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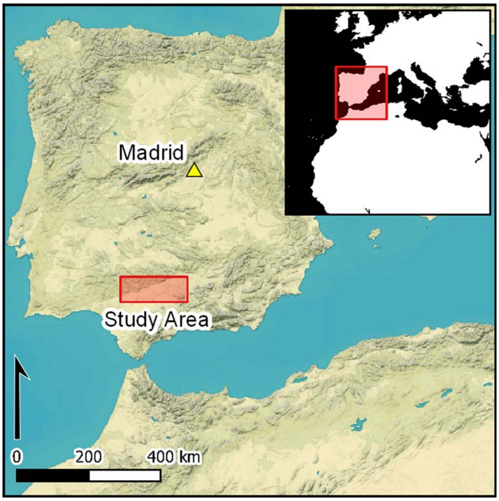
Research Article

Trends in the production of olive oil amphorae at ceramic workshops in Roman Baetica: a chrono-proportional representation method

Iván González Tobar[1,2,*]

[1] LabEx Archimède, University of Montpellier 3, France
[2] Facultat de Geografia e Historia (Departamento de Historia y Arqueología), University of Barcelone, C/ de Montalegre, 6, 08001 Barcelona
[*] Author for correspondence ✉ ivan.gontob@gmail.com



During the first few centuries AD, Rome and the imperial frontiers were supplied with olive oil from the province of *Hispania Baetica* (southern Spain). Vast quantities of oil were exported in Dressel 20 amphorae. But how did the agricultural economy of *Baetica* relate to global demand and how did it change over time? The author focuses on relative changes in agricultural output, using a new method to model fluctuations in amphora production based on more than 1000 waster sherds collected from 23 amphora workshops in the Guadalquivir Valley. The chrono-proportional representation method indicates variation in production between individual workshops and wider production districts, contributing to assessments of the scale and organisation of the Roman economy.

Keywords: Roman Spain, surface survey, statistical modelling, pottery production, transport amphorae, Roman economy

Introduction

Understanding of the scale and organisation of economic activity relies on the availability and accuracy of statistical information. For the contemporary world, these data are readily accessible through organisations such as *Eurostat*. Despite the great interest of archaeologists and historians in the dynamics of ancient trade and exchange, no comparable data are available to those who study the economy of the Roman world (Garlan 2000). No classical author cites any figures for the global quantities of commodities, such as olive oil or wine, produced and moved around the empire. Indeed, it remains unclear whether such data were collated

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and accessible to Roman officials and magistrates. The official records office of ancient Rome, the *Tabularium*, supposedly retained master copies of many transactions, though the degree to which public and private records were ever systematically centralised here or elsewhere is unknown (Posner 2003). With the exception of records for the production of the oil amphorae awarded as prizes at the Panathenaic Games (e.g. Oakley 1987: 199–200), understanding of production and trade in the ancient Mediterranean world depends on archaeological evidence. Yet, the fragmentary nature of the archaeological record presents its own challenges. For example, despite fundamental studies of the use of perishable containers, such as barrels and wineskins (e.g. Marlière 2002; Morillo *et al.* 2019), their underrepresentation or invisibility significantly complicates attempts to quantify global production (Tomber 1993: 145). In this context, ceramic containers—specifically, amphorae—are one of the few types of material which offers a potentially meaningful unit of measurement in its own right, and which are frequent enough in the archaeological record to allow robust quantification. The use of amphorae for the shipping of goods, such as wine, oil, fish sauce and other products, usually by sea and occasionally by river, therefore provides a basis for calculating the volumes of goods exported from a specific region. The first studies to use amphorae to evaluate Roman trade patterns began in the 1980s and focused in particular on large Roman port sites such as Ostia, Italy (Panella 1981). The degree to which these urban contexts are representative of wider production and exchange patterns, however, is not certain (Evans 1983: 79; Peacock & Williams 1986: 18).

Studies of other types of ceramic wares, such as Eastern Sigillata A (Willet 2014: 60), appear to confirm that quantitative research cannot hope to extend beyond a general sampling of each urban centre; moreover, it is then impossible to aggregate all the amphora evidence from many urban sites to create a single dataset. Influential examples of the modelling of the temporal distribution of finewares recovered from consumption contexts, however, include the pioneering studies of African Red Slip (Fentress & Perkins 1988; Fentress *et al.* 2004); such aoristic modelling has been refined using Gaussian and gamma distribution methods (Willet 2014) and applied to the study of Eastern Sigillata pottery within the framework of the ICRATES project (Bes 2015). The results of these studies document diachronic fluctuation in the volumes of finewares circulating in both urban and rural contexts, with potential relevance for the reconstruction of wider demographic and economic processes (Millett 1991; Bes & Poblome 2009). For example, fluctuations in the supply of African Red Slip ware appear to correlate with phases of building activity (Fentress & Perkins 1988: 210).

The quantification of amphorae used to transport goods from region of production to place of consumption therefore offers a promising means of estimating production and measuring exports. Acknowledging the problems of studying assemblages from consumption sites, as discussed above, we might therefore turn to the amphorae recovered from places of production. The amphorae recovered from such production sites offer great potential for quantification, as these sites are likely to have experienced less post-depositional disturbance than many consumption sites (Peña 2007) and, moreover, as they derive from the start of the economic process, this material will have passed through fewer transformative stages and should therefore present a more representative picture of production. In other words, amphorae that never left the workshop sites at which they were produced offer a more reliable set of data than those retrieved from distant consumption sites, and it is these data that must serve as the starting point for modelling global production.

To date, surveys of production areas—both of agricultural goods and the containers in which they were shipped—have focused primarily on archaeometric methods, notably petrography and provenancing studies, rather than the quantification of output. Examples of the latter, moreover, have encountered challenges. One study of amphora production at villa sites in the province of *Tarraconensis* (today, the north-east of Spain), for example, experienced difficulty differentiating between local and imported material (Tremoleda 2000: 295–302). Nonetheless, several studies have estimated the volumes of amphora production in Roman Gaul (Chabal & Laubenheimer 1994), and in the Guadalquivir Valley and around Cádiz in southern Spain (Carrato *et al.* 2018; García Vargas & Sáez Romero 2018). Focusing on production parameters, such as numbers of kilns and their capacities, firing frequency, use-life, and the size of the amphorae produced, these studies have quantified potential workshop output. Yet, many other considerations impact on overall output. Fluctuations in demand, for example, may lead to periods of kiln inactivity that complicate calculations based solely on the evidence of kiln structures.

The aim of the present study, therefore, is to advance a method that uses the evidence from amphora workshops as the basis for quantifying not their absolute production totals, but rather the relative change in their output over time. The method is tested using amphorae produced in the Roman province of *Hispania Baetica* (today, south-west Spain), which was the principal exporter of olive oil in the western empire during the first few centuries AD, including to the city of Rome (as part of the state-sponsored *annona* supply system) and to the military frontiers (the *limes*). Amphorae for the transport of Baetican oil, specifically the type known as Dressel 20, were manufactured at approximately 100 workshops (Berni 2008), with some three-quarters of these strung along the banks of the Guadalquivir (*Baetis*) for a distance of more than 100km, and along its main tributary, the Genil (*Singilis*); a smaller group of workshops was located on Spain's southern coast, around Cádiz, Málaga and Granada. The present study focuses on the northern part of the Baetican production area, comprising approximately one third of the total production zone in the Guadalquivir Valley and roughly corresponding to the *conventus Cordubensis*—that is, the territory of the Roman provincial capital of Corduba (today, Córdoba) (González Tobar 2022).

Materials and method

The method proposed here seeks to obtain a diachronic perspective on amphora production, as a proxy for agricultural exports, based exclusively on materials collected from amphora workshops. The workshops take the form of vast concentrations of amphora sherds distributed on the surfaces of agricultural fields (Figure 1). Most of these surface finds comprise amphora wasters—that is, sherds of amphorae discarded due to damage or deformation during the firing process. All pre-modern pottery workshops generated defective products; ethnographic studies point to a rate of between 5 and 10 per cent (Nicholson & Patterson 1985: 231). Based on the total number of wasters from a site, therefore, it is theoretically possible to arrive at a relatively accurate indication of overall production. It is impossible, however, to quantify all the wasters generated from each workshop in the study area, as there are

Figure 1. Aerial view of the Dressel 20 amphora workshop of Cortijo de Romero (Palma del Río, Córdoba), September 2016 (Base photograph: PNOA). Inset: detail of a concentration of surface amphora sherds (photograph by the author).

typically many tens of thousands of such sherds from each site. Furthermore, the object of interest here is not the absolute quantity of amphora production, but the relative fluctuations in production over time.

The method of quantification used here involves grouping and quantifying amphora rim sherds according to their typo-chronology. These absolute numbers are converted into percentages, with 100 per cent representing the total number of rims from each workshop; the resulting figures are plotted on a graph, with time (in the form of historically defined time periods) on the *x* axis. In this way, the amphora rim wasters act as proportional indicators of the varying volume of production over time. Moreover, as the graphs show relative change in amphora production, it is also possible to compare directly between sites with different sample sizes resulting from variation in post-depositional processes, site preservation, surface visibility and survey intensity.

Although the material from any individual workshop cannot be considered representative of fluctuations in production of the surrounding district, combining the results of multiple workshops can nonetheless yield sufficient data to identify overall trends. The Mean CPR percentage of each chronological period at each workshop can thus be combined with that of other workshops to determine a Mean CPR of a wider production district. This calculation not only takes into account variation in the average production of all workshops, but also specifies the number of workshops that were active or inactive at any time (inactive sites for a given period = 0 per cent). The resulting graphs thus approximate the fluctuations of a district's general production output.

From a statistical perspective, the Mean CPR percentages for each phase correspond to real values, but the time intervals are of varying lengths, complicating comparison between periods. For example, if two periods each represent 10 per cent of production, but the first period lasts 40 years and the second period lasts 20 years, then the second produced amphorae at twice the rate of the first. A simple rescaling is therefore required: each percentage is divided by the number of years of the corresponding time period. The new values are converted into a percentage and plotted as the Mean Scaled CPR.

To generate meaningful results, the method set out above requires data to meet a series of general conditions. First, although previous diachronic distribution modelling has incorporated material from both excavated and surface contexts (e.g. Willet 2014; Bes 2015), the size of assemblages recovered by limited excavations of small workshops is insufficient and potentially unrepresentative of those sites' full production histories. Hence, unless a workshop is completely excavated, yielding all discarded amphora waster sherds, the data should comprise surface finds only. Second, the surface survey data should derive from intensive and systematic surface collections, which maximise sample sizes. Amphora rim sherds are the most reliable vessel elements, as they are easily quantified and offer good chronological control; moreover, they do not require use of the Minimal Number of Individuals (MNI) method, which is needed for comparison of absolute sherd counts between assemblages recovered from excavated archaeological strata, where pottery fragmentation may vary significantly. Here, using surface survey data, the intention is not to compare absolute numbers, but rather the relative quantities of the different amphora subtypes. For the same reason, it is therefore also unnecessary to adopt the Estimated Vessels Equivalent (EVE) (Egloff 1973) or Modulus of Rupture (MR) (Mateo & Molina 2016) methods. Consequently, in the current analysis, one waster rim fragment equates with a unit of one, regardless of size or completeness. A final general requirement of the data demanded by the method used here is a minimum sample size of 20 amphora rim sherds per workshop. Smaller values are only used here for those workshops which were focused on demonstrably brief production activity. At the opposite end of the spectrum, there is no maximum limit on sample sizes. In fact, the greater the number of sherds, the more robust the results are likely to be.

Applying CPR to Baetican oil amphorae

The amphora workshops of the *conventus Cordubensis*, like their modern-day counterparts, were located in an easily accessible rural landscape. Repeated ploughing has progressively scattered archaeological materials across field surfaces and has standardised the degree of sherd fragmentation; it is rare to find complete rims still attached to their necks. Between 2016 and 2018, as part of the OLEASTRO research programme, I conducted surface surveys with a team of students, investigating 79 sites. Following a detailed review of the various additional criteria, other than amphora wasters, used to identify the sites as workshops (i.e. kiln fragments, firing supports and potters' stamps), 35 sites were classified as probable workshops and 23 as definite workshops (Figure 2).

The corpus used here comprises a total of 1018 Dressel 20 amphora rim sherds. By way of comparison, 1000 is the initial minimum number advocated by Fentress and Perkins (1988: 208) as necessary for their own statistical analysis of tablewares. The sample sizes of other projects include the database of the ICRATES Project, with 3660 entries (Bes & Poblome 2009: 75), and the excavations at Augst (Switzerland), which have yielded 1015 Dressel 20 rim sherds (Martin-Kilcher 1987: 198). Each rim sherd in the current corpus was drawn (González

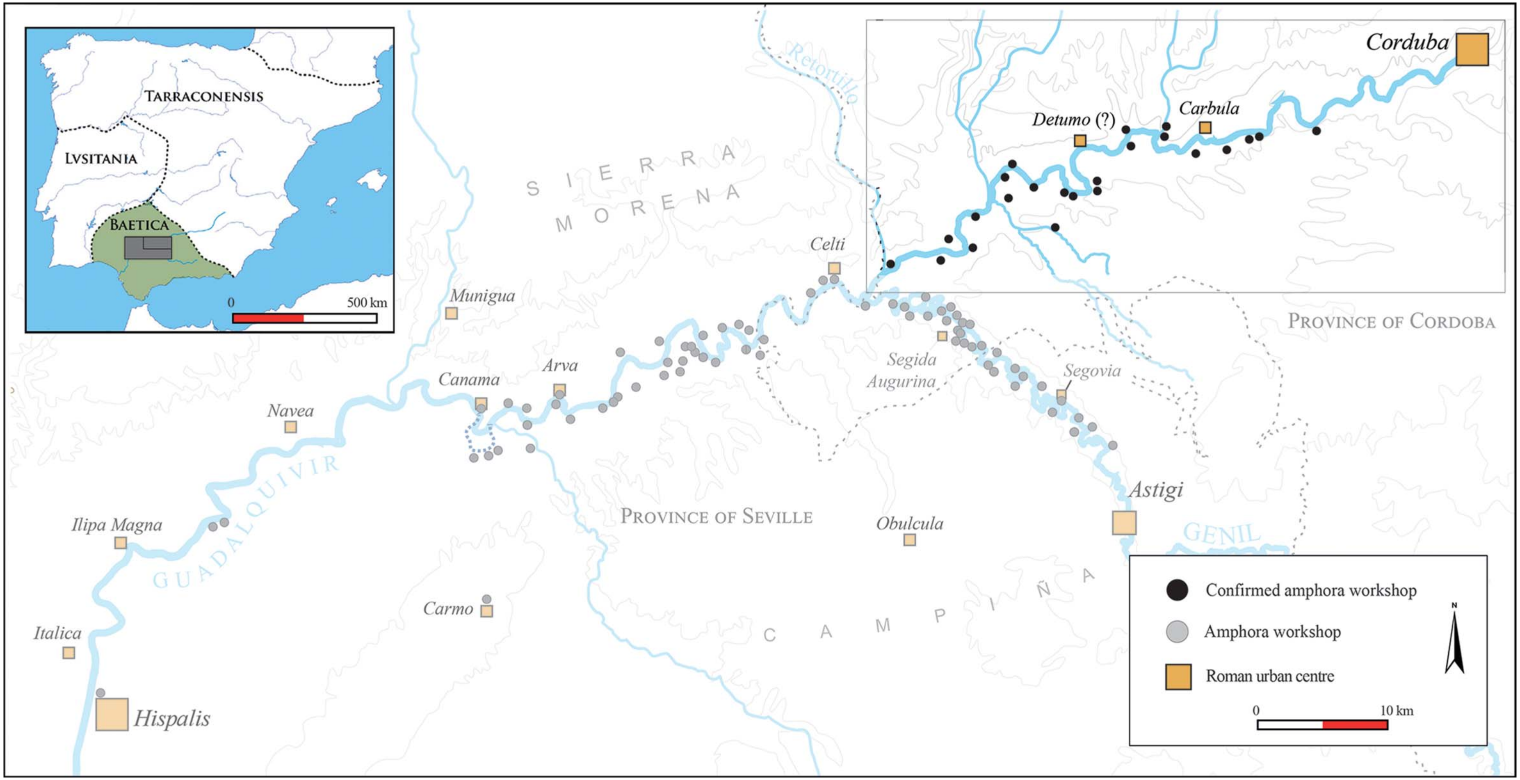
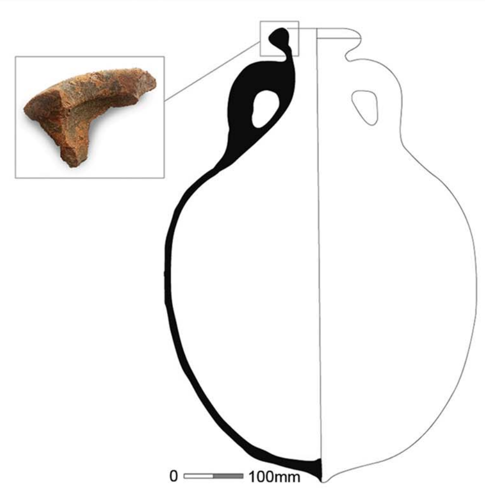


Figure 2. Map of the south of the Iberian Peninsula, with the position of the Baetican oil amphora workshops along the Guadalquivir and Genil Rivers. The study area is indicated by the frame to the upper right (figure by I. González Tobar, O. Bourgeon and Q. Desbonnets. ©LabEx Archimède).

Tobar 2020), prior to classification. The chrono-typological classification of Baetican oil amphorae is based on finds from consumption contexts, notably Augst (Martin-Kilcher 1987; Berni 2008, 2017). The present study uses the Martin-Kilcher (1987) typology. The latter resembles that subsequently advanced by Berni (2017: 186), with some variation of ±10 years in the dates assigned to specific types. For consistency, the current study retains the well-established categories of A to G from Martin-Kilcher (1987), rather than the revised A to F scheme of Berni (2017) (Figure 3).

Several issues merit attention. The first concerns undatable amphora rims. In this case, as MNI is not used and since any inability to a date a rim sherd can be assumed to be the same for all Dressel 20 subtypes, their exclusion here has no impact on overall chronological trends. In research for the current corpus, their small number (n = 7) is insignificant and they are excluded from the final total of 1018.

It is also necessary to comment briefly on the definition of wasters. The vast majority of Dressel 20 wasters are, in fact, indistinguishable from the sherds of Dressel 20 amphorae that were deemed to have been successfully fired and used for the export of oil. The number of confirmed over- or underfired examples is negligible, probably reflecting the success of workshop specialisation and a high level of control over firing temperatures. In the case of Dressel 20s, as for other amphorae, the high discard rate of vessels that were not visibly deformed can be explained by the strict quality requirements for containers whose breakage during transport would have led to the loss of approximately 70l of oil per vessel, and by the fact that production problems may have affected the amphora bodies, leaving the rim sherds studied here without obvious evidence of deformation. Each amphora, fresh from the kiln, must have undergone demanding quality control checks to cull any potentially defective vessels. The definition of a waster used here therefore encompasses both deformed sherds and those without any visible production faults. In order to be certain that the latter were indeed discarded



	Martin-Kilcher 1987	Berni 2017	Example
A (or Ob. 83 and Halt. 71)	30BC-AD30	20BC-AD30	
B	AD30-50	AD30-50	
C	50-70	50-80	
D	70-110	80-120	
E	110-150	120-160	
F	150-210	160-200	
G	210-280	200-270	
H (or Dr. 23)	280-400	270-400	

Figure 3. Drawing of a Dressel 20 amphora, photograph of the state of fragmentation of a typical rim (left) and typo-chronological data (right) (figure by I. González Tobar).

before use, and not later imported, the corpus includes only sherds from confirmed production phases of the 23 definite workshop sites (for an overview of the controversy around workshop identification and how to distinguish non-local amphorae recovered from workshops, see González Tobar 2020: 855–77).

Informed by foundation and abandonment dates derived from a wider study (González Tobar 2020), CPR graphs were generated for each amphora workshop (for individual values and percentages, see Table S1 in the online supplementary material (OSM)). These CPR graphs visualise the temporal development of production. The graph corresponding to the Mohíno workshop CPR (Figure 4a), for example, indicates that 40 per cent of its total production dates to just two decades, between AD 30 and 50. In contrast, production at Cortijo de Romero (Figure 4b) was more constant, maintaining relatively stable percentages for more than a century, between AD 30 and 50 and the mid second century AD, corresponding to approximately 80 per cent of its total production.

The combination of all the CPRs of all the workshops across the study area (Figure 5a: grey) yields a Mean CPR (Figure 5a: black); the data simplified in Figure 5b provide a clearer view. As noted above, the raw figures of the Mean CPR can then be scaled to account for uneven time intervals used by the two different chrono-typological schemes. The resulting plots reveal the strong influence of the choice of specific typology on the proportion of production over time (Martin-Kilcher versus Berni (Figure 6)).

Assessment of method

The Mean CPR (scaled or unscaled) offers an overview of the percentage rates of amphorae discarded during each of the Dressel 20 chronological phases relative to the total number produced. It represents a first quantification of the relative volume of Dressel 20 amphorae produced in an area in a specific chronological period. The results corroborate the impression gained by a simple count of the changing number of active workshops—that is, a peak of activity towards the second century AD; at the same time, the results qualify the pace of that growth and decline in production. The reliability of these findings rests on a representative sample of datable amphorae and an understanding of effects of the unequal lengths of the periods used (Figure 6). Two major issues thus require discussion. The first pertains to data collection, notably the validity of surface sampling; the second is statistical, notably the problem of unequal chronological intervals.

With regard to the validity of the materials recovered by surface sampling, two phenomena relevant to the districts producing Dressel 20 amphorae bolster confidence. The first is post-depositional and relates to the acute anthropogenic disturbance. Throughout the Guadalquivir Valley, irrigation works, deep ploughing and levelling of agricultural fields have inverted deep archaeological stratigraphy raising representative samples of sherds to the surface (see Table S2). The second process which encourages confidence in the representativeness of surface materials derives from the way in which ancient potters disposed of misfired amphorae. Large surface concentrations of sherds generally correspond to ploughed out waster dumps (Figure 7). These dumps may stem from two different disposal strategies: the filling of deep clay extraction pits with wasters, as suggested by earlier research (e.g. Ponsich 1979; Chic García 1985), or the horizontal spreading of wasters around the kiln site. More recent

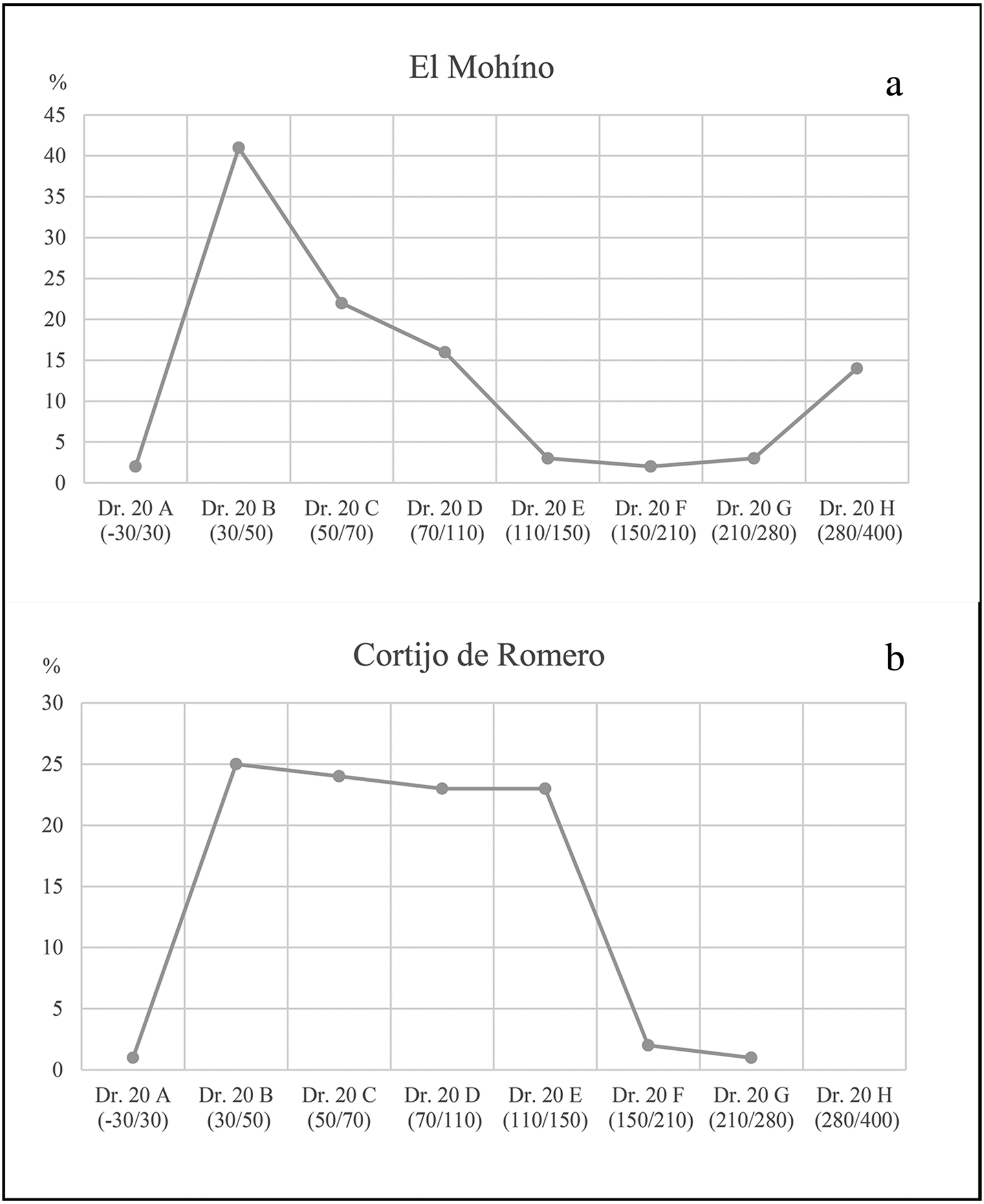


Figure 4. Examples of CPR charts based on samples from two workshops in the area of Córdoba: a) El Mohíno (Palma del Río) and b) Cortijo de Romero (Palma del Río) (figure by I. González Tobar).

stratigraphical analyses of Dressel 20 workshops within the framework of the OLEASTRO project demonstrate that although deep pits were used for the discard of some wasters, potters also discarded them in low heaps at floor level (or near floor level, in large, shallow clay extraction hollows). The heaps rarely grew to any great height before the locus of production and

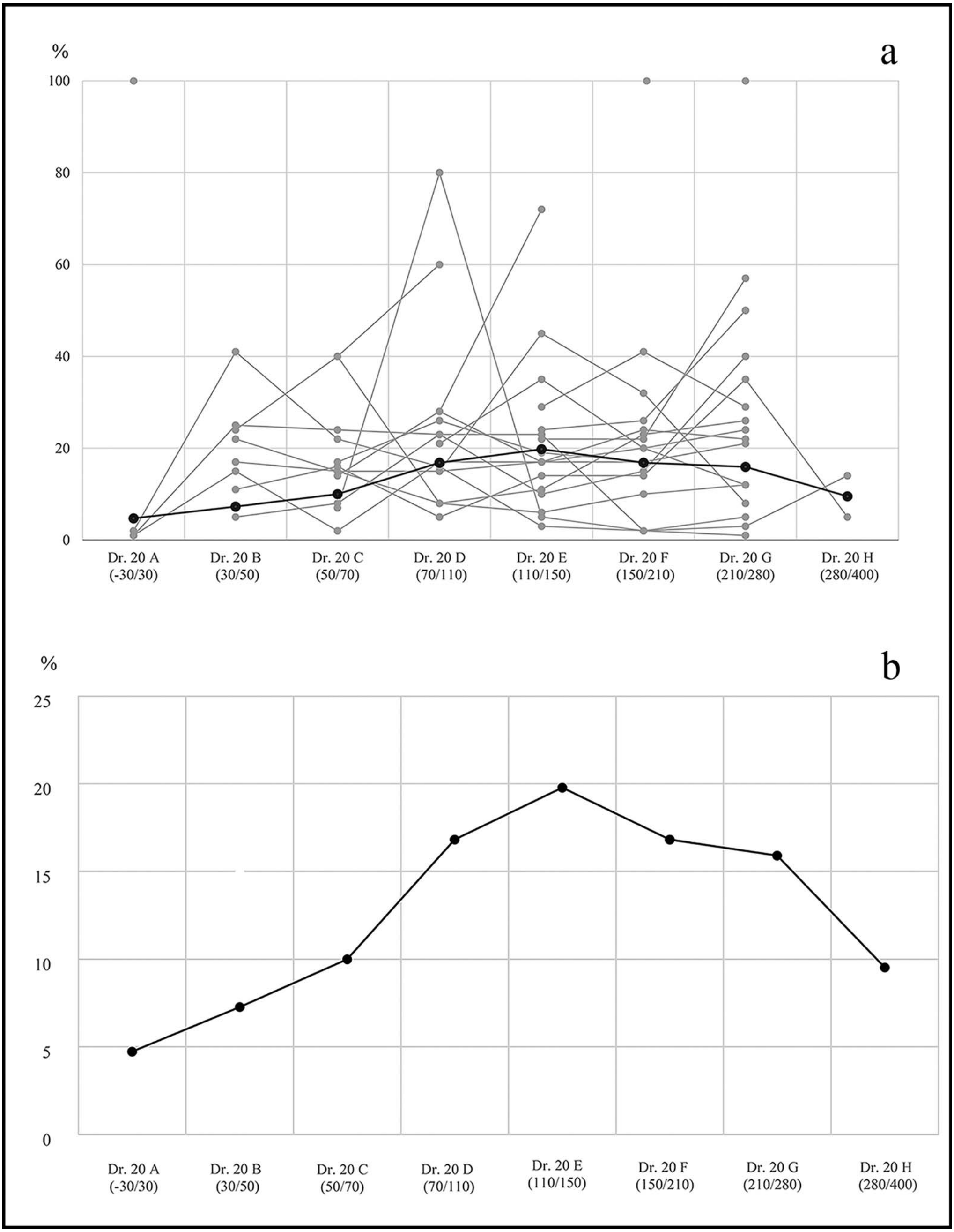


Figure 5. a) Cumulative CPR chart based on the data of all the individual workshops of the study area (grey) and Mean CPR (black) combining the cumulative data; b) a simpler view of the Mean CPR (black), showing general economic trends (figure by I. González Tobar).

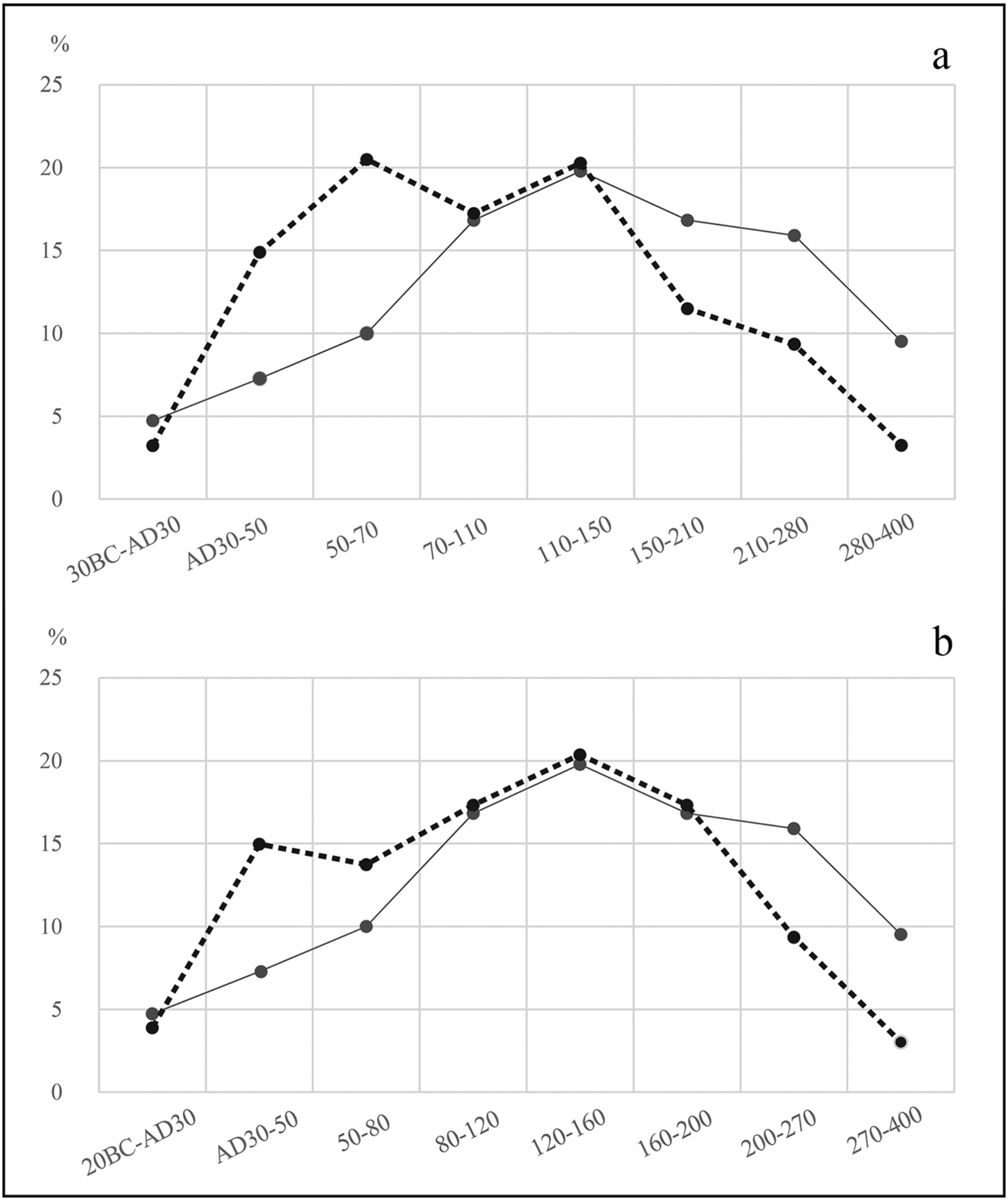


Figure 6. Scaled CPR charts indicating the intervals of the chrono-typological classifications of (a) Martin-Kilcher (dark dashed line) superimposed on the cumulative data of the Mean CPR (thin grey lines); and (b) Berni (dark dashed line) superimposed on the cumulative data of the Mean CPR (thin grey lines) (figure by I. González Tobar).

waste disposal shifted, leading to a general spreading out of wasters and incremental distancing of these heaps from the original workshop centre (Figure 7). Indeed, typically, rural environments have fewer restrictions on space than urban contexts and hence favour such horizontal shifts in production and waste disposal. Crucially, this spatial displacement,

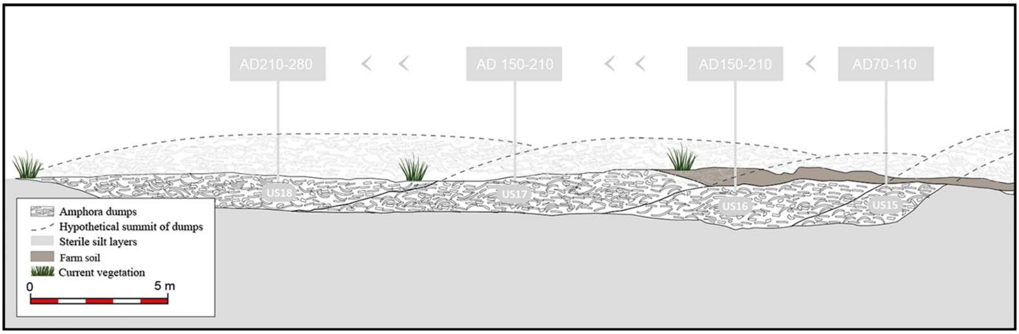


Figure 7. Cross section of the succession of amphora waster dumps at the workshop of El Sotillo (Almodóvar del Río, Córdoba) (figure by I. González Tobar).

combined with post-depositional disturbance, permits us to track with some confidence the chronological development of production through surface materials.

Regarding the variation in the length of specific production periods, we should note that, although the scaling of the graphs leads to results that appear only to differ slightly from the unscaled Mean CPR results (dark dashed lines versus thin grey lines in Figure 6), the key point to note is that the two scalings each correct the Mean CPR in the same manner. In other words, the scaled production of the first century AD consistently surpasses that suggested by the Mean CPR, while the situation reverses for later centuries.

Another means of addressing this particular issue is to apply the method developed by Fentress and Perkins (1988) cited above. Their technique, which standardises time into units of equal length—designated the 'linear method' by Willet (2014: 44–46)—is applied here to the Mean CPR using intervals of 50 and 25 years (Figure 8). The chart based on 50-year intervals (Figure 8a) is of limited value as resolution is lost within a single general expansion and contraction of production. The chart with the 25-year intervals (Figure 8b), in contrast, offers a better view as it reveals a sharp decline in production from the mid third century AD, which coincides with the cessation of three important indicators: the use of Monte Testaccio for the dumping of imported amphorae, the use of Dressel 20 for the export of oil, and the use of the complex *tituli picti* system, all of which permit the tracking of production. The use of 25-year intervals, however, may be somewhat artificial, as the typology of the pottery is not always as precise as this. The real value of the Fentress and Perkins method is that it can combine several different ceramic forms with varying chronologies into a single, standard time-interval series. Yet, as the current study pertains to only a single type of amphora which evolves over time, the calculated CPR does not obviously benefit from this type of standardisation. A more precise future typological amphora classification, taking into account overlapping periods of production, will likely lead to a more accurate diachronic mapping of the data. For the time being, however, I believe that the simple CPR scale offers the most reliable results.

Finally, it is necessary to note that the potential application of the CPR method presented here to other types of pottery production requires consideration of several problems. The main drawback concerns the issues that arise when considering two or more different types of pottery, where it cannot be assumed that wasters will be generated, and discarded

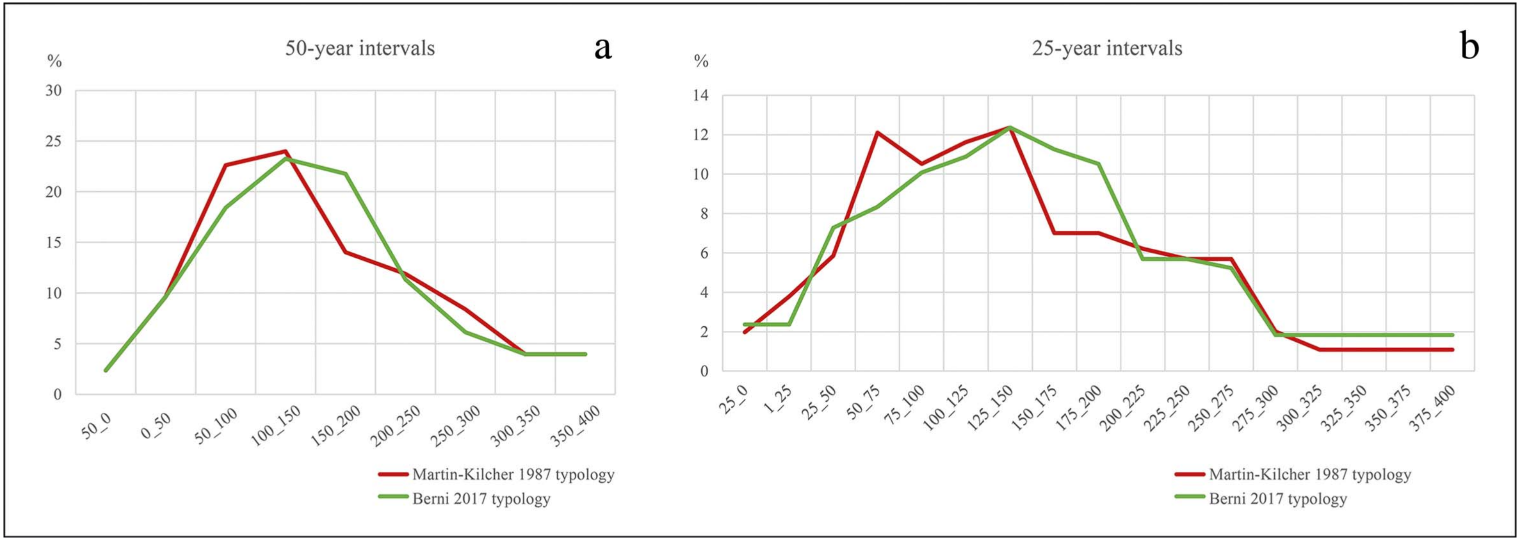


Figure 8. Mean CPR scaled by the Fentress and Perkins (1988) linear graph method, following the amphora typologies of Martin-Kilcher (1987) and Berni (2017): a) 50-year intervals; b) 25-year intervals (figure by I. González Tobar).

vessels fragmented, in the same ways. Although ethnographic research suggests regular discard rates (Nicholson & Patterson 1985: 231), these can vary considerably in practice. Indeed, piles, and sometimes entire kiln loads, of vitrified, melted *sigillata* pottery (Genin *et al.* 2002) can hardly be compared with the discarded amphorae discussed above; the vitrified cases of the latter, as noted above, are relatively uncommon. Hence, presently, CPR seems best suited for the analysis of amphora types but may also serve, when adopting certain precautions, to determine production rates of other vessel types, even if direct comparisons between types are not appropriate.

Results and discussion

While recognising that the sites considered here comprise approximately only one third ($n = 23$) of the total number of workshops in the Guadalquivir Valley, it is still possible to advance several observations on the basis of the CPR method. To date, assessments of the Baetican oil trade and the volume of its exports have relied on pottery stamps (Remesal Rodríguez 1986, 2018: 387). Yet, as the practice of stamping fluctuated in frequency over time, these stamps provide an unreliable basis for gauging economic activity (Rodríguez Almeida 1984; Berni 2008: 33–34; González Tobar *et al.* 2018: 335). Mean CPR, which is independent of stamping, demonstrates the inappropriateness of resorting to stamps for statistical propositions. The CPR method modifies, for example, the dramatic decline in the number of Dressel 20 stamps observed along the Germanic frontiers from the middle of the second century AD (Remesal Rodríguez 2018: 387), suggesting that the drop in the number of stamped amphorae reflects an organisational change in the workshops producing amphorae rather than a decline in the export of oil to the frontiers.

A second key insight of the CPR method is a greater representation of Dressel 20 amphorae in the Claudian and pre-Flavian phases (AD 30–70). To date, their presence in these phases has been underestimated due to the low frequency of stamping during these decades. Yet, the Mean Scaled CPR clearly reveals significant production during these early phases when, despite fewer active workshops, production output resembled that of the subsequent Flavian period (AD 70–110). Based on the CPR, this period of approximately 40 years (AD 30–70) saw the manufacture of 35 per cent of all output across four centuries (Figure 6a). The graph therefore reveals a period of great expansion of oleoculture, a phenomenon that is concomitant with a surge in the power of Hispanic families, and more precisely families from Baetica, within the Roman world, culminating in the elevation of the emperors Trajan and Hadrian (Des Boscs-Plateaux 2005). Although the origins of the oil trade lie in the Augustan era at the end of the first century BC and start of the first century AD, its development surged over the following century. The results of the CPR method used here reveal that the capacity of oil production in the *conventus Cordubensis* quintupled between the time of Augustus and Hadrian's accession to the throne in AD 117.

Lastly, it is important to recognise the method as a means for conducting comparisons with consumption sites. Despite the great frequency of Dressel 20 amphora throughout the Western Roman Empire, diachronic studies of the changing proportions of sub-types (Dressel 20A to 20G, plus the late form, Dressel 23) are scarce. Large quantities of precisely dated Dressel 20 rims recovered from consumption contexts are only available for two sites:

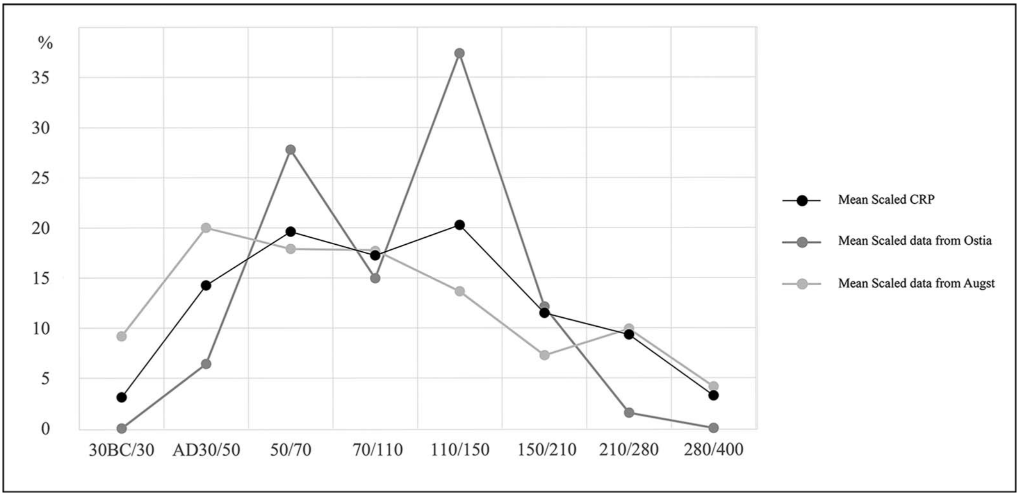


Figure 9. Comparison of the diachronic distribution of olive oil amphorae at the sites of Augst (Martin-Kilcher 1987: 183) and Ostia (Panella & Rizzo 2014: 210–13), with Mean CPR data of the Baetican Dressel 20 amphora workshops in the conventus Cordubensis *(figure by I. González Tobar).*

Augst and Ostia. A visual review of these published data (Ostia, 169 rims; Augst, 988 rims) forms the basis for a comparison between these consumption contexts and the Baetican production sites. Converting the Ostia and Augst data into percentages, as if they were the CPR of a workshop, and applying the simple scale with the time intervals of the Martin-Kilcher typology, leads to Figure 9.

This comparison reveals notable differences between the two consumption sites. Baetican oil exports (at least those from Córdoba) were guided more by the demand of Ostia than Augst. Although the inclusion of oil in the *annona* explains Córdoba's reliance on the Ostia/Rome markets, we should not expect one consumption site to reflect the production trends of every specific import. A good example of this is the fact that Dressel 23 amphorae (AD 280–500) (Rizzo 2018: fig. 2) demonstrate that oil exports from Baetica continued into late antiquity—evidenced by the CPR of the production sites, as well as by fieldwork in the *Hispalis* (Remesal Rodríguez 1983) and Genil areas (Bourgeon 2017)—but these amphorae are not found at Ostia. The Augst data identify a different flow of oil towards the German frontier, with a progressive reduction of imports from the middle of the first century AD (Figure 9). Comparisons of CPR of production and consumption sites are therefore useful as they reveal that a decrease of imports to specific sites is not tantamount with a decline in global production, but rather linked to other reasons, such as changes in local demand. The key point here is that mean CPR can serve as a reliable tool for determining economic tendencies and can offer insight into local demand and global production.

Conclusions

This article has presented a new method of tracking the changing levels of olive oil exports from Baetica—a key component of the Roman imperial economy—by focusing specifically on sites of production rather than consumption. The results draw attention to the potential of amphora workshops and their discarded wasters, elements that have gained limited interest among Roman archaeologists (Peña 2007: 35), in casting new light on economic aspects of antiquity. The method calls into question assumptions, such as that a greater number of workshops over any given period is necessarily synonymous with a larger overall output. Another theme that can be explored through the CPR method is that competition from other provinces manufacturing the same good does not necessarily lead to a decrease in global output. As CPR represents the output of the specific products of entire production districts, it can offer a view of the global fluctuation of regional production and, therefore, of variation in levels of growth and investment.

The current analysis specifically based on the rims of oil amphora rim waster sherds from 23 workshops can be optimised in future research by more precise chronologies and larger samples. A necessary step in broadening the discussion is to extend this type of research to other production districts of the province of Baetica, notably those around Seville in the Guadalquivir Valley and the Genil Valley. Furthermore, future CPR research should attempt to calibrate amphora output estimates based on the number and capacity of the kilns of the different workshops. Such work will contribute to the significant revitalisation of the study of ancient economies over the past two decades and help to provide robust quantification to underpin empirical assessments of the scale and performance of the Roman economy.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.15184/aqy.2023.69.

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