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ROMAN OIL LAMP OF TERRACOTTA ON SYRIAN COAST: STATISTICAL ANALYSIS

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Abstract: In 64 B.C., the Romans turned Syria into a Roman province and this occupation continued, with many vicissitudes, until 638 A.D. when it fell into Arab hands. This occupation originated an important material and social development for almost 400 years. The oil lamps located in Syria were objects located in hypogea (funeral contexts) and in cut pits (domestic contexts) mainly along the Syrian coast, showing aspects of the social, cultural and domestic life.

From the data published in the scientific literature, four quantitative variables (length, width, discus diameter and shape index) and two qualitative variables of great archaeological relevance (context and chronology) from Syria oil lamps have been recorded, which has allowed us to analyze the oil lamps by applying bivariate and multivariate statistical analysis. The results obtained indicate different factory patterns regarding the context and chronology as well.

The application of Cluster Analysis provides a classification of the oil lamps into a large group consisting of small and very rounded lamps, perhaps dedicated to domestic and everyday use, versus other group with larger and highly stylized lamps, possibly with functionality more associated with burials or ceremonial rituals. Also, the graphics sequences of each variable constitute a pattern for the lamps in each cluster with respect to the metric variables, allowing to graphically comparison between the oil lamps and the variable values also.

Keywords: *chronology, quantification, roman oil lamps, statistical classification, Syrian coast, terracotta.*

INTRODUCTION

In the eastern Mediterranean during the first millennium B.C., a large number of kingdoms emerged on the coast from the north to the south. From this period, we find material remains belonging to the Phoenician and other cultures.[1] During the Hellenistic period the Syrian coastal region was subject to various occupations and invasions, which produced great political and social instability due mainly to the arrival of Alexander the Great in 330 B.C.[2] when he invaded the Syrian coastal region. Some kingdoms in the region maintained their independence, such as Arwad/Amrīt due to policies carried out by its king Gerastart (Greek Gerostratus).[3] The new authority managed

[1] AUBET 1993; OGGIANO 2012; MUSTAFA 2015; MUSTAFA/ CHÁVET 2016; MIKDISI/ ISAAC 2017

[2] AKKERMANS/ SCHWARTZ 2003; COHEN 2006.

[3] ELAYI/ELAYI 1986: 17; ELAYI/HAYKAL 1996.

to continue the independence of these kingdoms even as regional monarchs continued to benefit under the control of the Seleucid kings of Syria (Alexander's Macedonian successors, and their representatives in Antioch).[4]

The Romans arrived in Syria in 64 B.C. promoting the development of great building construction activity during their first 300 years of occupation,[5] as well as further urbanization and improved agricultural production.[6] According to this researcher, the period of Hadrian's rule as Emperor was very significant due to the Syrian coast, as a geographical zone, being part of the Syro-Phenicia province.[7]

In this work, a stylistic analysis of the manufacture of a set of Roman terracotta oil lamps found in the excavations on the Syrian coast was carried out by means of a quantification of qualitative and quantitative variables that characterize the Roman terracotta oil lamps of this region. This analysis provides a quantification of these lamps and allows analysing manufacturing patterns, typologies, materials, etc.

MATERIALS AND METHODS

The data set is made up of the 41 almost complete Roman terracotta oil lamps found in the excavations carried out on the Syrian coast and which are referenced in the literature. This material was analysed registering a total of 12 variables including the quantitative variables of length, width, diameter and number of holes and the qualitative variables both of contextual type (city, site, context and chronocultural dating) and others of technological and figurative type (technique of manufacturing, typology of decorations, decorative figures and manufacturing technique of the figures). All the lamps are made of clay and all come from Cyprus except a single example from Corinth.

The data have been obtained from the lamps referenced in the literature based on an exhaustive search for articles in scientific journals, printed articles and articles from the digital magazines of the various publishing groups. From the graphs that appear in these publications, the numerical variables have been measured with a precision of ±1 mm.

To store and manage the registered data, a database of oil lamps has been developed to which new discoveries will be incorporated. The data have been analysed using univariate and multivariate statistical methods appropriate, in each case, to the type of variables to obtain archaeological information about oil lamps regarding their dimensional features, typological characterization, decorative patterns, etc.

DATA DESCRIPTION

For archaeologists and historians, the remains of material culture are as fragments of a puzzle that help to know ancient societies. However, it is rare that small artefacts such as lamps make a significant contribution to the ability to analyse the societies of the past.[8] In ancient times, lamps were important objects of daily life, with both funerary and domestic use; the need to have light at any time and place gave oil lamps a prominent place in human society.

Oil lamps appeared the first time in the late 3rd millennium BC in the Near East.[9] Since then, typology and form changed according to the culture that produced the lamp.[10] Lamps were exported to and imported from the entire Mediterranean basin. Trade began in the north and developed as it moved southward at the Ibn Hani site on the north of the city of Lattakia, an important settlement that was inhabited since the Late Bronze and Early Iron Ages.[11] Additionally, one lamp was discovered at a hypogeal tomb, associated chronologically, with the Hellenistic period I.[12]

To the south west we find the Jbeibat site, which belongs to a Jablé suburb (Lattakia City) (Fig 1a), and flourished during the Hellenistic and Roman periods.[13] In 2001, the team of Syrian archaeologists that excavated the necropolis discovered 24 oil lamps in a funerary context in eight rock-cut tombs, each lamp displaying different typologies. These lamps were consigned to a chronology between II-III centuries A.D., which places them in the Roman period.[14] Also, a few kilometres to the west, at the village of al-Thawra in 2005, one incomplete piece of a terracotta lamp was recorded as found in a rock-cut tomb of type Cypriote datable to V AD.[15] (Fig. 1a). To the south in Arab al-Mulk, which belonged to the Jableh district, were registered eight lamps in a hypogeal tomb, all datable to III-IV centuries B.C.[16]

At the Amrīt site, known for being a Phoenician city,[17] inhabited since the third millennium B.C., at the Ras-shagry tomb a lamp dated to the Roman period ca. II B.C.[18] was uncovered (Fig. 1b). Another lamp was documented as having been found inside a hypogeal tomb from the Azar necropolis, previously unknown in the archaeological record. A few kilometres to the south of the city of Tartus, at the Tabbat al-Hammam site, which has ties to the Phoenician culture,[19] another four lamps were recorded, also dated to the Roman period.[20]

In this paper, all the lamps studied are "disc lamps" having a circular body with a wide edge sloping outwards, a small disc and a short, rounded spout. The border may be smooth or decorated with simple geometric or vegetal elements such as bunches of grapes and leaves. We find the disc usually decorated with motifs of larger and coarser figures, but in variants of the latest periods, the ornamentation disappears. The handle, which is not present in all types, may be perforated or solid. The base is annular,

4 DE JONG 2007, 3.
5 ZIEGLER 2000; SHAHID 2007.
6 BUTCHER 2003.
7 GRAINGER 1990, 24.

8 ELRASHEEDY/SCHINDLER 2015, 36.
9 BUSSIÈRE/WOHL 2017, 17.
10 MŁYNARCZYK 2013.
11 JANEWAY 2017.
12 BOUNNI *et alii*, 1978, 287.
13 DE JONG, 2007, 17.
14 BADAWI 2007, 190.
15 BADAWI 2010, 269.
16 BADAWI 2015, 77.
17 KONTNO 2001, 278; BRIAN 2014, 105.
18 MUSTAFA 2013, 48.
19 SCHREIBER, 2003, 237.
20 BRAIDWOOD 1940, 187-188.

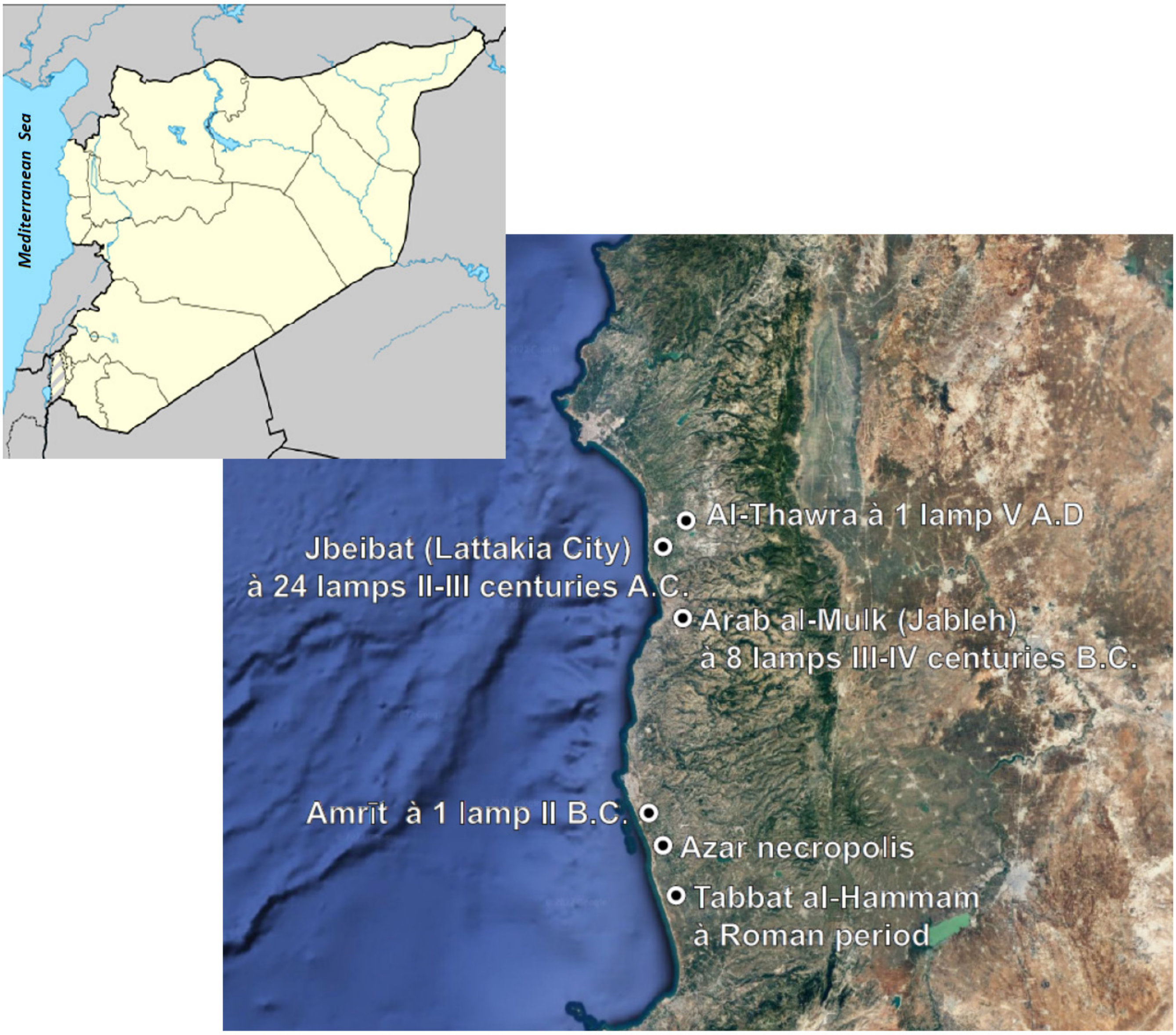

Fig. 1. *Syrian coast. Archaeological sites with lamps.*

often occupied for the most part by the potter's firm mark. Sometimes they incorporate lateral fins, which may have either a functional or solely ornamental character (Fig. 2[21]):

Its morphology is based on a fuel deposit - 1 infundibulum - with a flat or annular base destined to contain the oil, and a spout (2 *rostrum*) where the vegetable wick that came out through the wick hole or illumination hole (3 *myxus*) is placed. The tank had an upper cover in the form of a flat or concave disc (6 discus) having a central illumination hole (7 *orificium*) to fill it, which is surrounded by several mouldings in addition to one or more bands or outer borders (4 *margo*) next to one external trim (5 *moldedura*). In general, the lamps have a handle to hold them by hand (10 *ansa*) which is a part that protrudes from the body in a curved or ring shape. At the base (9 *basis*) we usually find the potter's mark. In addition, occasionally we find ornamental scrollwork (11 *volutae*) between the discus and the mixus.[22] On some occasions, the lamp may have a small breather hole between the disc and the beak (8 *oculos*) which prevents a vacuum effect and the oil from overflowing.[23] In each lamp, some of these elements may be absent due to stylistic variations that occur over time.

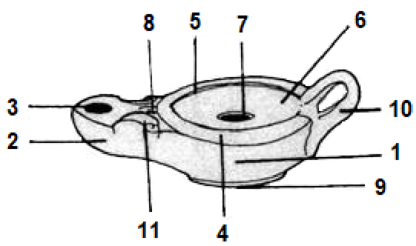

Fig. 2. Schematic drawing of a disc lamp (modified from).

[21] AMARÉ 1987; MORILLO 2015.

[22] AMANTE 1984, 1985; AMARÉ 1987; RODRÍGUEZ 2005; CELIS 2008; MORILLO 2015.

[23] MORILLO 2015.

Oil lamps of the Syrian coastal region have not yet have been sufficiently investigated by researchers. In this work, our focus will be only on those sites on the Syrian coast within the known archaeological record of oil terracotta lamps.

STATISTICAL ANALYSIS

The data set is composed of 41 well-preserved roman ceramic lamps found in deposits on the Syrian coast, which have been registered to include 14 qualitative and quantitative variables obtained from scientific publications. These variables are spatial (city, settlement and archaeological context), origin of the lamp, chrono-cultural periodisation, manufacturing (material, manufacturing technology and manufacturing technique), geometric shape, decorative motif, number of holes on the discus for oil and three metric variables (length, width and diameter of the discus). All the lamps are made of clay, so this fact is a constant and therefore not informative without variability. This quality does, however, have great archaeological importance, indicating that clay is the only material used in the manufacture of the oil lamps found in the area. From a technological point of view, we also note all the lamps, except one, were made with molds. The single exception was made using a pottery wheel.

1.1. Univariate quantitative analysis

Using the metric variables, an initial analysis indicates that length, height and diameter of the discus are quite standardized with very small coefficients of variation, thus showing great technical perfection and standardisation in manufacturing (Table. 1):

Table. 1. Statistical descriptive parameters.

	Descriptive Parameters		
	μ	σ	CV
Length	9,20	**1,37**	0,15
Width	**6,95**	**0,89**	**0,13**
Discus diameter	**4,72**	**0,85**	**0,18**

The values of quantitative variables (X1=length, X2=width, X3=discus diameter) have been normalized to mean 0 and variance 1 in each variable to ensure that the possible influences of measurement units are essentially eliminated according to:

$$X'_i = \frac{X_i - \mu_i}{\sigma_i}$$

Being the mean and the standard deviation of variable *i*.

In addition, to analyze the relationship in the shape between the longer lamps compared with the more square ones as well as the chronological evolution between the various shapes, a new calculated variable from the raw variables length and width is defined as:

$$shape\_index = length/width$$

Detection of possible differences in each metric variable follows the normality check of the data. In our case, the Kolmogorov-Smirnov test indicates that the data do not fit to a normal distribution with a two-sided asymptotic significance $\alpha<0.05$ in each variable.

Since only one lamp appears in the domestic context, the analysis of differences between the other contexts ("cut pit" and "hypogeal") was carried out by means of a Mann-Whitney nonparametric test. The results show statistically significant differences in all variables with significance level $\alpha<0.05$ (Table. 2), thus showing different measures between the contexts:[24]

Table. 2. Results of Mann-Whitney test applied to "cut pit" and "hypogeal" contexts.

	U	p-value
Length	43,500	0,000426
Width	4,562	0,000364
Discus diameter	74,500	0,007340
Shape index	30,500	0,000093

Using the chrono-cultural periods except for V century (there is only one lamp in our sample from this period), the application of the Kruskal-Wallis test for independent samples to the raw numerical variables and the shape index shows that there are statistically significant differences between the various chronologies regarding the length, the width and the shape index, while there are no differences regarding the diameter of discus variable, with signification level $\alpha<0.05$ (McCluskey and Lalkhen 2007). The discus diameter has not statistically differences between chronological periods (Table. 3).

Table. 3. Results of the Kruskal-Wallis test showing significant differences between chronological periods.

	$\chi 2$	p-value
Length	14,564	0,012
Width	11,610	0,041
Discus diameter	5,977	0,308
Shape index	18,285	0,003

A box-and-whisker plot shows these statistically significant differences graphically (Fig. 3):

Length, width and shape analysis variables show statistically significant differences between the different

[24] MCCLUSKEY/LALKHEN 2007.

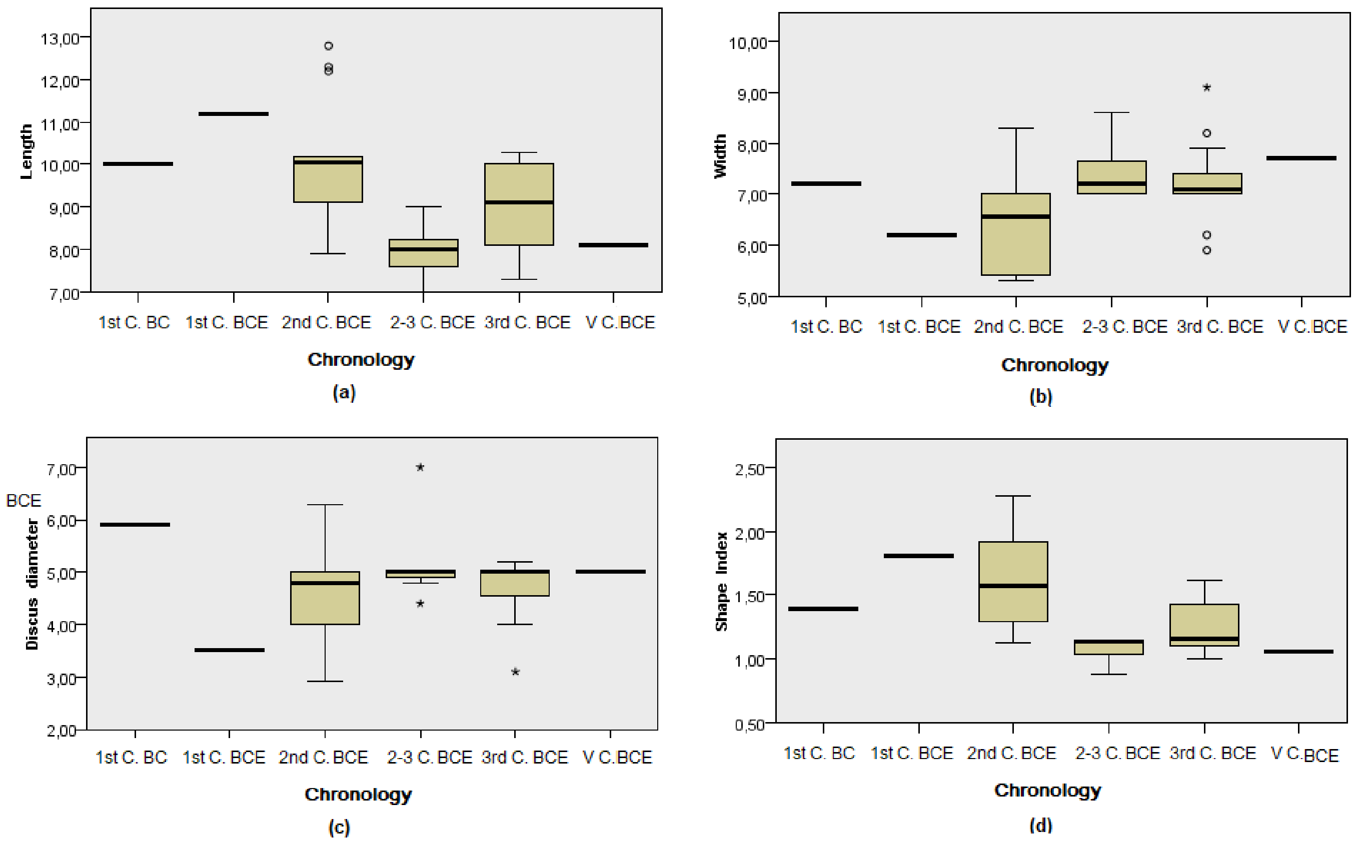

Fig. 3. Box-and-whisker plot for each variable.

chrono-cultural periods, with the exception of the diameter of the disks. The main features appear during the transition between the 2nd and 3rd centuries, with a trend toward lamps of small length, large width and circular shape. This fact points to an evolution in the dimensions of the lamps that occurs, fundamentally, in the 2nd century, between 2nd and 3rd centuries and within the 3rd century. However, the Kruskal-Wallis test applied to discus diameter values shows that there are not statistically significant differences between the chrono-cultural periods, thus showing that the dimensions of the disc have not undergone significant variations between the 1stand 4th centuries. The values (correspond to the confidence interval (4.0141, 4.5346) with a signification level =0.95, and n=41 computed by means of the expression:

$$\mu \in \left(\bar{x} - \frac{Z_{\alpha} \cdot s}{\sqrt{n}}, \bar{x} + \frac{Z_{\alpha} \cdot s}{\sqrt{n}} \right)$$

Being the mean of population, and the mean and the standard deviation of the sample respectively, the number of elements and the typified value in the N (0.1) with α signification level (usually α=0.05). The range of variation for the sample mean is ±5 mm, indicating that the error in the manufacture of the discus is very small, perhaps because its manufacture is highly standardized.

UNIVARIATE QUANTITATIVE ANALYSIS

These three measures are the basis for carrying out a preliminary classification of the lamps showing graphically the association between the dimensions of the lamps and the context in which the material appears. In addition, the variable "shape index" recording whether the shape is longer than it is wide (shape index >1) or vice versa (with the shape being shorter than it is wide, or shape index <1). Lamps found inside a pit are in the first category (greater length than width), unlike those found in a hypogeum.

The correlation between is strong with positive value the length versus shape index (r=0.870) and between the shape index versus width negative value (-0.813), whilst the rest of the variables have weak correlations between them (Table 4):

Table. 4. Pearson lineal correlation between the quantitative variables of lamps.

	Length	Width	Discus diameter
Length	-		
Width	-0,440	-	
Discus diameter	-0,358	0,648	-
Shape Index	**0,870**	**-0,813**	-0,594

The scatter plots of the well-correlated variables show two distinct patterns. The plot shape index versus length shows the lamps are highly positively correlated (r = 0.870)

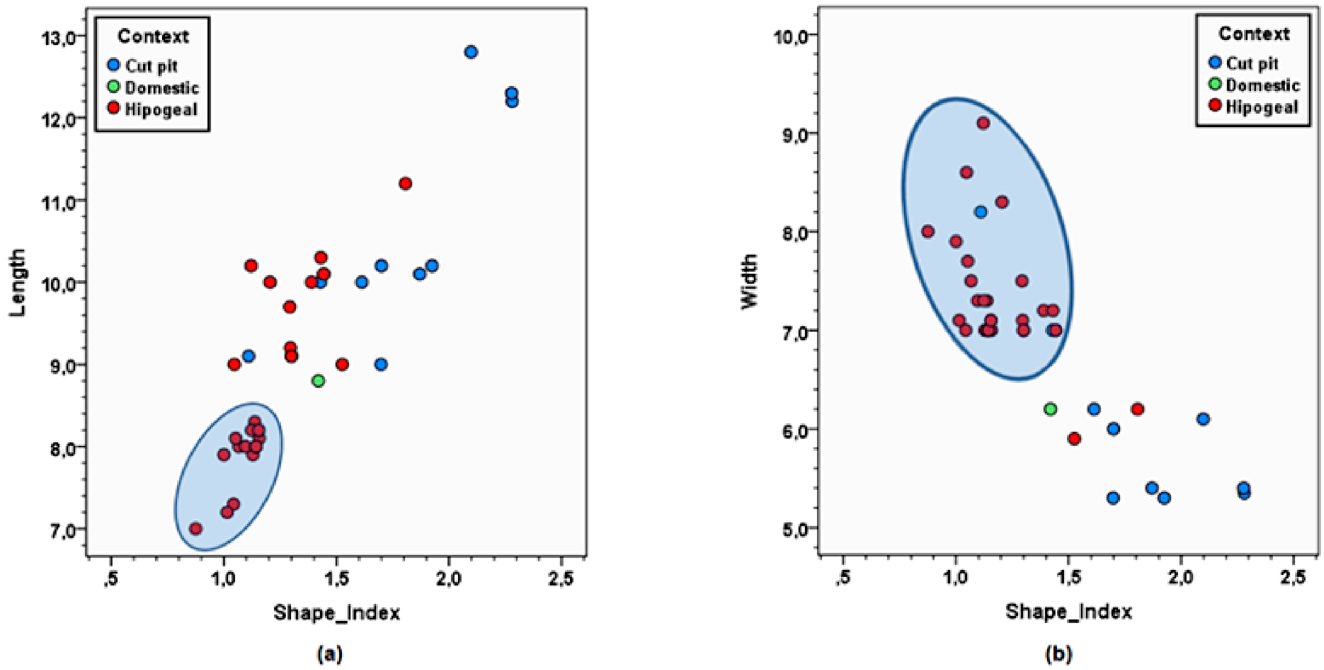

Fig.4. 2D Plot showing the groups in hypogeal a) lamps with small length and small shape index, and b) lamps with large width but small shape index.

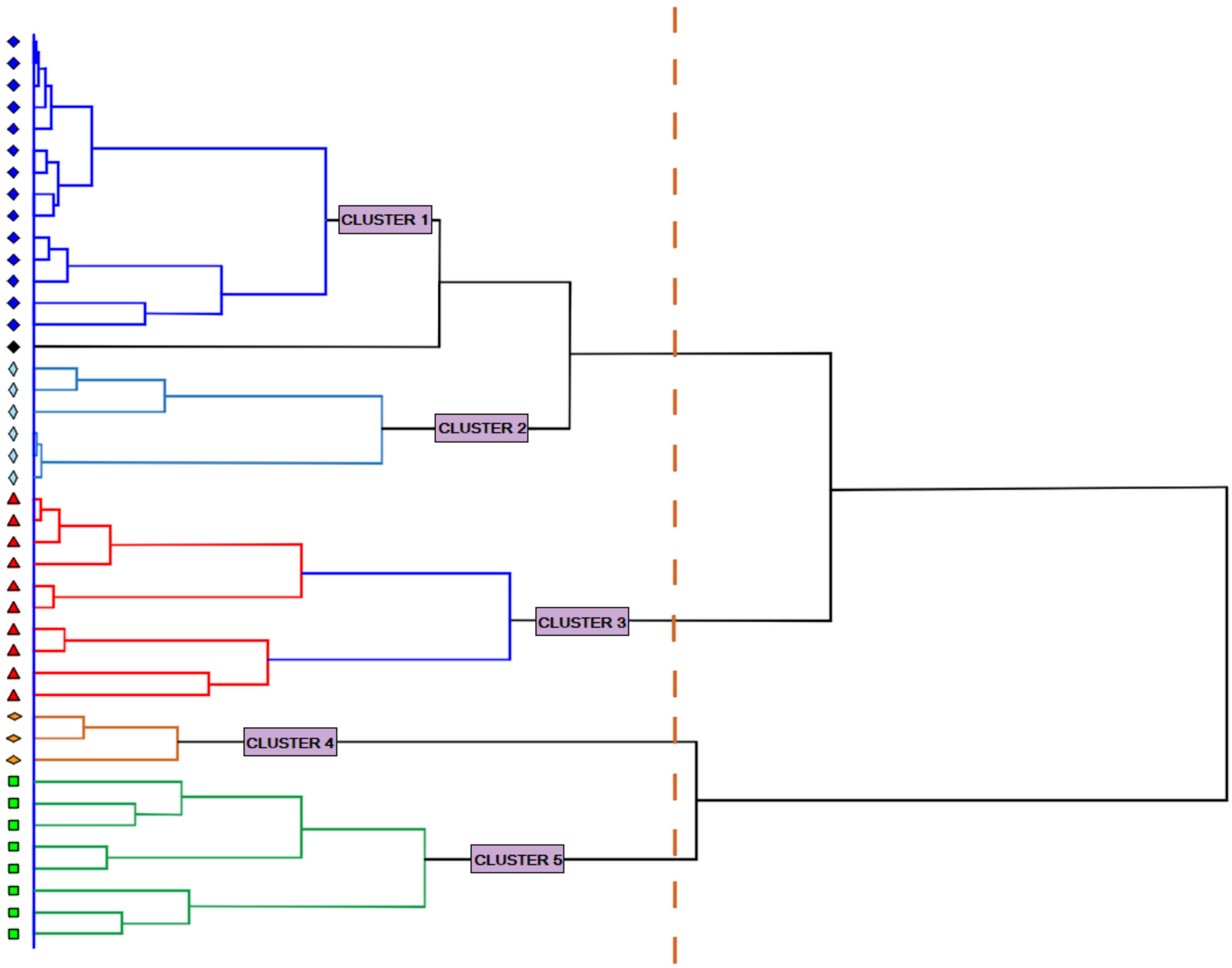

Fig. 5. Dendrogram obtained from cluster analysis using quantitative metric variables.

Table. 5. Refined qualitative classification from dendrogram.

CLUSTER A	CLUSTER 1	Small	Small	Medium	Small
	CLUSTER 2	Medium / Large	Small	Small / Very Small	Very Small
	CLUSTER 3	Large	Small / Medium	Medium / Large	Small / Very Small
CLUSTER B	CLUSTER 4	Very Large	Medium	Very Small	Very Large
	CLUSTER 5	Large / Very Large	Small / Very Small	Small / Very Small	Medium / Large

corresponding to elongated lamps and highlights a group of small dimensions (Fig. 4a) that appear exclusively in the context of the hypogea. However, the graph shape index versus width, highlights that the lamps have a very high negative correlation (r = -0.813), corresponding to narrow lamps (Fig. 4b) and, again, the group in hypogeal context is separated from the rest due to the fact that they are relatively large lamps. In addition, the lamps found in the pit context are smaller; this difference is perhaps due to their serving a different function.[25]

A classification of lamps according to the four quantitative variables (length, width, discus diameter and shape index) was carried out obtaining the dendrogram generated by a cluster analysis classification technique SAHN (Sequential, Hierarchical, Agglomerative and Non-overlapping) considering the Euclidean distance as the similarity measure and the Ward's clustering algorithm (minimum variance) as the clustering method.[26] The Ward's method is more flexible to outlier values and to identify groups and subgroups. This algorithm was applied to the lamps data (Fig. 5):

The dendrogram shows two large groups composed of CLUSTER A and CLUSTER B. CLUSTER A is made up of lamps that are short to medium length, very wide in relation to the length, having a disk with large diameter and having no stylized shape, but rather a rounded shape. CLUSTER B is made up of long, very narrow lamps with respect to length, with medium or small discs and a very stylized shape. From the dendrogram, a refined qualitative classification can be considered in 5 subgroups (CLUSTER 1, CLUSTER 2, CLUSTER 3) and (CLUSTER 4 and CLUSTER 5) (Table 5):

A plot sequence based in the mean variables show the differences between the values of the variables, showing that the length and the shape index follows a specific increasing trend while the other variables are more associated with each other with different trends from a decreasing plot. Clearly width and discus diameter follow the same patterns with respect to the five clusters (Fig. 6), with a peak in CLUSTER 3. On the other hand, length and shape index adjust to a different pattern, highlighting the peak in CLUSTER 4, than is greater for length.

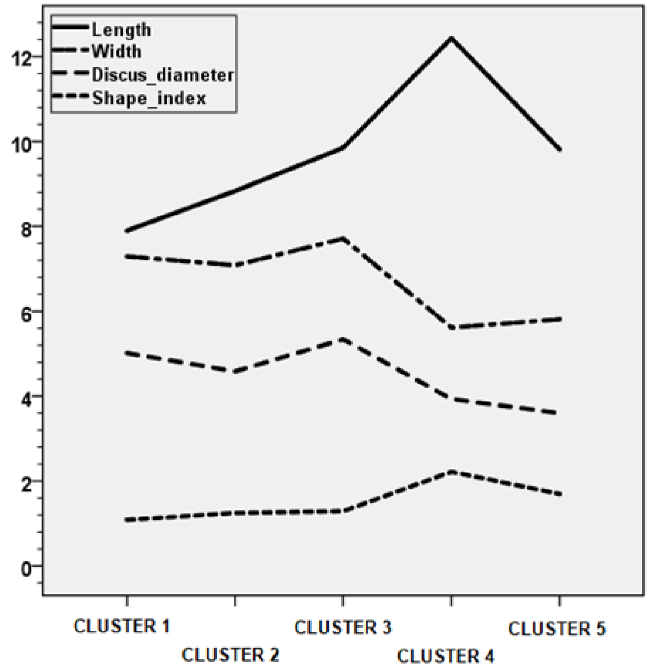

Fig. 6. Plot of means for quantitative variables between clusters.

These graphics sequences constitute an important pattern of the lamps in each cluster with respect to the metric variables, allowing graphic comparisons between them.

CONCLUSIONS

The Syrian coast of the first millennium B.C. is replete with material remains belonging to the Phoenician era as well as examples from other cultures as it was successively subject to various invasions and occupations. The arrival of the Romans in 64 B.C. promoted significant economic and political development and the Syrian coast became part of the Syro-Phoenicia province. Statistical analysis has made it possible to characterize and document the oil lamps found off the coast of Syria from the lamps referenced in the literature.

[25] SOKAL/ ROHLF 2001.
[26] EVERITT *et alii* 2001; KRIEGER *et alii* 2014; HENNIG *et alii* 2015.

The metric quantitative variables are fairly standardized, indicating that their manufacture was highly regulated, with some variations depending on the context and the period to which they are assigned. There are great differences based on the context in question indicating that, from a metric point of view, the lamps found in the hypogea have very different characteristics from those found in pits. This fact suggests that the form of burial determines the metric characteristics of the lamps.

The analysis based on chronology highlights very important differences regarding the metric variables in each period except for discus diameter. The measures of lamps show variations in manufacture over time, highlighting the 2nd and 3rd centuries B.C. in which the width ranges from small values in the 2nd century, to very large values in the transition between 2nd century and 3rd century, to finally be manufactured again using small values in the 3rd century. These changes seem mainly due to aesthetic reasons since the discus diameter values do not differ between periods. Perhaps this is because this variable is related to the capacity of the deposit.

The classification obtained from cluster analysis consists of a large group constituted by small and very rounded lamps, perhaps dedicated to domestic and everyday use, compared with another group formed by larger and highly stylized lamps, possibly with functionality more associated with burials or ceremonial rituals.

Finally, the analysis of the means of each variable with respect to the groups in dendrogram shows the existence of two different patterns related to some of the groups established by the cluster analysis. Based on the width and the discus diameter, the lamps belonging to CLUSTER 3 are characterized by constituting a common pattern with a peak in that cluster, while the length and shape index also form a pattern, but they are a peak associated with CLUSTER 4. The shape of the curves and their geometric features, peaks and valleys, allow us to graphically establish the similarities and differences in each group.

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