 1266 and 1291. After elimination of clearly erroneous examples and dates, there is no alternative to a solid dating of the Last Byzantine Amphora between ca. 1250/1275 and ca. 1325/1350 (see tab. 2).

THE LAST BYZANTINE AMPHORA: MANUFACTURING TECHNIQUES

On the basis of fabric comparisons, Sanders was the first to suggest that these vessels (which he does not group as a separate type) were manufactured with local clays in the Peloponnese, perhaps even in the surroundings of Agios Stephanos. He points to the fact that his Laconian examples were made of marl clays, of which extensive beds were common in this neighborhood[85]. Later, Williams suggested that the large quantity of limestone inclusions also make it likely that these amphorae were produced in a calcareous sedimentary region, like the southern Peloponnese[86]. In addition, the laminated fabric of the Last Byzantine Amphora looks very similar to fabrics typical of the southern coasts of the Peloponnese (Messenia and Laconia).

In addition, the fabric of the Last Byzantine Amphora seems to be highly analogous to fabrics of local Late Byzantine vessels manufactured in the southern Peloponnese, which were found in Laconia and on the nearby island of Kythera[87]. In fact, the fabric looks strikingly similar in structure, color, and inclusions to fabrics of large storage jars or *pithoi*, which were still made during the 19th and 20th centuries in potters' villages near Koroni on the Messenian Gulf and which are known in modern Greek as *Koroneika*[88]. These potters used primarily local calcareous Pliocene clays from coastal hills north of Koroni[89]. Furthermore, the fabric of the Last Byzantine Amphora looks similar to that of so-called Measles Ware. This is a glazed decorated tableware of the Middle Byzantine period that was probably produced in the Peloponnese: Corinth, Argos, and Sparta have been suggested as potential areas of provenance, although the last site has only yielded an unfinished product thus far[90]. A further argument for a southern Peloponnesian origin of the Last Byzantine Amphora could be that most specimens of this vessel type have been recognized in this region; such a cluster of finds suggests local production[91].

6 Storage jar/*pithos* from Koroni, southern Peloponnese (from: Vroom 2014, 196 fig. EMOD 8.2)

E. Tzavella has proposed that due to variations in the fabric and shape of the Sikyon fragments, the

85 Sanders (2008, 398) notes specifically beds »along the edge of the Helos Plain between Skala and Stephania, and more extensive beds border the eastern side of the plain from Phlisi to well south of Asteri«. Since a high level of standardization seems lacking, the production of this amphora type can be characterized as not extremely specialized in comparison to other Byzantine wares.

86 Cf. Zmaić 2013, 86.

87 Personal observations of the authors.

88 Blitzer 1990; see fig. 6.

89 See also Giannopolou 2010, 166 f., who describes petrographic analyses carried out on typical 19th-cent. large *pithoi* from Koroni. In particular, the fabrics of her *Koroneika* samples 24–26 (on p. 173 f. and in photo 8) appear to be very similar in clay and temper composition to the ones of the Last Byzantine Amphora type reported above.

90 Vroom 2014, 88 f. ›Measles Ware‹ has, interestingly, a slightly similar westward distribution to the Adriatic Sea.

91 See Arnold 1989, 35–38. 57–60; Rice 2015, 340–342.

Last Byzantine Amphora was produced by multiple workshops, which has led her to conjecture that a ›family‹ of similar-looking amphorae existed rather than just one type from a single origin[92]. In her view, the Last Byzantine Amphora was certainly not made in one workshop with a high degree of standardization[93]. Some diversity in the potting techniques is also evident in the published specimens and fragments from sites and shipwrecks along the Dalmatian coast[94]. When the Croatian archaeologists compared their finds, they noticed undeniable differences in rim dimensions, handle shapes, and ribbed surface patterns (see tab. 3). In fact, none of the Merara specimens of the Last Byzantine Amphora have any symmetry in rim or vessel profile, and all handles were deformed and rather sloppily made[95].

One find from Corinth seems to offer an interesting clue about the manufacturing technique for the Last Byzantine Amphora. Apparently, the body of this example was »slightly pinched at the middle«[96]. This could indicate that the vessel was made by the potter(s) in two separate parts: a lower half and an upper half which were put together in a next stage of production. At this moment, it is unclear whether this holds true for the type in general.

The pronounced ribs or ridges, which are so typical of the Last Byzantine Amphora, were certainly added to the exterior of the body during the last stage of the potting process and were sometimes flattened or pared with a sharp tool (tab. 3). Finally, the surface was self-slipped or smoothed with a cloth or wet sponge inside and out. Sometimes this created a buff-colored wash on the exterior body or the handles, on which the potter(s) in some instances added a painted decoration in a matte red-brown or light red wash (2.5 YR 6/6). Painted motifs on the Last Byzantine Amphora varied from vertical and horizontal stripes or broad strokes to, in one case, a possible large version of the Greek letter *theta* (Θ) from the shoulder towards bottom[97]. It is possible that more examples were painted; however, many of the amphorae discussed here were found in conditions (field surveys and underwater sites) not ideal for the preservation of such delicate decorations.

THE LAST BYZANTINE AMPHORA: FUNCTION AS MOBILE CONTAINER

The morphological features of amphorae are certainly related to the way they were used, particularly for loading and unloading, transportation, storage, etc. (see tab. 3). In addition, the features may also offer valuable indications about the nature of maritime trade, the ships, and the harbor types through which they changed hands[98]. When one sets out to correlate shape to function for the Last Byzantine Amphora, one may observe that the vessel has a pointed toe, which made it unsuitable for storage on a floor but very suited for stacking in a ship. In terms of function, one should therefore think of maritime transport rather than storage in a fixed location, such as, for instance, a household.

Furthermore, the wide and thick strap handles of the Last Byzantine Amphora were specifically suited for easy handling, while the limited size and thick walls were well-suited for fast and not over-careful handling during loading and unloading on ships. All of these features point to a function as a transport container for typical Mediterranean staple goods, such as wine, oil, or grain. Notwithstanding its modest size, the vessel was probably heavy when full (ca. 40 l), and the pronounced horizontal ribs on its exterior body may well have aided grip during loading and

92 Tzavella (forthcoming).
93 Specialization leads to routine production of pottery and thus to a decrease in variety, which results in more standardized output (cf. Costin 1991, 34; Rice 2015, 364 f.). This is not seen in the production of the Last Byzantine Amphora.
94 Zmaić 2013, 83.
95 Zmaić 2013, 83 fig. 6.
96 Williams – Zervos 1992, 164.
97 As described in Sanders 2008, 404; see fig. 2 left.
98 McCormick 2012.

Shape	Pres. H./L. (cm)	Rim Diam. (cm)	Body Diam. (cm)	Handles (cm)	Capacity (litres)	Surface exterior	Surface interior	Date	Label/ Decoration
Agios Stephanos (2008, no. 4017)	33.1	4.8–6.2		Broad and flat		Ribbed	Wheel-ridged	Late 13th to early 14th cent.	Painted Greek letter *theta* (?)
Agios Stephanos (2008, no. 4073)	38.7	7.5		4.4 (W.); 1.3 (Th.) slightly ribbed	40–41	Ribbed	Wheel-ridged	Late 13th to early 14th cent.	
Corinth (1992, no. 36)	37.5; 2 (rim-neck)	6.8	18.2	5.4 (W.)		Ribbed			Painted broad vertical (4) and horizontal (1) strokes in red wash
Corinth (1988, no. 19)	34.5		19.2			Ribbed			
Kalydon (2011, no. 12)	9.5; 20; 6.5					Ribbed	Thick black substance coating		
Kalydon (2011, no. 13)	19					Ribbed			
Sikyon (no. 30)	5.4		18-21			Heavily ribbed; yellow-ish beige slip	Self-slipped		
Sikyon (no. 31)	5	8.5				Overfired (?)	Self-slipped		
Sikyon (no. 32)	5.3	8.5				Yellowish white slip	Yellowish white slip		
Nemea (2016, no. 238)				9.5 (W.); Slightly ribbed		Yellowish beige slip			
Kastri (2014, no. M 42)	16.5			6.5 (W.); 1.6–1.7 (Th.); Slightly ribbed		Smoothed			Painted dark red-brown wavy stripe
Krapanj	39–40	ca 6.4	18	Broad, flat, loop-handles		Ribbed		1266–1291	
Lučnjak						Ribbed			
Merara				Deformed		Ribbed			
Stymfalia		ca 6.0							
Dürres						Ribbed			
Aipeia				Broad, flat		Ribbed			

Table 3 Overview of various features of the Last Byzantine amphora according to sites mentioned in this chapter

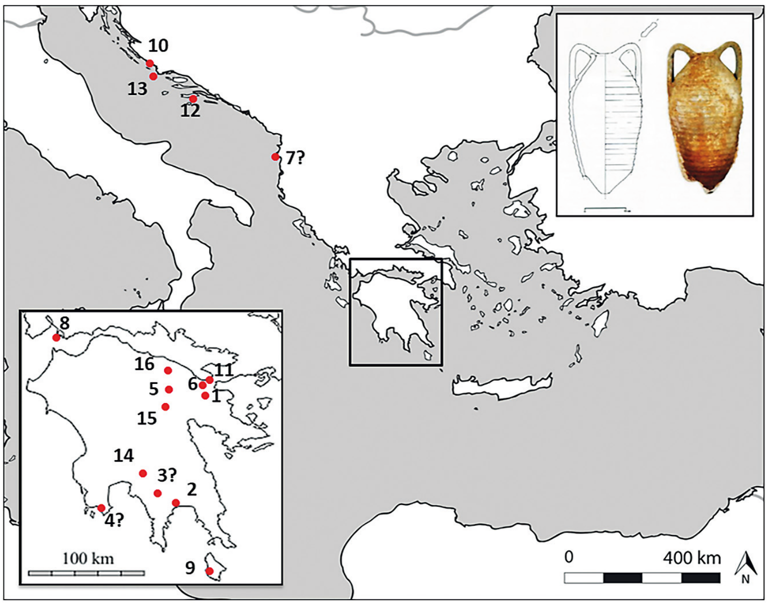
unloading from docks to ships, which was of course especially needed in the case of the transport of fluid commodities.

THE LAST BYZANTINE AMPHORA: FUNCTION AS A TRANSPORT VESSEL

The transportability of amphorae is a complex subject[99]. The manner of transport of mobile containers, such as amphorae, depended on the value of their contents as well as their shape, size, weight, and fragility. Access to roads and waterways was crucial[100]. All of these aspects must be considered in conjunction with each other when discussing the function of such an amphora as a transport vessel.

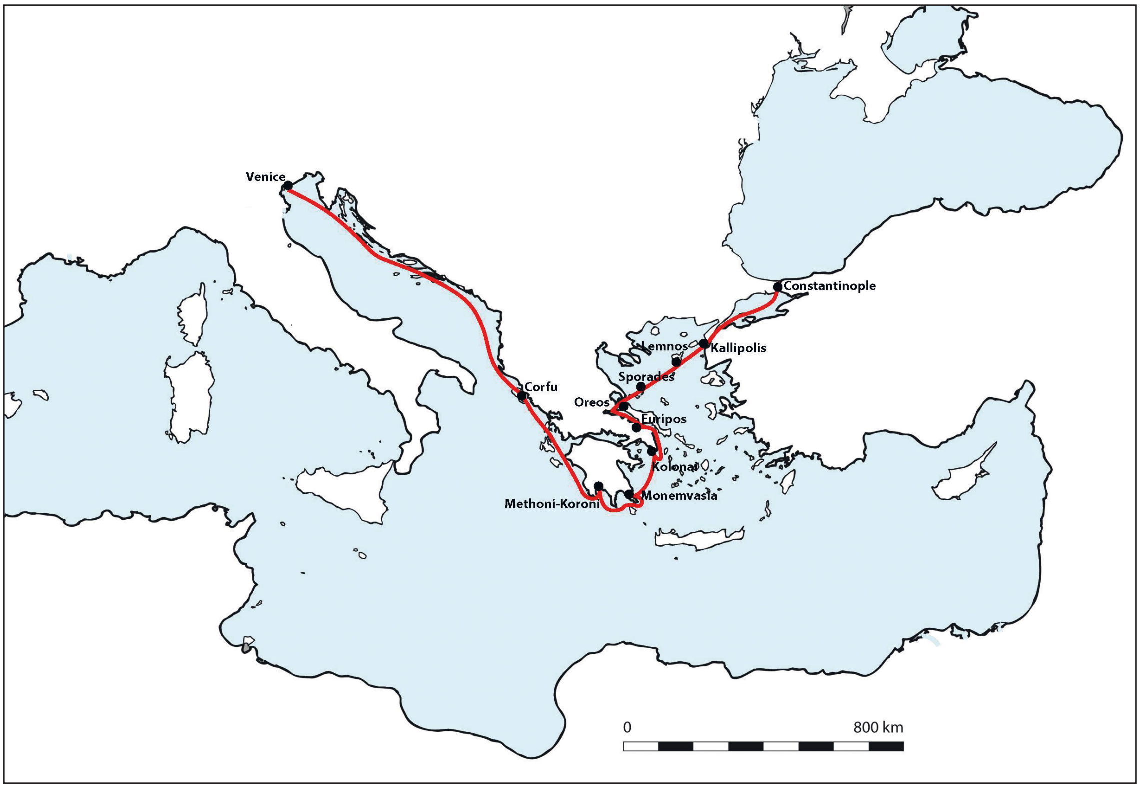
From the perspective of ease of transport, a striking aspect of the Last Byzantine Amphora is the geographical distribution of finds. The circulation of the vessel seems to have stretched on an interregional scale from the southern Peloponnese to the Corinthian Gulf, with a find-spot cluster near Corinth and along the eastern Adriatic coastline (see fig. 7). As several examples of the Last Byzantine Amphora have been recovered from shipwrecks or underwater sites off the Dalmatian coast, it is certain that these containers were transported on boats to these places.

The firm dating of the type makes it clear that this transport occurred in a period when Venice gradually came to rely more and more on the Adriatic as its agricultural hinterland, as the city-state steadily secured its access to valuable staple goods in the region and regulated their circulation where possible[101]. This concerned not only the import of grain, olive oil, salt, wine, and other crops but also the supply of manpower for Venice's industries and service aboard its galleys. However, the inhospitable environment of the eastern Adriatic coastline between Istria and Albania, with its rocky shores and mountainous hinterland, was too infertile to sustain much cultiva-

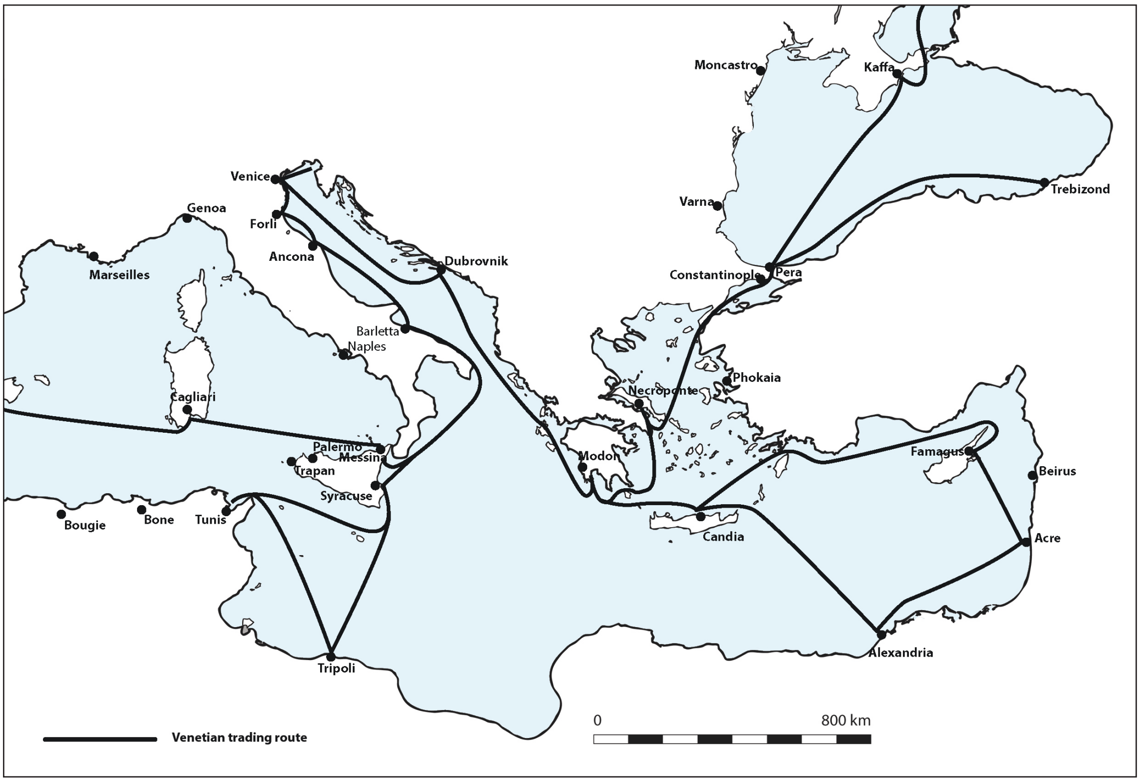


7 Distribution map of the find-spots of the Last Byzantine Amphora in the Adriatic Sea and the eastern Mediterranean: 1: Acrocorinth, 2: Agios Stephanos, 3: Agios Vasilios, 4: Aipeia, 5: Stymfalia, 6: Corinth, 7: Dürres, 8: Kalydon, 9: Kastri, 10: Krapanj Island, 11: Loutraki, 12: Lučnjak Island, 13: Merara Islet, 14: Mystras, 15: Nemea, 16: Sikyeon (Vroom – van IJzendoorn; amphora drawing after: Zmaić 2013, fig. 7)

99 Rice 2015, 372–374.
100 Peacock 1982, 8 f. 106.
101 Lock 1995, 246–249; Dorin 2012, 241 f.; Zmaić Kralj 2017, 55 f.



8 Map with route of the Byzantine Emperor John VIII Palaiologos (1392–1448), shown with a red line (© by the authors)



9 Map with maritime trading routes of Venice in the Mediterranean and in the Black Sea (© authors after Haldon 2005, map 11.5)

tion of wheat or olives[102]. Consequently, harbor cities along the Dalmatian coast themselves relied increasingly on agrarian imports from other regions, especially as their populations grew beyond the productive capabilities of their surroundings[103].

Soon Venice was forced to look beyond the Adriatic for imports of essential commodities. From the mid-13th century, there was clearly a growing western demand for large volumes of specific Mediterranean foodstuffs and wines, which resulted in an intensification of Venetian trade[104]. Thus, a string of key ports along the Dalmatian coast came under the control of the city-state to facilitate and secure a shipping lane for the maritime voyages whose final destinations lay outside the Adriatic region[105]. In this way ships were able to stay close to the shore while they were also able stop regularly in safe ports to stock up on supplies of fresh food and drinking water, which offered the opportunity to take advantage of these stops and exchange products.

Hence, the crew and merchants aboard Venetian ships could engage in small-scale trade in each Adriatic or Aegean harbor they visited through a close-knit system of port-hopping or coasting trade[106]. It seems many of the ships that sailed beyond the Adriatic eventually returned there from eastern Mediterranean destinations (specifically Crete, Constantinople, and Alexandria) carrying high-value, low-weight commodities in addition to bulky staple goods and ballast[107]. A good example of this system of port-hopping is shown by the maritime journey from Venice to Constantinople undertaken by the Byzantine Emperor John VIII Palaeologus (1392–1448)[108]. While traveling between these two cities, he stopped at Corfu, Methoni-Koroni, Monemvasia, Kolonai (Sounion), Euripos (Chalkis/Negroponte), and Oreos (both on the island of Euboea), the northern Sporades, Lemnos, and Kallipolis (see fig. 8).

As a result, it seems that the ships carried a mix of products of local or regional origin and products obtained by long-distance trade, perhaps exchanging these as opportunities arose (fig. 9). Apart from carrying staple goods to Venice, there was also space for small-scale trade at various harbors, as it seems that large wooden barrels and smaller ceramic transport vessels, such as the Last Byzantine Amphora, were stored and transported together on ships. According to D. Jacoby, merchants diversified the distribution of goods from the mid-13th century onward by enlarging the range of brands and qualities of oil and wine they offered. This flexible and efficient strategy was not only successful thanks to competitive prices but also stimulated new demands in taste[109].

A NEW PERSPECTIVE ON PROVENANCE AND HISTORY OF USE OF THE LAST BYZANTINE AMPHORA

The new data and arguments presented above offer grounds for a new perspective on the vessel type which is here called the Last Byzantine Amphora. It certainly allows us to formulate the following conjectures, arguments, and ideas about this interesting ceramic container (fig. 1 and tab. 3).

Firstly, the evidence indicates that the Last Byzantine Amphora was relatively frequently found at inland sites in the Peloponnese, with a concentration in the southern as well as the north-eastern Peloponnese. The fabric of these vessels, with its many limestone inclusions, suggests that these amphorae were made in a calcareous sedimentary region (the use of marl lime-rich clays was common for pottery throughout the Peloponnese). The laminated fabric of the amphora looks

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102 Dorin 2012, 242.
103 Dorin 2012, 259–261.
104 Jacoby 2010, 144.
105 Dorin 2012, 278; Zmaić Kralj 2017, 49 fig. 4.
106 Lock 1995, 253; Dorin 2012, 238.
107 Lock 1995, 249. 251–254; Dorin 2012, 264. Examples of the Late Byzantine Amphora from shipwrecks near the island of Vela Arta off the Dalmatian coast were found with ballast stones: see Brusić 1976, 42 pl. 10 cat. 6.
108 Koder – Hild 1976, 102 n. 392, based on Sylvester Syriopoulos' Mémoires.
109 Jacoby 2010, 145.

similar to fabrics typical of the southern coasts of the Peloponnese (Messenia and Laconia). A southern Peloponnesian provenance for the Last Byzantine Amphora is therefore probable, even more so because the fabric of some 20 % of locally manufactured pottery in this area has a similar fabric[110].

Secondly, the shape of the Last Byzantine Amphora, with its modest size and pointed toe, made it suitable for stacking in ships for maritime transport. Its large, broad handles were convenient for easy handling during loading and unloading between docks and ships. The effectiveness of this vessel during transport is further shown by its maximum volume capacity of ca. 40 liters, which works well for a human porter who can generally carry a container of 25–45 kg[111].

Typical for all specimens of the Last Byzantine Amphora found so far is the pronounced ribbing on the exterior surface. This kind of distinct ribbing is not to be found on any other Byzantine amphorae, ranging from the earliest ones in the 7th century to the later products of the late 12th–early 13th century[112]. In fact, a clear parallel for such ribbing, but on large storage jars, is offered by the 19th- and early 20th-century *pithoi* from Koroni, which were predominantly used for the packing and storing of large amounts of olive oil[113]. It is therefore highly likely that the smaller-sized Last Byzantine Amphora was used for the transport of such a highly processed fluid commodity.

In this respect, the two specimens of the Last Byzantine Amphora at Agios Stephanos in Laconia are significant. They were found during the excavation of a Late Byzantine house, which has been associated with the production, storage, and transportation of agricultural products, such as olive oil and wine[114]. This makes the existence of a nearby pottery workshop for the manufacture of large bulk containers and amphorae needed for storage and transport likely, as such a symbiotic organization of local production of valuable liquids and their containers seems to have been a recurring phenomenon in the Byzantine countryside[115]. The production of amphorae is a specialized skill but not necessarily linked to extreme specialization and industrialization typical of a production center located in a city or port, and it could also have taken place in a rural environment, which could explain the rather sloppy and crude appearance of many specimens of the Last Byzantine Amphora.

Thirdly, written sources clearly indicate that the southern Peloponnese was producing vast quantities of quality fluid commodities during the period of Frankish and Venetian occupation (13th–15th cent.), and the olive in particular was an important crop in the rural exploitation of Messenia and Laconia. Jacoby suggests that Byzantine landowners on the peninsula reacted to growing demand and lucrative export prospects by encouraging the intensification of oil production in this region during the early 13th century. Apparently, Messenia was the richest region for growing olive trees and producing high-quality oil[116]. Olive oil was expensive, but prices varied according to quality, ranging from *olio chiaro* (refined virgin olive oil) to *olio grosso* (coarse olive oil)[117].

The written documents mention not only the cultivation of olive trees and the production of oil but also the export of considerable amounts of olive oil from the southern Peloponnese to Venice through the Adriatic by the second half of the 13th century[118]. As there is no evidence in the ar-

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110 D. Williams in: Zmaić 2013, 87.

111 Bevan 2014, 402. The amphora volume was calculated by an application developed by CréA-Patrimoine (Research Centre in Archaeology and Heritage).

112 Vroom 2014, 52–61. 94–103.

113 Blitzer 1990, 687 fig. 2; Vroom 2014, 196 f.; see fig. 6. The ribs on the *pithoi* from Koroni were known as ζωνάρια (*zonaria*). Wine was only stored in these »if one could not afford a wooden barrel, which was always considerably more expensive« (Blitzer 1990, 685 f.).

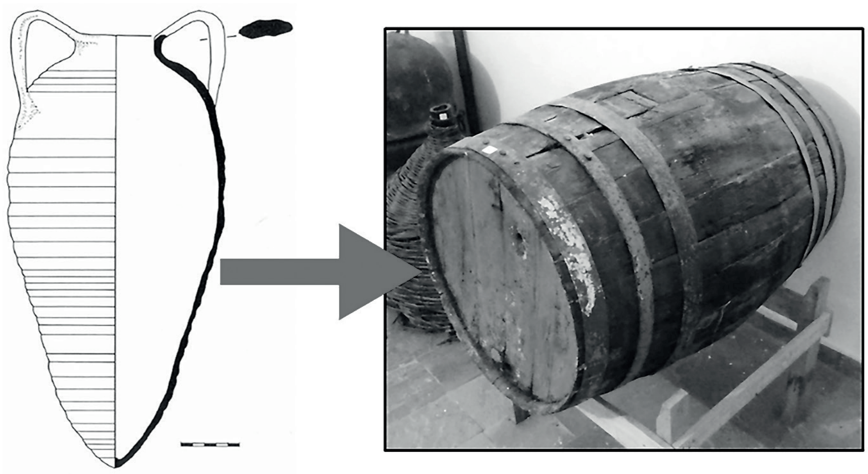
114 Sanders 2008, 98; Armstrong 2009, 317.

115 Cf. Rice 2015, 373. A similar situation existed, for instance, at the monastery of Ganos, where, from the 11th until the early 14th cent., wines were produced together with the ceramic containers in which to export them: Günsenin 2009, 147.

116 Jacoby 2015, 239 f.

117 Jacoby 2015, 242.

118 Jacoby 2015, 243 f.



10 The Last Byzantine Amphora type eventually being replaced by a wooden barrel (amphora drawing after: Sanders 1989, fig. 5 left; photo: J. Vroom)

chaeological repertoire of large numbers of late medieval ceramic containers, one must conclude that transport on this scale predominantly took place in wooden barrels. Before the 12th century, wooden casks were only sparsely used in the eastern Mediterranean, but somewhere in the course of the 14th century, they replaced ceramic vessels as the main transport container, and thus amphorae disappeared (see fig. 10). The demise of the fragile vessels is clearly related to the success of containers, such as barrels, bellows, and sacks, which could be stacked more efficiently, were less breakable, and were much lighter in weight, hence facilitating more economical loading and unloading as well as safer transport of their contents[119].

However, the use of wooden barrels for transport also had disadvantages because they were notoriously leaky for most of their history[120]. This held true especially for contents such as olive oil »that was prone to expand at hotter temperatures and ooze out between the staves«[121]. New barrels also soaked up some of their contents (especially olive oil), wasting the ship's cargo and leading to residues that were difficult to remove. Thus, wooden barrels needed constant maintenance and were not easily recyclable, which is why coopers were often part of a ship's crew[122].

Despite the competition with contemporary wooden barrels, which were by then obviously more suitable for the transport of wine than ceramic containers, the transport of liquids in smaller quantities still took place in ceramic containers during the 13th and 14th centuries, as shown by the presence of the Last Byzantine Amphora at Peloponnesian sites and in shipwrecks in the Adriatic. To prevent the spilling of wine and especially olive oil, this vessel with its distinctive ribbed exterior had an advantage over a wooden barrel because the ribs offered better grip for bare hands. The thick black substance coating the interior of one example from Kalydon, which was applied to make the amphora less porous, seems also to point to the transportation of a liquid[123]. In short, all the evidence suggests that is it highly likely that the Last Byzantine Amphora was used primarily for the transport of olive oil from the southern Peloponnese northwards to the Adriatic, possibly all the way up to Venice. However, no find-spot on the Italian peninsula has been discovered yet.

Fourthly, specimens and fragments of the Last Byzantine Amphora are often found in both Greece and the Adriatic in combination with Archaic Maiolica, which was produced in central or

119 Bakirtzis 1989, 81. 84–87 pls. 22, 5; 53 b; Vroom 2003, 155.
120 Jacoby 2010, 142 n. 181.
121 Boulanger 1996, 26; Bevan 2014, 402.
122 Bevan 2014, 402.
123 Bollen 2011, 259.

northern Italy (see tab. 2). This ware can be dated between the mid-/late 13th and mid-14th century. It is more than likely that Venice played a role as a transit station for the circulation of these decorative Italian tablewares by way of its ports and strongholds to the Peloponnese and beyond[124]. The locations at which the Last Byzantine Amphora has been found so far surely match one part of the long-distance maritime route between Venice and important commercial hubs in the eastern Mediterranean (e.g., Crete, Constantinople, Alexandria; see fig. 9). The Venetian Republic was heavily involved in this eastern Mediterranean traffic and trade system through the frequent traffic of its galleys along the Dalmatian shores, the Corinthian Gulf, and the western Peloponnesian coast to the east, whereby olive oil from the southern Peloponnese was conveyed on return voyages to Venice, as the written sources clearly indicate[125].

During this period, large amounts of local wine were transported from the Peloponnese and Crete to Constantinople and Venice as well[126]. Early 13th-century records suggest the presence of *Monemvasios oinos* (the highly sought-after malmsey wine from Monemvasia in southern Laconia) served during a Latin banquet at the Byzantine court[127]. However, not a trace of the Last Byzantine Amphora has been documented so far in the Aegean or in the Black Sea region[128]. Even more telling perhaps is that this vessel type has not been found yet in important Byzantine commercial cities to the east and northeast of the Peloponnese, such as Athens, Thebes, Chalkis/Negroponte, Thessaloniki, and Constantinople/Istanbul. This suggests that the Last Byzantine Amphora did not play a part in the transport of wine (or any other staple goods) in an eastern direction. Probably the transport of wine throughout the Aegean was carried out by Günsenin 3 amphorae, which were produced in Chalkis/Negroponte until sometime in the 13th century and thereafter in wooden barrels, which was probably more in line with the Frankish tradition[129]. It is likely that this distribution pattern correlates somehow to the economic and/or geopolitical situation of the time[130]. Whether competition between producers or rivalry among Italian middlemen from various city-states played a role is as yet unclear. Boundaries between Byzantine territories and newly established Frankish states could have shaped commercial networks as well.

Fifthly, if it is true that the Last Byzantine Amphora was produced in the southern Peloponnese, it could have been transported overland via Kalamata, Sparta, Mystras, and Tripolis to Corinth and other locations in the northern Peloponnese where the vessel type has been found. Although Laconia is partly a mountainous region providing difficult terrain for the transport of liquids, this does not seem to have hindered regional trade overland[131]. The high-quality olive oil from the southern Peloponnese was so much in demand that it found its way throughout the peninsula, probably traded through local and regional fairs[132]. It is known from Early Modern times that intra-Peloponnesian distribution occurred via a network of overland routes to cities and settlements using both pack animals and carts[133]. Networks consisting of major land routes crossing the peninsula did exist, thus creating inland areas of high connectivity[134].

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124 Vroom 2011, 417–419. 426.

125 Jacoby 2015, 237 f.

126 Jacoby 2010, 143.

127 Lock 1995, 80 f. 253. Some have related the Venetian trade of this Peloponnesian wine, meant to meet the demands of European markets, to the Last Byzantine Amphora (Zmaić Kralj 2017, 58). However, because many specimens have been found in famous olive oil-producing regions in the southern Peloponnese and none at the city of Monemvasia, we conclude that this amphora type was likely utilized more for the transportation of oil.

128 A single handle fragment found at an excavation at Ephesos/Selçuk might indicate the first find of this amphora type on the Aegean coast of Asia Minor (personal observation). However, this small piece is of uncertain identification. Finding the Last Byzantine Amphora at this site is not surprising since Ephesos was important in several Crusades against the Turks and was located within the Italian sphere of influence: see Carr 2015.

129 See Harris 2007; Vroom 2014, 97–99; Jacoby 2015, 251–253; Waksman et al. 2018, 1118.

130 Bradley 1971, 348.

131 Armstrong 2009, 316 f. This is perhaps because in the mountains the transport of amphorae on pack animals is generally easier and cheaper than transport of barrels on carts.

132 Jacoby 2013, 235; Jacoby 2015, 75.

133 Blitzer 1990, 700.

134 See Sanders – Whitbread 1990, 354 fig. 7.

Sixthly, in light of all the evidence, it is more than probable that the Last Byzantine Amphora also passed through the fortified coastal towns of Koroni (Coron) and Methoni (Modon) on the southwestern Messenian peninsula. These settlements were the first Venetian possessions in the southern Peloponnese since 1206/1207, and both were major ports of call for ships returning to Venice from the eastern Mediterranean. Due to their strategic position on long-distance trade routes that were so crucial for Venice, they were known as »the chief eyes of the Republic«[135]. In particular, Koroni flourished as a major transhipment center for merchants and pilgrims traveling to and from the east.

In 1242, the presence of merchants from Ragusa (modern Dubrovnik) was recorded at Methoni[136]. It is also known from the sources that in 1386 one Greek resident of Koroni, named Jani Crimolisi, exported eleven barrels of olive oil from his city to Kotor on the Dalmatian coast[137]. Furthermore, the texts mention large-scale commercial transfer of olive oil from the inland areas of the Peloponnese to Koroni and Methoni, whence it was conveyed in casks to Egypt. It is well-documented that both towns were centers of wooden cask manufacture for the transport of fluid commodities; by around 1350, plenty of coopers and a hoop maker were active at Methoni and Koroni[138]. Records show that one Venetian merchant in Venice owned wooden casks from Koroni and Methoni containing at least 6,714 to 12,327 liters of oil[139].

In the mid-14th century, however, the two Venetian outlets suffered heavily from the Black Death and the increasing turmoil in Greek lands. This included the destruction of olive groves by the Ottoman Turks, who began plundering the Peloponnese from ca. 1358, and ultimately forced the quarreling Byzantine despots and Frankish rulers to acknowledge Ottoman suzerainty and pay tribute. These events seriously limited the production and export of oil[140]. This mid-14th-century collapse of the olive oil industry at Koroni and Methoni coincides with the end of the circulation of the Late Byzantine Amphora in the Peloponnese, the Corinthian Gulf, and the Adriatic region. The conclusion that Koroni and Methoni, and especially the oil exports from these Venetian strongholds, played a main role in the rise and fall of the Last Byzantine Amphora seems inescapable.

CONCLUDING REMARKS

During the Late Middle Ages, ceramic containers, such as amphorae, were certainly in decline in the eastern Mediterranean. The demise of these vessels, once the main means of single-use transport for liquid and nonliquid staple goods, was a result of the increased use of wooden barrels, bellows, and (leather) sacks. These were more stackable, lighter, and, in general, more efficient, though sometimes also more expensive, especially in the case of casks, which needed constant maintenance by coopers. Hence, changes in amphora fabrics, shapes, and sizes, as well as their use history and distribution in Late Byzantine times are revealing indicators for the changes in scale and overall organization of Mediterranean trade of bulk goods and other commodities in that period. This holds true for what must have been one of the last ceramic transport containers used in the eastern Mediterranean, labeled here the Last Byzantine Amphora (see fig. 10).

The archaeological evidence of contexts, and especially the lime-rich fabric, strongly suggest that the Last Byzantine Amphora was manufactured in the southern Peloponnese. Although the exact place of production is not yet clear, it is highly probable that manufacture took place in either Messenia or Laconia, as the fabric looks similar to the fabric of (later) *pithoi* from Koroni (*koroneika*) or to the fabric of (contemporary) ›Measles Ware‹, which was most likely produced somewhere in the southern Peloponnese.

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135 Miller 1908, 39 f. 152.
136 Dorin 2012, 267.
137 Jacoby 2015, 243 n. 239.
138 Jacoby 2015, 251 n. 322.
139 Jacoby 2015, 243.
140 Jacoby 2015, 244; see also Sanders 2008, 390.

The shape of the Last Byzantine Amphora appears to have been standard, though the quality of production seems not to have been particularly outstanding, and some variation occurs. There is, for example, not always symmetry between rim or vessel profiles, while handles were obviously misshapen in some specimens. The archaeological record suggests that the potting of the vessels was rather careless and quick. Still, the standardization in shape is evident in the overall morphological features: elongated ovoid body, pointed toe, very short neck, broad flat strap handles, and pronounced horizontal ribbed exterior. These characteristics offered instant recognition for small-time traders and consumers. Finally, the record shows that the vessel was suitable as fill material for architectural structures (such as churches and houses). Its production in an era when barrels became more common is perhaps related to a form of ›path dependence‹ on the part of traditional potters, who had already spent time developing ceramic vessels in small-scale production and invested in an economic system best suited to continue doing so, even if others produced differently or conditions favored another technological approach[141].

The distribution of the Last Byzantine Amphora seems to have stretched on a local/regional scale overland by simple transport (using pack animals) from the southern Peloponnese to the northern part of the peninsula and on an interregional scale by maritime routes to the Corinthian Gulf and the eastern Adriatic shores. So far, it has not been found elsewhere in the eastern Mediterranean: not in the Aegean, the Black Sea region, or the Levant. This restricted distribution seems to relate to the export in late medieval times of high-quality products, such as olive oil and wine, from the southern Peloponnese to adjacent regions as well as to the Dalmatian coast, where urban demand increased after the Adriatic route to the southern Peloponnese was secured by the maritime expansion of the Republic of Venice.

All evidence suggests that the Last Byzantine Amphora was transported from port to port by a system of one-way cabotage along the Peloponnesian and eastern Adriatic coasts. The ships most probably carried both large wooden casks full of valuable commodities. such as wine and oil, together with a limited number of smaller ceramic vessels. This would explain the relatively small quantities of the Last Byzantine Amphora currently known from sites and shipwrecks. Maybe this smaller-sized vessel was used as a specially developed container for the transport of high-quality commodities, such as the expensive virgin olive oil (*olio chiaro*) from the southern Peloponnese. It is known that wooden barrels could be inconvenient for the maritime transportation of olive oil, as they leaked and influenced the quality. The Last Byzantine Amphora was not only better equipped (smaller sized, less porous, better grip, recyclable) for the carriage of limited amounts of a valuable fluid commodity; perhaps it was also better for the preservation of its taste.

The maritime distribution of the Last Byzantine Amphora seems to have been part of the late medieval maritime system of the Venetian Republic, which ran by way of the southern Peloponnese to the east and to Constantinople. The written sources indicate that vast amounts of olive oil from the southern Peloponnese were loaded at the Venetian-controlled transit stations of Koroni and Methoni on the return voyage to Venice. The chronology of the economic rise and fall of these Venetian ports would explain the relatively short history of use of the Last Byzantine Amphora, which was restricted to the period between the second half of the 13th and the early 14th century. The end of its circulation in the Peloponnese, the Corinthian Gulf, and the Adriatic region coincides with the demise of these two Venetian strongholds around the mid-14th century as a result of the Black Death and the first Ottoman invasion of the Peloponnese. After reviewing all these arguments, we are confident in coining this type now as the ›Last Byzantine Amphora‹ from the Peloponnese.

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BIBLIOGRAPHY

Armstrong 2009 P. Armstrong, Merchants of Venice at Sparta in the 12th century, in: W. G. Cavanagh – C. Gallou – M. Georgiadis (eds.), Sparta and Laconia. From Prehistory to Pre-Modern. Proceedings of the Conference Held in Sparta, Organised by the British School at Athens, the University of Nottingham, the 5th Ephoreia of Prehistoric and Classical Antiquities and the 5th Ephoreia of Byzantine Antiquities, 17–20 March 2005, BSA Studies 16 (London 2009) 313–321.

Arnold 1989 D. E. Arnold, Ceramic Theory and Cultural Process (Cambridge 1989).

Athanassopoulos 2016 E. F. Athanassopoulos, Nemea Valley Archaeological Project. II: Landscape Archaeology and the Medieval Countryside (Princeton, NJ 2016).

Avramea 2002 A. Avramea, Land and sea communications, fourth-fifteenth centuries, in: A. E. Laiou (ed.), The Economic History of Byzantium: From the Seventh through the Fifteenth Century (Washington, DC 2002) 55–88.

Bakirtzis 1989 Ch. Bakirtzis, Βυζαντινά Τσουκαλολάγηνα (Athens 1989).

Bakirtzis 2009 Ch. Bakirtzis, Ceramiques et comblement des voutes a Sainte Sophie de Thessalonique, in: J. Zozaya – M. Retuerce – M. A. Hervás – A. De Juan (eds.), Actas del VIII Congreso Internacional de Cerámica Medieval, Ciudad Real-Almagro, del 27 de febrero al 3 de marzo de 2006 (Ciudad Real 2009) 697–702.

Bevan 2014 A. Bevan, Mediterranean containerization, Current Anthropology 55, 4, 2014, 387–418.

Blitzer 1990 H. Blitzer, ΚΟΡΩΝΕΪΚΑ: storage-jar production and trade in the traditional Aegean, Hesperia 59, 1990, 676–711.

Bollen 2011 E. Bollen, Byzantine pottery on the Central Acropolis, in: S. Diets – M. Stavropoulou-Gatsi (eds.), Kalydon in Aitolia 1: Reports and Studies. Danish/Greek Field Work. 2001–2005, Monographs of the Danish Institute at Athens 12, 1 (Aarhus 2011) 251–264.

Bommeljé 2009 S. Bommeljé, Three forts in a sea of mountains: The Lidoriki district and the Medieval history of Aetolia, in: J. Bintliff – H. Stöger (eds.), Medieval and Post-Medieval Greece: The Corfu Papers, BARIntSer 2023 (Oxford 2009) 1–13.

Boulanger 1996 P. Boulanger, Marseille, marché international de l'huile d'olive: un produit et des hommes de 1725 á 1825 (Marseille 1996).

Bradley 1971 R. Bradley, Trade competition and artefact distribution, WorldA 2, 3, 1971, 347–352.

Braudel 1992 F. Braudel, Civilization and Capitalism (15th–18th Century), II: The Wheels of Commerce (Berkeley, CA 1992).

Braudel 1998 F. Braudel, Mediterranean in the Ancient World (London 1998).

Brusić 1976 Z. Brusić, Byzantine amphorae (9th–12th century) from eastern Adriatic underwater sites, AJug 17, 1976, 37–49.

Brusić 2010 Z. Brusić, Ranosrednjovjekovni nalazi iz hrvaskog podmorja, Archaeologica Adriatica 4, 2010, 243–255.

Carr 2015 M. Carr, Merchant Crusaders in the Aegean, 1291–1352 (Martlesham 2015).

City of Mystras 2001 The City of Mystras, Mystras, August 2001–January 2002 (Byzantine Hours: Works and Days in Byzantium) (Athens 2001).

Costin 1991 C. L. Costin, Craft specialization: Issues in defining, documenting, and explaining the organisation of production, Archaeological Method and Theory 3, 1991, 1–56.

Cunliffe 2017 B. Cunliffe, On the Ocean. The Mediterranean and the Atlantic from Prehistory to AD 1500 (Oxford 2017).

Demangel – Mamboury 1939 R. Demangel – E. Mamboury, Le quartier des Manganes et la première région de Constantinople (Paris 1939).

Dorin 2012 R. W. Dorin, Adriatic trade networks in the twelfth and early thirteenth centuries, in: C. Morrisson (ed.), Trade and Markets in Byzantium. Dumbarton Oaks Byzantine Symposia and Colloquia (Washington, DC) 235–279.

Epstein 2009	S. A. Epstein, An Economic and Social History of Later Medieval Europe, 1000–1500 (Cambridge, NJ 2009).
Gertwagen 2004	R. Gertwagen, Does naval activity – military and commercial – need artificial ports? The case of Venetian harbours and ports in the Ionian and Aegean Sea till 1500, in: G. K. Livadas (eds.), Graeco-Arabica IX–X. Festschrift in Honour of V. Christides (Athens 2004) 163–181.
Gertwagen 2016	R. Gertwagen, A chapter on maritime history: Shipping and nautical technology in the Medieval Mediterranean (11th–16th century), in: M. Borgolte – N. Jaspert (eds.), Maritimes Mittelalter: Meere als Kommunikationsräume. Vorträge und Forschungen 83 (Ostfildern 2016) 109–148.
Giannopoulou 2010	M. Giannopolou, Pithoi: Technology and History of Storage Vessels Through the Ages, BARIntSer 2140 (Oxford 2010).
Günsenin 2009	N. Günsenin, Ganos wine and its circulation in the 11th century, in: M. M. Mango (ed.), Byzantine Trade, 4th–12th Centuries The Archaeology of Local, Regional and International Exchange. Papers of the Thirty-eighth Spring Symposium of Byzantine Studies, St John's College, University of Oxford, March 2004 (Oxford 2009) 145–153.
Harris 2007	J. Harris, More Malmsey, Your Grace? The export of Greek wine to England in the later Middle Ages, in: L. Brubaker – K. Linardou (eds.), Eat, Drink, and Be Merry (Luke 12:19). Food and Wine in Byzantium. Papers of the 37th Annual Spring Symposium of Byzantine Studies, in Honour of Professor A. A. M. Bryer (Farnham 2007) 249–254.
Horden – Purcell 2000	P. Horden – N. Purcell, The Corrupting Sea. A Study of Mediterranean History (Hoboken 2000).
Jacoby 2010	D. Jacoby, Mediterranean food and wine for Constantinople: The long-distance trade, eleventh to mid-fifteenth century, in: E. Kislinger – J. Koder – A. Külzer (eds.), Handelsgüter und Verkehrswege. Aspekte der Warenversorgung im östlichen Mittelmeerraum (4. bis 15. Jahrhundert), Veröffentlichungen zur Byzanzforschung 18 (Vienna 2010) 127–147.
Jacoby 2012	D. Jacoby, The eastern Mediterranean in the later Middle Ages: An island world?, in: J. Harris – C. Holmes – E. Russell (eds.), Byzantines, Latins, and Turks in the Eastern Mediterranean World after 1150 (Oxford 2012) 93–117.
Jacoby 2013	D. Jacoby, Rural exploitation and market economy in the Late Medieval Peloponnese, in: S. J. Gerstel (ed.), Viewing the Morea. Land and People in the Late Medieval Peloponnese (Washington, DC 2013) 213–275.
Jacoby 2014	D. Jacoby, The economy of Latin Greece, in: N. I. Tsougarakis – P. Lock (eds.), A Companion to Latin Greece (Leiden 2014) 185–216.
Jacoby 2015	D. Jacoby, The Byzantine social elite and the market economy, eleventh to mid-fifteenth century, in: A. Frazier – P. Nold (eds.), Essays in Renaissance. Thought and Letters. In Honor of John Monfasani (Leiden 2015) 67–86.
Jacoby 2016	D. Jacoby, Constantinople as commercial transit center, tenth to mid-fifteenth century, in: P. Magdalino – N. Necipoğlu (eds.), Trade in Byzantium. Papers from the Third International Sevgi Gönül Byzantine Studies Symposium (Istanbul 2016) 193–210.
Jacoby 2017	D. Jacoby, Western commercial and colonial expansion in the eastern Mediterranean and the Black Sea in the Late Middle Ages, in: G. Ortalli – A. Sopracassa (eds.), Rapporti mediterranei, pratiche documentarie, presenze veneziane: Le reti economiche e culturali, XIV–XVI secolo (Venice 2017) 3–49.
Johnston et al. 2014	A. Johnston – K. Slane – J. Vroom, Kythera forty years on: The pottery from historical Kastri revisited, BSA 109, 2014, 3–64.
Kocabaş et al. 2016	U. Kocabaş – I. Özsait-Kocabaş – E. Tűrkmenoğlu – T. Gűler – N. Kılıç, The world's largest collection of Medieval shipwrecks: The ships of the Theodosian harbor, in: P. Magdalino – N. Necipoğlu (eds.), Trade in Byzantium. Papers From the Third International Sevgi Gönül Byzantine Studies Symposium (Istanbul 2016) 363–378.
Koder – Hild 1976	J. Koder – F. Hild, Hellas und Thessalia, TIB 1 (Vienna 1976).
Kolditz 2017	S. Kolditz, Connectivity and sea power – entangled maritime dimensions in the Medieval Mediterranean, in: C. Buchet – M. Balard (eds.), The Sea in History (Martlesham 2017) 58–69.

Konstantinidou 2018 A. Konstantinidou, Medieval pottery from two Messenian churches: The Transfiguration at Metamorfosi (Skarmingas) and Saint Nicholas in Aipeia, in: E. Zimis – A.-V. Karapanagiotou – M. Xanthopoulou (eds.), Το Αρχαιολογικό Έργο στην Πελοπόννησο 1. Πρακτικά του Διεθνούς Συνεδρίου Τρίπολη, 7–11 Νοεμβρίου 2012 (Kalamata 2018) 825–833.

Lock 1995 P. Lock, The Franks in the Aegean, 1204–1500 (London 1995).

MacKay 2018 C. MacKay, The Medieval pottery, in: S. Campbell (ed.), The Cistercian Monastery of Zaraka, Greece, Library Staff Research and Scholarship Paper 10 (Kalamazoo, MI 2018) 113–135.

Makris 2002 G. Makris, Ships, in: A. E. Laiou (ed.), The Economic History of Byzantium. From the Seventh through the Fifteenth Century (Washington, DC 2002) 91–100.

Mango 2009 M. M. Mango, Byzantine trade: Local, regional, interregional and international, in: M. M. Mango (ed.), Byzantine Trade, 4th–12th Centuries. The Archaeology of Local, Regional and International Exchange. Papers of the Thirty-eighth Spring Symposium of Byzantine Studies, St John’s College, University of Oxford, March 2004 (London 2009) 3–14.

Maniatis 2003 G. C. Maniatis, The perishable produce market in Byzantium: Organization, marketing and pricing policies, Byzantinoslavica 61, 2003, 143–150.

Manolova-Voykova 2018 M. Manolova-Voykova, Import of Middle Byzantine pottery to the western Black Sea coast: An overview, in: F. Yenisehirlioglu (ed.), XIth Congress AIECM3 on Medieval and Modern Period Mediterranean Ceramics Proceedings. October 19–24, 2015 (Ankara 2018) 93–105.

McCormick 2012 M. McCormick, Movements and markets in the First Millennium. Information, containers, and shipwrecks, in: C. Morrisson (ed.), Trade and Markets in Byzantium, Dumbarton Oaks Byzantine Symposia and Colloquia (Washington, DC) 51–98.

Miller 1908 W. Miller, The Latins in the Levant: a History of Frankish Greece (1204–1566) (New York 1908).

Muhaj 2019 A. Muhaj, The origins of the rivalry between the Ottomans and Venice in the Adriatic, in: H. B. Öcalan – Y. Z. Karaaslan (eds.), Uluslararası Yıldırım Bayezid Sempozyumu. 27–29 Kasım 2015, Bursa (Ankara 2019) 201–213.

Nakas – Krapf 2017 Y. Nakas – T. Krapf, Medieval ship graffiti from Amarynthos, Euboea, Greece, The IntJNautA 46, 2, 2017, 433–437.

Necıpoğlu 2017 N. Necıpoğlu, The Byzantine economy and the sea: The maritime trade of Byzantium, 10th–15th centuries, in: C. Buchet – M. Balard (eds.), The Sea in History (Martlesham 2017) 437–448.

Orlandos 1935 A. K. Orlandos, Ἐργασίαι ἀναστυλώσεως βυζαντινῶν μνημείων, ABME 2, 1935, 197–208.

Pagratis 2017 G. Pagratis, The Byzantine and Greek merchant maritime enterprises in the Medieval Mediterranean, in: C. Buchet – M. Balard (eds.), The Sea in History (Martlesham 2017) 425–436.

Papayannis – Sorotou 2008 T. Papayannis – A. Sorotou, Cultural landscapes of Mediterranean islands, in: I. N. Vogiatzakis – G. Pungetti – A. M. Marini (eds.), Mediterranean Island Landscapes. Natural and Cultural Approaches, Landscape Series 9 (Berlin 2008) 82–99.

Peacock 1982 D. P. S. Peacock, Pottery in the Roman World: An Ethnoarchaeological Approach (London 1982).

Rice 2015 P. M. Rice, Pottery Analysis. A Sourcebook ²(Chicago 2015).

Sanders 1989 G. D. R. Sanders, Three Peloponnesian churches and their importance for the chronology of late 13th and early 14th century pottery in the eastern Mediterranean, in: V. Déroche – J.-M. Spieser (eds.), Recherches sur la céramique byzantine. Actes du colloque EFA-Université de Strasbourg, Athènes 8–10 avril 1987, BCH Suppl. 18 (Athens 1989) 89–199.

Sanders 1993 G. D. R. Sanders. Excavations at Sparta: the Roman Stoa, 1988–91 preliminary report, part 1: (c) Medieval pottery, BSA 88, 1993, 251–286.

Sanders 2008 G. D. R. Sanders, The Medieval pottery, in: W. D. Taylour – R. Janko (eds.), Ayios Stephanos: Excavations at a Bronze Age and Medieval Settlement in Southern Laconia, BSA Suppl. 44 (London 2008) 389–410.

Sanders – Whitbread 1990 G. D. R. Sanders – I. K. Whitbread, Central places and major roads in the Peloponnese, BSA 85, 1990, 333–361.

Shear 1984 T. L. Shear Jr., The Athenian Agora: excavations of 1980–1982, Hesperia 53, 1984, 1–57.

Sotiriou 1956 M. G. Sotiriou, Mystra. Une ville Byzantine morte ²(Athens 1956).

Stilwell MacKay 2003 T. Stilwell MacKay, Pottery of the Frankish period, 13th and early 14th century, in: C. K. Williams – N. Bookidis (eds.), Corinth 20. The Centenary 1896–1996 (Princeton, NJ 2003) 401–422.

Tartari 1982 F. Tartari, Amforat e muzeut arkeologjik të Durrësit, Illiria 12, 2, 1982, 239–279.

Tzavella (forthcoming) E. Tzavella, The Middle Byzantine, Frankish and Ottoman periods, in: Y. Lolos (ed.), Sikyon 1. The Urban Survey, Meletemata (Athens forthcoming) 347–369.

van Doorninck 2002 F. van Doorninck, Byzantine shipwrecks, in: A. E. Laiou (ed.), The Economic History of Byzantium. From the Seventh through the Fifteenth Century (Washington, DC 2002) 899–905.

Vroom 2003 J. Vroom, After Antiquity. Ceramics and Society in the Aegean from the 7th to the 20th Century A.C. A Case Study from Boeotia, Central Greece, ASLU 10 (Leiden 2003).

Vroom 2011 J. Vroom, The Morea and its links with southern Italy after AD 1204: Ceramics and identity, Archeologia Medievale 38, 2011, 409–430.

Vroom 2014 J. Vroom, Byzantine to Modern Pottery in the Aegean. An Introduction and Field Guide ²(Turnhout 2014).

Vroom 2016 J. Vroom, Byzantine sea trade in ceramics: Some case studies in the eastern Mediterranean (ca. seventh – fourteenth centuries), in: P. Magdalino – N. Necipoğlu (eds.), Trade in Byzantium. Papers from the Third International Sevgi Gönül Byzantine Studies Symposium (Istanbul 2016) 157–177.

Vroom 2017 J. Vroom, The Byzantine web: Pottery and connectivity between the southern Adriatic and the eastern Mediterranean, in: S. Gelichi – C. Negrelli (eds.), Adriatico altomedievale (VI–XI secolo): Scambi, porti, produzioni, Studi e Ricerche 4 (Venice 2017) 285–310.

Vroom 2018 J. Vroom, On the trail of the enigma amphora: Following the flow of Middle Byzantine ceramic containers, Archeologia Medievale 45, 2018, 77–90.

Waksman et al. 2018 S. Y. Waksman – S. S. Skartsis – N. D. Kontogiannis – E. P. Todorova – G. Vaxevanis, Investigating the origins of two main types of Middle and Late Byzantine amphorae, JASc 21, 2018, 1111–1121.

Whitbread 2003 I. K. Whitbread, Clays of Corinth: The study of a basic resource for ceramic production, in: C. K. Williams – N. Bookidis (eds.), Corinth 20. The Centenary 1896–1996 (Princeton, NJ 2003) 1–13.

Williams – Zervos 1988 C. K. Williams – O. H. Zervos, Frankish Corinth: 1987. South of Temple E and east of the Theatre, Hesperia 57, 1988, 95–146.

Williams – Zervos 1992 C. K. Williams – O. H. Zervos, Frankish Corinth: 1991, Hesperia 61, 1992, 133–191.

Zmaić 2013 V. Zmaić, Late Byzantine amphorae from eastern Adriatic underwater sites, Skyllis 13, 1, 2013, 81–88.

Zmaić Kralj 2017 V. Zmaić Kralj, Byzantine maritime trade based on underwater archaeological finds of the eastern Adriatic, Skyllis 17, 1, 2017, 46–61.

Zmaić – Miholjek 2011 V. Zmaić – I. Miholjek, Medieval Byzantine shipwrecks in the eastern Adriatic, Skyllis 11, 1, 2011, 94–99.

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