
# Archaeological Quantification of Pottery: The Rims Count Adjusted using the Modulus of Rupture (MR)

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## Abstract

Archaeological quantification is a recurrent issue in research about pottery, its typologies and its distribution. We accept the validity of other methods of quantification—sherd count, minimum number of individuals (MNI) or sherd weight—but the methodology that we have proposed for quantification of assemblages of archaeological contexts is the rims count, which has to be transformed into coefficients of reference through a correction using the modulus of rupture (MR). Such correctors are obtained through measuring the percentage of preserved rim of a significant number of sherds of each type and establishing the average of that percentage. This quantification method is easily applicable to all pottery types and it is also statistically reliable. Besides, it can be used in any study in which the gross number of rims is published. Finally, in the case of ceramic transport containers, a second correction can be applied by multiplying the corrected coefficient (number of rims × MR) by its average capacity (AC), another corrector that will allow us to gather statistics according to the litres of transported product. We believe that the rims count (the easiest part to classify) is a fast, relatively easy and very reliable method that needs to be corrected using the MR.

## 1. Introduction

Since at least the 1970s, archaeological quantification has been a recurrent issue in research about pottery, its typologies and its distribution. The differing degrees of acceptance of the various methods and the lack of clarity in their application have led to their rejection or questioning in some areas of archaeology. The proposal to unify quantification criteria presented on the Protocol of Beuvray (Arcelin and Tuffreau-Libre 1998), a key reference for methods based on sherd count, was more than reasonable. However, over time, some difficulties have become apparent in the application of this approach, together with a need for it to be updated and improved. In addition to this, the counting of sherds, and all its variants, are not the only quantification methods used, since there are many statistical methods of analysis based on sherd weight.

Quantification methods can be classified into two groups, those yielding an approximate estimation of the amount of pottery and those designed to calculate the number of vessels (Orton 1982b, 1). To be more specific, there are methods that for different contexts (territory, site, landscape, stratigraphic units etc.) assess the actual presence of vessels or individuals, and from this 'actual data' proportions are determined. We will refer to such methods as quantification of individuals (actual, effective, of presence or of effective presence). Conversely, other methods intend to represent the relative proportion of pottery in these contexts by generating numerical values that represent the whole population from 'sample data'. One method considers the amount of pottery found and counted as a population of reference, while the other considers it as a sample of population, a representation the validity of which should be assessed from the total amount of pottery of a certain type; for example, amphorae or black varnished pottery that circulated or were used in that period but that no longer exist.

## Archaeological Methods of Pottery Quantification: Sherds Weight and Count

Sherds weight is a frequently used method, especially in the United Kingdom, which does not consider the differing degrees of fragmentation and only accounts for large amounts of uniform material. However, it is a method that requires a high degree of specialization, specific knowledge about fabrics, slips or other non-typological elements, knowledge that is very rare among non-specialists. Moreover, the sample generated shows a higher degree of uncertainty than a sample including only those parts that provide a more reliable typology and classification, such as rims. Also, since shapeless sherds are allocated to identifiable forms, there is a risk of over-representing more specialized types of production sites and with less variety of typology over sites with massive manufacturing, as happens with the wide-ranging records of amphorae produced in Baetica during the High Roman Empire (Molina Vidal 1997, 32–3). Moreover, it gives more representation to large pottery, thicker walls or higher density, forcing the use of correction coefficients. Lastly, it should also be considered that at sites with a large amount of pottery, walls and shapeless sherds are usually dismissed or not collected, thus producing a record that is biased by weight.

Nevertheless, there are differing variants of this method that try to compensate for such problems: adjusted weight, surface correction (Hulthén 1974) and water displacement (Hinton 1977). Another approach with the same aim is the average vessel weight (Rice 1987, 292), which intends to overcome one of the most important limitations of weighing, the overestimation of large and thick pottery. Perhaps that is why Tomber (1993, 150) considered it the best method for amphorae quantification, although its application has to deal with the variability in weight among pottery of the same type and the difficulty of accessing standardized tables of average vessel weights for all types of pottery.

In order to establish comparisons limited to the same type, the estimation of densities from the total sherds weight and from the estimated amount of excavated sediments has been proposed (Sidrys 1977; Rice 1987, 289), thus avoiding one of the problems of establishing relative comparisons by using percentages. This approach is, however, very difficult to apply and consequently the application of an easier and more convenient method is preferred, consisting of calculating the density per excavated area (De Boer 1984; Carreras Monfort 2000, 5408). The information collected is usually displayed by using density maps that allow comparisons of the presence of the same type of pottery at different sites. However, one of the objections to this method is that sometimes it is impossible to know the extent of the excavated area to which the sample belongs. Also, it only takes two dimensions into account, omitting depth, which could lead to giving the same value to an amount of pottery obtained from a shallow investigation or from a deeper one, in addition to the difficulty of including pottery from surface prospections. Moreover, with this method all excavated areas are given the same importance, regardless of the type. In this sense, if layers from dumps of a specific site are analysed, the density yielded will be higher than in settlements where occupation strata are excavated and where a lower amount of pottery should be expected. This problem could be partially resolved by collecting many samples from different areas in the same settlement, but real practice in archaeology usually constrains the capacity to obtain samples according to those conditions.

The other method of archaeological quantification, namely sherds count, shows more variety and disparity in its application. Generally speaking, its main advantage is that it is very convenient and easy to use, but it also poses problems such as over-representation of types that tend to break into more fragments, or the differing degrees of difficulty when classifying some sherds, such as bases or shapeless walls. Therefore, only recognizable sherds (mostly rims, handles and bases) are usually counted, or even only rims, which is the part that provides a more reliable typological allocation for most pottery types.

The most basic and less reliable method is 'number of sherds', which merely consists of counting sherds without any analysis whatsoever. Other widely used methods are 'maximum number of individuals', which corresponds to the number of different sherds remaining after attempting to match and join them and, especially, the 'minimum number of individuals' (MNI), which is an estimation of the minimum number of complete vessels represented by the sherds that have been recovered (Baumhoff and Heizer 1959, 308; Orton *et al.* 1993, 172; Arcelin and Tuffreau-Libre 1998; Voss and Allen 2010; Feely and Ratto 2013). There is, however, a great deal of confusion over these methods (Pollard 1990, 75) and in many cases it is often said that the MNI is being used when it is actually the maximum number of individuals that is being calculated. Both methods demand a huge methodological effort, except for specific cases that are more ideal than real and, therefore, they are applied only to the counting of rims, handles and bases (Raux 1998, 13), or often the MNI is even used just to count rims (Slane 2000, 378). As proven in a test with material from *Iesso* (Guissona, Spain), the MNI depends directly on the time invested in joining sherds (Carreras Monfort 2000, 48).

The 'estimated vessels equivalent' (EVE) defines each sherd as a part of the complete vessel, although for practical reasons it is usually limited to counting the proportion of bases and rims—adding the two results and dividing by two—or frequently it is reduced to the so-called 'rim equivalent' (Egloff 1973; Orton 1982a, 164–7). The percentage of preserved rim is easy and fast to calculate in pottery such as amphorae with the assistance of a template. Nevertheless, the EVE has also been calculated by measuring the weight (Baumhoff and Heizer 1959, 309; Raux 1998, 12) or the surface of the vessel (Hulthén 1974; Byrd and Owens 1997). After carrying out several simulations, Orton *et al.* (1993, 172) cautiously suggest that the vessels equivalent method is the one that provides the best results. One of the advantages of using the EVE is that it solves the problem caused by the differing degrees of breakage in pottery types, although it is still a slow method, applicable only to direct research rather than to already published research, which usually only provides a gross number of sherds. In order to correct such flaws and to increase the degree of reliability of analysis of samples, we suggest establishing a fixed coefficient of breakage for each type: the modulus of rupture (MR). This is a new term, taken from the Spanish 'módulo de ruptura' (Molina Vidal 1997), and it has been chosen over other designations such as 'breakage rate' because it has a different meaning.

Ultimately, all methods have advantages and disadvantages and, as pointed out previously, there is still no consensus among the scientific community as to which one is the best. After testing various methods, Orton (1982a, 167) does not specifically show a preference for any of them, although in a later paper he seems more prone to use vessel equivalents, also accepting the weight in order to compare different assemblages (Orton *et al.* 1993, 172). Other authors find weight and average weight (Keay 1984; Tomber 1993) preferable and claim that a handles count or a rims equivalent count should be dismissed, since both handles and rims are very small parts of large vessels such as amphorae, and this may consequently lead to overestimation or underestimation of minority types (Peacock and Williams 1986, 19). On the other hand, the Protocol of Beuvray (Arcelin and Tuffreau-Libre 1998) suggests that the MNI is the most suitable method for the quantification of pottery and includes a protocol on how to use it. It is suggested that the method should be applied on a selection of ceramic material, especially on complete sherds, rims, bases and handles. In the case of amphorae, handles values are divided by two. Once the sherds belonging to the same individual have been collected, the MNI is the highest value obtained from the different morphological parts. In samples with a large number of sherds, it is accepted that the MNI should only be applied on rims (Arcelin and Tuffreau-Libre 1998). This method has also been specifically considered as best suited for dating archaeological contexts (Husi 2001; Bellanger *et al.* 2006). Conversely, the MNI proved to yield a disparity of results according to a quantitative study of amphorae from Sagalassos (Turkey) (Corremans *et al.* 2010), which prompted the use of the weight and a sherds count, including body sherds. A case study (Strack 2011) has been recently published in which a large group of pottery assemblages from Kalapodi (Greece) has been quantified by applying different methods: sherds count, weight, the EVE of rims and bases, the MNI, and the counting of rims, handles and bases. The author claims that the methods that provide the better results are the MNI and EVE as well as the counting of sherds, handles and bases, the latter being preferable since it is faster than the others. However, she points out that the general trends in pottery assemblages can be reflected by any of the methods used (Strack 2011, 21–2). In this sense, and contrary to Orton's suggestion (Orton 1975), she also claims that data of assemblages from different sites obtained by different methods can be studied in a comparative framework and that it is very unlikely that large irregularities will occur.

Given the lack of standardization in quantification methods, one possibility may be to quantify pottery using as many tools as possible, thereby allowing comparison with other assemblages (Carreras Monfort 2000, 50). This approach, however, although suitable for small pottery assemblages, it is very difficult to apply to large groups. In any case, it is always essential to present gross data (Raux 1998, 15) and also to specify the method that has been used (Hesnard 1998), including a detailed description of the quantification criteria so that the data can be reassessed.

## The Rims Count and the Modulus of Rupture (MR)

After analysing the main methods used for counting pottery in archaeology, we believe that, for statistical analysis of archaeological samples, the most reliable and useful quantification method is the rims count. Tests that we have conducted on amphorae assemblages, for example, have revealed that the number of unknown bases and handles is remarkably higher than that of rims (Molina Vidal 1997), and that including these sherds may lead to overestimation of those types of handles or bases that are easier to identify, as happens with the Dressel 2–4 amphora and its characteristic bifid handle, or those types with fabrics that are a distinctive element because they are the only ones produced in an specific area. On the other hand, types of pottery sharing the same handle or base morphology and from the same area of production would be underestimated due to the impossibility of classifying them according to their ceramic fabrics. The difficulty in classifying the walls is even higher, thus making the already mentioned problems more evident. Therefore, we believe that the most suitable approach is to limit the procedure to a rims count, which also contributes to a faster analysis.

One of the pitfalls of the rims count is that it overestimates the pottery that tends to break into a higher number of sherds, contrary to what happens with the rim EVE, which, as we have mentioned before, is based on the percentage of preserved rim. In the research on amphorae that we have conducted, we have found that when amphorae have a similar breakage rate, the results using the rims count and the rim EVE (Molina Vidal 1997, 32–8) are similar and, therefore, the application of the same MR is perfectly valid as well as useful, since it is faster. In spite of that, there is a problem when the breakage rate differs, which is necessarily the case when working with pottery with differing diameters, wall thicknesses or manufacturing techniques. For those cases, we suggest the establishment of a correction rate for each type of pottery fabric: the modulus of rupture (MR). This correction rate is based on the assumption that ceramics that break by accident—which is usually the case—tend to do so into a stable number of sherds. Once we have accepted this assumption, it is not difficult to calculate the fragmentation pattern or the MR.

The MR of a specific type can be obtained through the arithmetic mean or average of different percentages of preserved rims. After verifying that the average and the median presented similar values, we decided to use the average as a measure of central tendency, since it is easier to use for calculation purposes. In this sense, part of the procedure is similar to that of the rim EVE, except that we have to add the division by the number of rims. Therefore, as in the case of the EVE, it is problematic since diameter estimations in small assemblages are hardly reliable (Chase 1985, 217)—although in any case the error is not remarkable, and Chase estimates it at 1.7%. Since the main aim is to assess the degree of rim breakage, it is necessary to exclude those examples with completely preserved rims in order not to distort the statistical validity:

where MR is the approximate modulus of rupture, $X$ is the proportion of preserved rim, with values $> 0$ and $< 100$ (excluding complete rims) and $n$ is the total number of rims (excluding complete rims).

Obviously, as happens with averages calculated from a sample, the MR obtained is only an approximation to the real value and its reliability depends directly on both the number of rims used for its calculation and the variability of the preserved percentages, which we can calculate through the standard deviation. In order to know if we have a suitable and sufficient sample, we will use confidence intervals. The confidence interval defines the range of values within which there is a certain probability—or level of confidence—that the parameter that we are searching for is going to be found. We have decided to apply a level of confidence of 95% and therefore, after adding and subtracting the obtained estimation error, a range is defined in which there is a 95% probability of finding the actual MR. In other words, if the approximate MR calculated for type Dressel 2–4 is 23.4 and the estimation error is 0.96, this means that there is a 95% probability that the real MR will be 23.4 ± 0.96; that is, the confidence interval would be [22.44, 24.36]. From a statistical point of view, the best approach would be to use intervals, but this would complicate the research enormously, and therefore we have decided to maintain the average number using the calculation of confidence intervals only as an indicator of higher or lower accuracy in the estimation of the obtained MR.

Confidence intervals for the average, for a confidence level of 95%, are as follows:

where $I_{95\%}$ is the confidence interval level of 95%, is the average of the sample (in our case, the MR), $t$ is Student's $t$-distribution rate, $s$ is the standard deviation and $n$ is the size of the sample (the number of rims).

From the formula, it can be derived that the estimated MR will be closer to the real MR depending on the number of rims used for estimation in each type. That is why the values that we are presenting are not definitive, but they will be improved as long as this approach is incorporated into new studies.

As long as new data is produced, the MR values could be recalculated and updated. In order to do so, it is necessary to publish the new MR value—even in those cases where it is hardly reliable—along with the number of rims used to obtain the MR vale for each type. The calculation of a new MR that includes new information would be very easy and would consist of calculating the weighted average:

where MR is the updated modulus of rupture, $MR_1$ is the previous modulus of rupture, $N_1$ is the number of rims of the previous modulus of rupture, $MR_2$ is the modulus of rupture of the new group to be added and $N_2$ is the number of rims of the new group to be added.

Nevertheless, the estimation of a stable MR does not require thousands of rims for each type of pottery, which means that in a reasonably short period of time they could be calculated for most of the types that are already known. However, an MR with a wide range of confidence interval does not invalidate either its capacity for providing information or its use, but limits the accuracy of the estimation. In this sense, we think that there is no need to wait until an exceptionally low estimation error is achieved in order to start using this method, although in those cases where the confidence interval is remarkably wide, we suggest using the MR of a type that is morphologically closer and for which we have reliable data.

First, we prepare a table with the MR values and their corresponding confidence intervals (Table 1). Once we have that table, we can use the values obtained as correctors, so that those types that tend to break into more sherds are not overestimated when compared with those that break into fewer sherds. In order to do so, the number of rims of a specific type should be multiplied by the corresponding MR and then the effect produced by the differing degrees of rims fragmentation can be corrected. Raux (1998, 15) suggests the creation of tables including the MR values of the different pottery types of each stratigraphic unit, since some layers contain more fragmented material than others. We believe that this task would require a huge methodological effort and that, in general, the deviation would be almost negligible, especially if working with large samples from different sites.

Table 1. Amphora types with their corresponding MR values and confidence intervals

| ***Type*** | ***MR*** | ***Number of rims*** | ***Confidence interval*** |
|---|---|---|---|
| • * Includes types 7.1.2.1, 7.2.1.1, 7.3.1.1, T-7.3.2.1, 7.3.2.2, 7.4.1.1 and 7.4.2.2 (Ramón Torres 1995).<br>• ** Includes types T-7.4.2.1 and 7.4.3.1 (Ramón Torres 1995). | | | |
| Almagro 51a–b | 22.73 | 11 | ±4.89 |
| Almagro 50 | 28.71 | 34 | ±4.13 |
| Almagro 51C | 29.03 | 141 | ±1.94 |
| Beltrán II A | 21.83 | 126 | ±1.97 |
| Beltrán II B | 23.15 | 332 | ±1.22 |
| Brindisian amphora | 20.45 | 20 | ±5.54 |
| Dressel 1 A | 16.81 | 181 | ±1.20 |
| Dressel 1 B | 20.69 | 58 | ±2.24 |
| Dressel 1 C | 18.35 | 110 | ±1.77 |
| Dressel 14 | 18.76 | 80 | ±2.04 |
| Dressel 20 | 26.21 | 215 | ±1.50 |
| Dressel 20 A | 19.78 | 63 | ±1.75 |
| Dressel 21–22 Baetica | 16.43 | 56 | ±2.35 |
| Dressel 2–4 | 23.43 | 307 | ±0.96 |
| Dressel 28 | 19.34 | 79 | ±1.87 |
| Dressel 7–11 | 19.61 | 684 | ±0.76 |

| *Type* | *MR* | *Number of rims* | *Confidence interval* |
|---|---|---|---|
| Gauloise 4 | 25.99 | 74 | ±2.76 |
| Greco-Italic | 19.18 | 148 | ±1.70 |
| Haltern 70 | 19.31 | 220 | ±1.15 |
| Iberian amphora | 19.53 | 193 | ±1.26 |
| Keay VI | 21.96 | 24 | ±2.49 |
| Keay VII | 27.16 | 25 | ±5.37 |
| Keay XXV | 24.00 | 56 | ±2.53 |
| Lamboglia 2 | 20.94 | 163 | ±1.53 |
| Lomba do Canho 67 | 22.04 | 144 | ±1.75 |
| Maña C1* | 17.29 | 14 | ±7.03 |
| Maña C2a** | 14.62 | 37 | ±2.26 |
| Ovoid 4 | 17.09 | 64 | ±1.78 |
| Ovoid 5 | 19.55 | 11 | ±5.51 |
| Pascual 1 | 17.56 | 18 | ±3.05 |
| Punic–Ebusitan 25 | 26.07 | 27 | ±2.91 |
| Pellicer B–C | 20.50 | 14 | ±6.05 |
| Pellicer D | 18.58 | 31 | ±4.22 |
| Rhodian type | 26.28 | 29 | ±3.92 |
| T-10 | 20.40 | 20 | ±4.08 |
| T-11 | 20.20 | 45 | ±2.34 |
| T-12.1 | 17.34 | 105 | ±1.45 |
| T-5.2.3 | 17.43 | 30 | ±2.48 |
| T-7.4.3.2 | 18.15 | 13 | ±3.37 |
| T-7.4.3.3 | 13.71 | 259 | ±0.82 |

| *Type* | *MR* | *Number of rims* | *Confidence interval* |
|---|---|---|---|
| T-8.1.1.2 | 19.76 | 17 | ±4.60 |
| T-8.1.3 | 21.79 | 38 | ±3.31 |
| T-8.2.1.1 | 16.37 | 73 | ±1.67 |
| T-9.1.1.1 | 15.31 | 108 | ±1.15 |
| Ancient Tripolitanian | 21.57 | 63 | ±2.26 |

Since the biggest problem with the rims count method has been solved by using the MR, we believe that this is the easiest quantification method and the fastest to apply, and also that it has a high degree of reliability. Moreover, it can also be applied after the study has been conducted and where the number of rims is available, thus improving its reliability. It only requires that the scientific community create tables of MR values for pottery types in order to achieve low confidence intervals.

An example of the application of the MR to the amphorae assemblage of Castelo de São Jorge (Lisbon), a study published by another research group, is shown in Table 2. If we compare the percentages obtained from the rims count with those obtained after applying the MR correction, we can observe that there is hardly any difference between the proportional representation of some types, such as Dressel 1, which only increases by 3%. Conversely, the variations are quite remarkable for other amphora types, such as Dressel 2–4, which shows rise in the relative proportion of 32% or, especially, the Almagro 51c amphorae, which increase by 64%. This latter figure is an indicator of the traditional underestimation of small-sized and reduced diameter amphorae, which are very common in the Lower Empire, especially when found together with large and robust amphorae. In any case, the values obtained show the need to perform correction by using the MR.

Table 2. The rims count of amphorae from Castelo de São Jorge (Lisbon) (Pimenta 2005) with correction using the MR

| ***Origin*** | ***Type*** | ***Number of rims*** | ***Percentage of rims*** | ***Equivalent MR × number of rims*** | ***Percentage of MR*** |
|---|---|---|---|---|---|
| African | Ancient Tripolitanian | 8 | 1.7 | 174.76 | 2.12 |
| | Total | 8 | 1.7 | 174.76 | 2.1 |
| Cádiz | Maña C2b | 36 | 7.7 | 492.20 | 5.96 |
| | T-9.1.1.1 | 6 | 1.3 | 91.66 | 1.11 |
| | Greco-Italic | 4 | 0.9 | 76.33 | 0.92 |

| *Origin* | *Type* | *Number of rims* | *Percentage of rims* | *Equivalent MR × number of rims* | *Percentage of MR* |
|---|---|---|---|---|---|
| | T-4.2.2.5 | 1 | 0.2 | 18.58 | 0.23 |
| | Total | 47 | 10.1 | 678.8 | 8.2 |
| Cádiz (probably) | Maña C2b | 8 | 1.7 | 109.38 | 1.32 |
| | Total | 8 | 1.7 | 109.4 | 1.3 |
| Cádiz or Circle of the Strait | Maña C2b | 46 | 9.9 | 628.92 | 7.62 |
| | Greco-Italic | 8 | 1.7 | 152.67 | 1.85 |
| | T-9.1.1.1 | 3 | 0.6 | 45.83 | 0.56 |
| | Lomba do Canho 67 | 1 | 0.2 | 22.22 | 0.27 |
| | Total | 58 | 12.4 | 849.6 | 10.3 |
| Guadalquivir | Lomba do Canho 67 | 5 | 1.1 | 111.08 | 1.35 |
| | Classe 24 o Lomba do Canho 67 | 3 | 0.6 | 66.65 | 0.81 |
| | Total | 8 | 1.7 | 177.7 | 2.2 |
| Hispanic (probably Circle of the Strait) | Greco-Italic | 12 | 2.6 | 229.00 | 2.77 |
| | Dressel 1 | 9 | 1.9 | 163.82 | 1.98 |
| | Total | 21 | 4.5 | 392.8 | 4.8 |
| Italic | Dressel 1 | 196 | 42.0 | 3567.56 | 43.22 |
| | Dressel 2–4 | 3 | 0.6 | 70.31 | 0.85 |
| | Greco-Italic | 91 | 19.5 | 1736.58 | 21.04 |

| ***Origin*** | ***Type*** | ***Number of rims*** | ***Percentage of rims*** | ***Equivalent MR × number of rims*** | ***Percentage of MR*** |
|---|---|---|---|---|---|
| | Brindisian amphora | 1 | 0.2 | 20.45 | 0.25 |
| | Lamboglia 2 | 2 | 0.4 | 40.32 | 0.49 |
| | Total | 293 | 62.7 | 5435.2 | 65.8 |
| Lusitanian | Almagro 51c | 1 | 0.2 | 29.06 | 0.35 |
| | Total | 1 | 0.2 | 29.1 | 0.4 |
| Unidentified (probably local) | T-12.1 | 17 | 3.6 | 294.83 | 3.57 |
| | T-4.2.2.5 | 4 | 0.9 | 74.32 | 0.90 |
| | Total | 21 | 4.5 | 369.2 | 4.5 |
| Unidentified | Greco-Italic | 1 | 0.2 | 19.08 | 0.23 |
| | Dressel 7–11 | 1 | 0.2 | 19.57 | 0.24 |
| | Total | 2 | 0.4 | 38.6 | 0.5 |
| Total | | 467.0 | 1.00 | 8255.2 | 1.00 |

Our research has confirmed the effectiveness of the application of the MR in order to determine reliable values for amphorae samples. However, we should not forget that the same principles might be applied to other types of pottery. It is evident that quantification of fine pottery is statistically skewed in the case of *terra sigillata*–type wares of small size and rim diameter, such as Dragendorff 27 cups, for example, in comparison to Dragendorff 17–type plates and dishes. More obvious is the over-representation of some types of African red slip ware (ARS), such as ARS D Hayes 102 cups of small size and diameter compared to large ARS D Hayes 65, 104, 105 or 106 dishes.

Nevertheless, we should bear in mind the disadvantages and limitations of the proposed method, some of them already discussed throughout this paper. Although the MR has originally been used as an indicator for amphorae, its application to other types of standardized pottery is perfectly viable. However, this depends on the acceptance of the coefficient and its calculation by other scientific teams, which can delay its use on those types of pottery. It is also necessary to have reliable MR values for each of the pottery types of the archaeological context in which we want to apply the method, although, as we have already mentioned, a temporary solution would be to use the MR values of morphologically similar types. This will be especially the case at the first stage and in the event of scarcely represented types. In those types that present higher morphological variability, the reliability of the MR is lower, which might lead to the use of MR subtypes in specific cases. Additionally, when calculating the MR, it thought should be given to the exclusion of those assemblages where a high level of breakage associated with intentional causes is found, such as in the case of the grinding of material in order to prepare a road. In any event, we should bear in mind that this is a new quantification method that, after presentation, will be reviewed by the scientific community, thus originating new issues that will have to be taken into account.

## Correction of the Average Capacity (AC) for Transport Containers

Finally, it should be noted that in the case of transport vessels, what we intend to analyse are the proportions of the contents coming to a specific site and therefore, not the container itself, especially since amphorae, the most commonly used type of ceramic container, were disposed of and destroyed immediately after the product had been discharged, sold or consumed, and were not usually used for other purposes. For these reasons and due to the huge variability of capacities in different amphora types, it would be necessary to establish rates for each type, representing its average capacity, so that the contents can be quantified rather than the containers.

The differences in capacity are very significant given that, for example, Dressel 20 amphorae have an approximate capacity of 78 L, while Dressel 2–4 is assigned an approximate capacity of 25 L; that is, a capacity three times lower, which results in a significant underestimation of its relative value in comparison with high-capacity containers.

We therefore suggest the application of a second correction rate for the case of transport containers, which establishes the average capacities (ACs) of amphora types, these average capacities not being absolute values, but average statistical rates. When establishing those correctors, we have to deal with several problems, one of the most important being that there is no uniform metric standard for each amphora type and even that in some cases—especially in types with a long life span—they may present a broad variability in their sizes and capacities. In spite of this, the values obtained are closer to reality than those yielded through a pottery count.

There are relatively few publications on capacity measurements of amphora types (Sealey 1985; Tyers 1996; Carreras Monfort 2000, fig. 2; Ejstrud 2005, fig. 1) and some of them have been obtained from just one vessel, thus affecting their reliability. Consequently, we have initiated a project to obtain reliable average capacities of amphora types from scale drawings of complete amphorae, extruding 2D drawings by means of CAD programs. We suggest a method for the estimation of capacities similar to the one proposed by McCaw (2007) and used in the Palatine East Pottery Project (Ikäheimo and Peña 2007). As we have already suggested for the estimation of the MR, the confidence intervals will be calculated in order to assess the degree of reliability, although it should be noted that calculation of the average capacity (AC) yields small confidence intervals without requiring a large number of measurements, since they show, proportionately, low standard deviations. Our aim is to calculate the AC with a small confidence interval in all amphora types with complete profiles. As already suggested for the calculation of the MR, for those types with no complete examples, we recommend the use of the AC of the most morphologically similar type.

Table 3 shows the average capacities of specific amphora types and their corresponding confidence intervals. Once we have estimated the average capacity of an amphora type, the data obtained should be corrected through a rims count. As in the case of the MR, the correction is easy to perform by multiplying the number of rims corrected with the MR ('Equivalent number 1'; cf., Table 4) by its average capacity (AC). Both correction factors (MR and AC) should be applied, thus obtaining results that are remarkably different from those yielded only through a rims count. Ultimately, the first step in the application of such a procedure will be a rims count, followed by working with values in litres and introducing correction factors for the differing degrees of fragmentation as well as correction factors for the size variability of different vessels, as shown in Table 4.

Table 3. A list of amphora types with their corresponding AC values and confidence intervals

| *Type* | *Average capacity (AC)* | *Number of rims* | *Confidence interval* |
|---|---|---|---|
| Almagro 51c | 24.9 | 8 | ±9.12 |
| Dressel 1 | 25.1 | 8 | ±3.54 |
| Dressel 20 | 78.4 | 9 | ±14.86 |
| Dressel 2–4 | 25.0 | 7 | ±2.91 |
| Dressel 7–11 | 21.9 | 10 | ±4.36 |
| Greco-Italic | 30.2 | 8 | ±3.02 |
| Haltern 70 | 32.7 | 6 | ±6.00 |
| Lamboglia 2 | 40.3 | 7 | ±2.91 |
| T-7.4.3.3 | 22.7 | 8 | ±7.21 |

Table 4. An example of the application of correction using the MR and the AC

| *Type* | *Number of rims (count)* | *Percentage* | *Modulus of rupture, MR* | *Equivalent number 1* | *Percentage corrected with MR* | *Average capacity, AC (L)* | *Equivalent number 2* | *Percentage of total, MR + AC* |
|---|---|---|---|---|---|---|---|---|
| Almagro 51c | 6 | 3.0 | 29.0 | 174.2 | 4.1 | 24.9 | 4 331 | 2.4 |
| Dressel 1 | 17 | 8.5 | 18.3 | 311.1 | 7.3 | 25.1 | 7 800 | 4.4 |
| Dressel 20 | 45 | 22.5 | 26.2 | 1 179.4 | 27.6 | 78.4 | 92 443 | 52.1 |
| Dressel 2–4 | 34 | 17.0 | 23.4 | 796.5 | 18.7 | 25.0 | 19 942 | 11.2 |
| Dressel 7–11 | 24 | 12.0 | 19.6 | 470.7 | 11.0 | 21.9 | 10 321 | 5.8 |

| *Type* | *Number of rims (count)* | *Percentage* | *Modulus of rupture, MR* | *Equivalent number 1* | *Percentage corrected with MR* | *Average capacity, AC (L)* | *Equivalent number 2* | *Percentage of total, MR + AC* |
|---|---|---|---|---|---|---|---|---|
| Greco-Italic | 8 | 4.0 | 19.2 | 153.4 | 3.6 | 30.2 | 4 626 | 2.6 |
| Haltern 70 | 34 | 17.0 | 19.3 | 656.5 | 15.4 | 32.7 | 21 458 | 12.1 |
| Lamboglia 2 | 12 | 6.0 | 20.9 | 251.3 | 5.9 | 40.3 | 10 134 | 5.7 |
| T-7.4.3.3 | 20 | 10.0 | 13.7 | 274.1 | 6.4 | 22.7 | 6 235 | 3.5 |
| Total | 200 | 100 | | 4 267.3 | 100 | | 177 290.1 | 1 |

As we can see in Table 4, some amphora types—such as T-7.4.3.3, with a low MR (MR = 13.7) and an average capacity that is not very high (22.7 L)—show remarkably lower amounts when applying their corresponding corrected values (MR + CM = 3.5%) than when using a gross rims count (10%). Conversely, other types—such as like Dressel 20, with an MR value over 25 (26.2) and a higher AC (78.4)—double their proportions from 22.5% to 52.1%.

## Conclusion

Although we accept the validity of other methods, the methodology that we have proposed for quantification of assemblages of archaeological contexts is the rims count, which has to be transformed into a statistical coefficient of reference through correction using the modulus of rupture (MR). Such correctors are obtained through measuring the percentage of preserved rim of a significant number of sherds of each type and establishing the average of that percentage. The lower the confidence interval, the more accurate the MR will be. This quantification method is easily applicable to all pottery types and it is also statistically reliable, particularly for highly standardized pottery (black-gloss pottery, *terra sigillata*, ARS etc.). Besides, it can be used in any study in which the gross number of rims is published. Finally, in the case of ceramic transport containers, a second correction can be applied by multiplying the corrected coefficient (number of rims × MR) by its average capacity (AC), another corrector that will allow us to gather statistics according to the litres of transported product.

We think that given the incomplete, random and biased nature of information about archaeological pottery, all the values that we may aspire to obtain will be representations of a sample, rather than actual data. The only way to establish the arrival or actual circulation of those goods in a real sense would be to have the port records or the original sales ledger, which is impossible. Therefore, archaeologically speaking, we only have access to samples that may be considered perfectly representative of reality provided that they show certain characteristics of size, shape, randomness or degree of representativeness, as in any statistical research. Accordingly, we believe that the rims count (the easiest part to classify) is a fast, relatively easy and very reliable method that needs to be corrected using the modulus of rupture (MR).

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