# Statistical approach to pottery quantification as ways to explore chronology, economy and culture of Roman and Late Antique settlements: the case of Artena (province of Rome)

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Quantify archaeological artifacts

Some of the **benefits** of ceramic quantification have long been established. Others are explored in more recent studies, such as its use in the restitution of the proportion of recyclable or perishable vessel (for instance Deru *et al.* 2016, applied to Artena in Dienst 2018). However, there is few recent publications in Central Italy with full quantifications.

Many methods exist, more or less adapted according to the problems, but often difficult to compare between them (Orton & Hughes 2013, 203-218; Arcelin & Tuffreau-Libre 1998; Santangeli Valenzani & Ceci 2016, 33-55). The abstract nature of best approaches (Orton & Tyers 1990) may partly explain the reluctance of some researchers to use them.

Moreover, the degree of representativeness of this information is difficult to evaluate. In order to distinguish significant differences from randomness, two tools can be used. The distribution of values as **boxplots** is useful for measuring the variability of observed quantifications when there are enough big assemblages (Banning 2000, 19-22; Baxter 2015, 34-37). The difference due to randomness can also be distinguished from the "significant" difference by the use of probabilistic laws (Banning 2000, 121-124; Baxter 2015, 191-196). However, the use of standard deviation calculation, which is often taught, should be avoided in the case of small populations, such as in archaeology, in favour of the **Exact Method**, Wald Adjusted Method or Score Interval (Sauro & Lewis 2005, applied in archaeology in Dienst & Frère forthcoming). It should be reminded that although it highlights "significant" differences, it in no way suggests their ceramic relevance (unusual randomness or the formation context may be a source of such differences). **Bayesian inference** should therefore be used to interpret the results and produce more meaningful conclusions. Buck, Cavanagh and Litton (1996) show the specific uses of bayesian inference in archaeology.

Boxplot of classes for the 19 major assemblages of the phase 19 at Artena (based on the MNI).
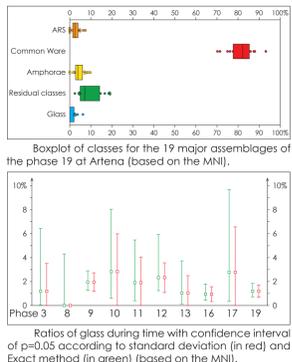
Ratios of glass during time with confidence interval of p=0.05 according to standard deviation (in red) and Exact method (in green) (based on the MNI).

Using statistics in pottery studies

In addition to the quantifications that directly allow conclusions to be drawn about an assemblage, several statistical tools can help to classify raw data. Two of the most interesting are cluster and correspondence analysis (CA). Given their very scarce use in the study of Roman and Late-Antique Mediterranean vessel (with the exception of archaeometry for the cluster), it is important to briefly recall their functioning. They are based on the use of a contingency matrix where the rows correspond to the assemblages and the columns to the variables employed (types, categories, factories, etc.). A serialization of the contingency table by calculating barycenters already provides an initial sorting of the data and highlights some of its characteristics (Djindjian 1991, 167-191; Banning 2000, 249-256).
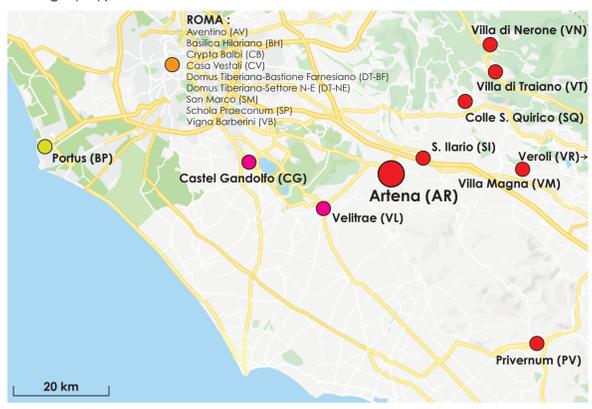
Highlight similarities with hierarchical clustering

This method is based on the computation of distances between the values of the variables of the various assemblages. They are successively linked to form a cluster, depending on the degree of similarity. The distance, which can be calculated by different methods, is reflected by the length of the cluster branches. When ruptures exist between different groups of assemblages, the cluster tends to reflect these groups. Although mainly used for archaeometry, it can also be applied to other variables (Drennan 2009, 309-320; Baxter 2015, 148-165).

Highlight transitions with correspondance analysis

When there is a continuum (whether geographical, chronological or otherwise), the cluster is not adapted to reflect this continuum. In addition, groups are often less distinct in this type of situation. The CA is then a very useful tool. Without going into the details of its complex process, it classifies both assemblages and variables on several axes (often only the first two of which are recorded). It has been shown that when the data show a linear evolution, the variables and assemblies are gathered in the form of a horsehoe, in which the related variables or assemblages are close to each other. Other shapes taken by the data may also reveal various phenomena (Orton & Tyers 1990, 101-103; Djindjian 1991, 178-182; Cool & Baxter 1999; Baxter 2015, 133-147). The use of CA varies greatly according to the period and territory. It is almost absent from the study of Mediterranean vessel from the Roman and Late-Antique periods (Groenenen & Poblome (2003) and Hoffmann and Faber (2009, 55-75) are notable exceptions).
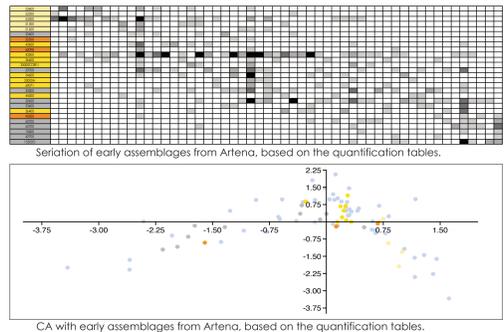
Case-study: Artena

The Piano della Civita in Artena is an archaeological site located south-east of Rome, currently under investigation by Cécile Brouillard and Jan Gadeyne. Its vestiges run from the 4th century BC to the 7th century AD. (Brouillard & Gadeyne 2012). However, the successive reuse of the buildings, the erosion of the site, the discontinuity of the remains and the mixing carried out by the Dark Layers make stratigraphy difficult to read. The stratigraphic groups created may concern a long period and/or be contemporary in several cases. In addition, a significant quantity of Late-Antique ceramics are indigenous and do not have well dated parallels. At the crossroads of several economic zones, its exchange network is also complex to understand. With its 60,000 stratigraphic sherds, it is a first-class site for assessing the efficiency of the statistical methods previously cited (with the use of the MNI for quantification, better suited for comparisons in central Italy). For comparative purposes, in particular economic ones, Late-Antique assemblages of several other sites in the area were examined (see bibliography). The Past3 software was used to create the charts.

ROMA :
Aventino (AV)
Basilica Hilariana (BH)
Crypta Balbi (CB)
Casa Vestal (CV)
Domus Tiberiana-Bastione Farnesiano (DT-BF)
Domus Tiberiana-Settore N-E (DT-NE)
San Marco (SM)
Schola Praeconium (SP)
Vigna Barberini (VB)

Villa di Nerone (VN)
Villa di Traiano (VT)
Colle S. Quirico (SQ)
Portus (BP)
S. Ilario (SI)
Veroli (VR)
Castel Gandolfo (CG)
Villa Magna (VM)
Artena (AR)
Velitrae (VL)
Privernum (PV)

20 km

Case-study: CA and clusters
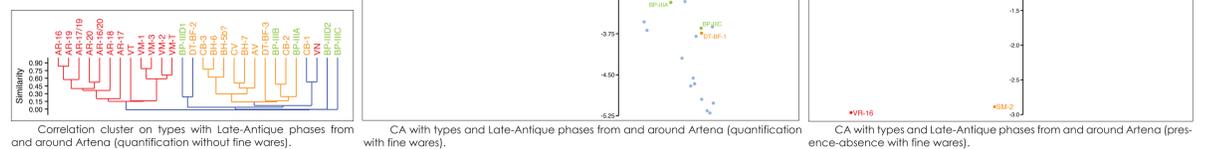
Chronological seriation

The level of residuality and strates such as Dark Layers make the use of serialization in Artena tricky. This problem requires partitioning the series for a sustainable result. However, a serialization on all of the vessel is not useless. Assemblages with the same formation characteristics (i.e. the same history and, therefore, presumably contemporary) are naturally grouped together, which contributes to a better understanding of the site's history. Both quantified and presence-absence data are to be taken into consideration. The constant back and forth between typological, statistical and stratigraphic data, which are difficult to report here, ultimately provide a significant amount of information.

CA with a large range of assemblages from Artena, based on the presence-absence table.

Seriation of early assemblages from Artena, based on the quantification tables.

CA with early assemblages from Artena, based on the quantification tables.

CA with a large range of assemblages from Artena, based on the quantification table. At right, the classification based on the second axe is a good indicator about the residuality phenomenon in the assemblages.

● Types ● Republican - phase 2 ● Imperial to Late-Antique destruction layers of the villa ● Late-Antique buildings
● Republican - phase 1 ● Imperial villa ● Imperial to Late-Antique occupations ● Dark Layers ● Undet.

Economic areas

Regarding the economy, we compared the different phases of each site according to type by quantification and presence- absence, considering all the types or only the common wares.

Quantitative tables give very good results. When considering all types, three areas stand out clearly, both on the CA (with a triangular configuration) and on the correlation cluster: Rome, Portus and the Artena-Villa Magna-*Villa di Traiano* trio. However, the *Villa di Nerone* and the *Bastione Farnesiano* are a little more distinctive. By eliminating fine wares, it can be seen that it is surprisingly this one that determines the distinction between Rome and Portus. With just the presence-absence, the areas are not as clearly delineated, even if this separation is rather well respected.

Correlation cluster on types with Late-Antique phases from and around Artena (quantification with fine wares).

Correlation cluster on types with Late-Antique phases from and around Artena (quantification without fine wares).

CA with types and Late-Antique phases from and around Artena (quantification with fine wares).

CA with types and Late-Antique phases from and around Artena (presence-absence with fine wares).
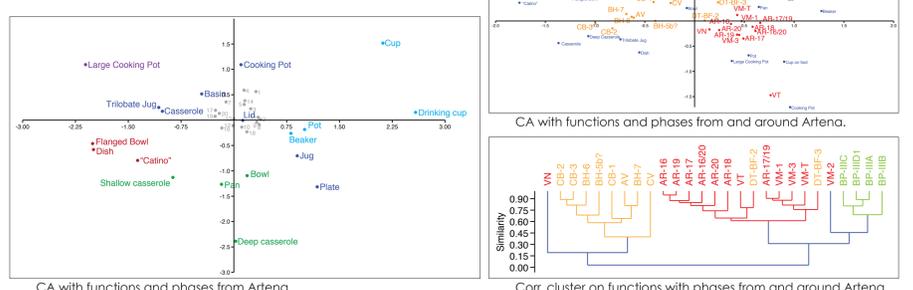
Food practices and culture

Food practices can be explored chronologically and geographically.

The CA for Artena shows on the left the classical Late-Antique forms, working together (flanged bowls, dishes, catini). The large cooking pots are mirrored, influenced by their presence during the Republican era. On the right there are the more characteristic forms of the earlier phases, from the beginning of the Empire upwards and in the middle, from the 2nd and 3rd centuries AD downwards and from the centre downwards.

A comparison between Artena's Late-Antique phases and the reference assemblages shows that food practices are clearly more influenced by geography than by chronology. The Roman assemblages (left) are quite different from the Portus ones, which are themselves very different from the assemblages of the western zone. The correlation cluster clearly shows these three areas, with a clear distinction between Roman and non-Roman assemblages.

CA with functions and phases from Artena.

CA with functions and phases from and around Artena.

Corr. cluster on functions with phases from and around Artena.

Potential bias

The variability in quantification methods in Lazio (or their absence) requires comparison of values that are not strictly equivalent. Although it is an improvement compared to a presence/absence study, it leads to a decrease in the quality of the analysis. In addition, the typology used [1] was created a posteriori, except in the case of Artena. This brings two problems: when only one specimen is drawn, it is difficult to be sure that all those referencing this drawing are exactly the same type. When an external drawing is referenced, there is not even any certitude of equivalence of types. This can force some connections between assemblages. However, geographical areas are globally consistent and not in contradiction with expectations. Lastly, regional categories are still poorly delineated and the general absence of fabric descriptions often makes equivalences problematic.

[1] The typology of common wares for central Italy will soon be available via the ONICer software, developed by Xavier Deru (University of Lille). The specifically Late-Antique types will be displayed at the LRCW 7 congress in Valencia on 15 October.

Conclusions

Combined with typological and stratigraphic studies, statistical tools are a valuable source of knowledge about archaeological artifacts and are still underused. They greatly help to classify a very large amount of information, identify some trends easily or weight results. However, their optimal application in Central Italy is facing several problems. In order to overcome them, it is essential to establish common quantitative and qualitative standards in the study of ceramics in Central Italy. The typology of common wares currently under development aims to partially fill this gap. Its use in Artena and the surrounding areas, which has only been overviewed here, already gives strong results in terms of chronology, economy and culture.

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