HAL open science

Standardized Vessels and number of Potters : looking for individual production

Valentine Roux, Avshalom Karasik

▶ To cite this version:

Valentine Roux, Avshalom Karasik. Standardized Vessels and number of Potters : looking for individual production. Ina Miloglav, Jasna Vukovic. Artisans rule : product standardization and craft specialization in prehistoric society, Cambridge Scholars Publishing, pp.20-39, 2018, 978-1-5275-0668-8. halshs-01996750

HAL Id: halshs-01996750
https://shs.hal.science/halshs-01996750

Submitted on 14 Feb 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

STANDARDIZED VESSELS AND NUMBER OF POTTERS: LOOKING FOR INDIVIDUAL PRODUCTION

VALENTINE ROUX AND AVSHALOM KARASIK

Introduction

Estimating the number of artisans involved in the manufacturing of ceramic assemblages is a major issue for characterizing the organization of ceramic production, be it at the scale of the site or the region. At the scale of the site, it should enable us to better approach the socio-economic status of the potters as well as the conditions for the emergence of craft specialization. Thus, recent studies have shown that pottery specialists during the Late Chalcolithic times, be it in Levant or Mesopotamia, were surprisingly in low numbers and attached to the local elites (Roux 2008; Baldi 2015). At the scale of the region, assessing the number of artisans should enable us to revisit ancient modes of production and distinguish, for example, between local workshops and production by itinerant potters. The latter mode is implying that a few potters were producing the same types over large areas as recorded by ethnographic and archaeological studies (Boileau 2005; Ramón 2011).

Among the researches that focused on how to estimate the number of artisans from the variability of ceramic assemblages (see Rice 1991 for a review), those on standardization have been in the spotlight (Benco 1988; Rice 1991; Arnold and Nieves 1992; Blackman et al. 1993; Costin and Hagstrum 1995; Arnold 2000; Costin 2001, 1991). The rationale is that motor habits are required to achieve standardized products, here defined as a production characterized by types whose objects within each of them present a low distance from each other. These motor habits develop depending on the intensity of production (Longacre et al. 1988; Roux 2003): the more intense the production, the stronger the motor habits and the more standardized the production. Standardization can be measured by the coefficient of variation (abbreviated CV) of the absolute dimensions of the vessels (Kvamme et al. 1996; Eerkens and Bettinger 2001). When CVs are low, they express intense production at the individual scale and therefore specialization. The number of artisans can be then assessed against the estimated annual production as indicated by the quantitative archaeological data: low CVs combined with low annual production suggest a low number of artisans since the latter have to practice regularly for developing the required motor habits. Low CVs combined with high annual production suggest a high number of artisans. When CVs are high, they express weak production at the individual scale. The number of artisans is then more difficult to make out given both intra- and inter-individual variability.

Now, inferring the number of artisans from the CVs of absolute dimensions and annual productions can give only an order of magnitude (low *versus* high). Moreover, evaluating annual production can be problematic since the representativeness of the ceramic assemblage excavated compared to the initial population can never be precisely known. At last and this is a significant point, the CVs apply to absolute dimensions whose mastering testifies to motor skills and potter's intention (to make standardized pots). The question then remains of a possible individual metric signature significant of the number of artisans involved in the ceramic assemblage.

In this paper, we propose to assess whether it is possible to highlight the number of artisans involved in a standardized production. The case study is ethnographic with the scope to build up reference data for interpreting archaeological data. The study took place in Rajasthan (India) where the same type of water jar is produced and distributed at a macro-regional scale. We will first describe the context of production. Then, the absolute dimensions, as well as the profiles of the potters' vessels, will be analyzed in terms of distance to each other to assess whether metric variability can reflect individual ways of making a same type of jar, and hence the number of potters.

The context of production

The area under study is the Jodhpur region (Jodhpur and Barmer districts) (Fig. 2-1). It is inhabited by two socio-religious communities of potters: Muslim (Moila) and Hindu (Prajapat). The Muslim potters fall in 40 villages, whereas the Hindu potters of the Jodhpur and Barmer districts are few in numbers. They fall in 10 settlements. They represent 10 percent of the Hindus practicing 30 years ago. All the potters, Muslim and Hindu, are independent craft specialists who distribute their goods either indirectly through middlemen or shopkeepers established in the city of Jodhpur, or directly to the local surrounding populations.

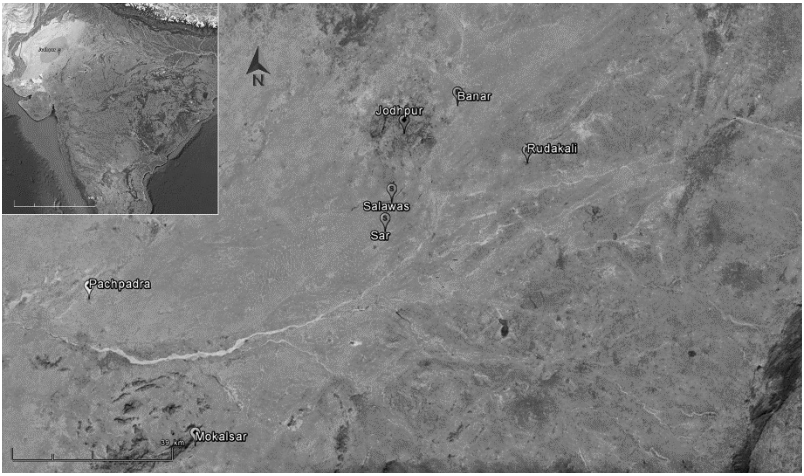

Figure 2-1: Localization of the villages of the Jodhpur region where data were collected.

Up to 30 years ago, Hindu and Muslim potters used to manufacture distinct ranges of vessels, the former being specialized in storage and transfer jars and the latter in "kitchen ware". Nowadays, ceramic production of the two communities includes mainly white water jars made out of salty clay and tempered with sawdust and granite. The shape is standardized. The body is globular, and the neck is short with a grooved lip (Fig. 2-3). No painting is applied. There are three sizes of jar: small (less than 10 liters), middle (15-20 liters) and big (over 30 liters). The history of the white water jar is a recent one. It started 30 years ago with the decrease in the consumption of earthenware because of the arrival of the plastic and metal objects (Roux 2015).

As a result, Hindu potters started to shift from pottery to other professional occupations, massively quitting the profession within 20 years. In parallel, the Muslim potters started to take over the manufacture of the water jars, the type of vessel which hitherto had been the monopoly of the Hindu potters. Directed by middlemen, they choose to make the same water jars than the ones made by the potters from the town Pachpadra, that is to say, water jars made out of salty clay and well-known for their capacity to cool down the water. In the late eighties, the demand for water jars changed. It was not anymore for "Pachpadra jars", but for

"Mokalsar jars", a town 40 km south of Pachpadra. The latter are granite tempered salty clay jars with high cooling properties. This demand was again directed by middlemen and shopkeepers. Nowadays, the demand for Mokalsar jars is still in high demand. The peak of the production is in January-February, before the festival of Holi which takes place usually in March and when all the water jars are renewed.

Methodology

Body of data

Our body of data includes 676 water jars of 15 and 20 liters made by 25 potters living in six different villages: Sar, Salawas, Rudakali, Banar, Mokalsar, Pachpadra (Fig. 2-1). The 25 potters belong to different age classes and different socio-religious communities, including 21 Muslim and 4 Hindu potters (Table 2-1). They produce an average of 25 water jars per day which corresponds to an average annual production of 4000 jars, knowing that they work around 20 days per month and eight months a year.

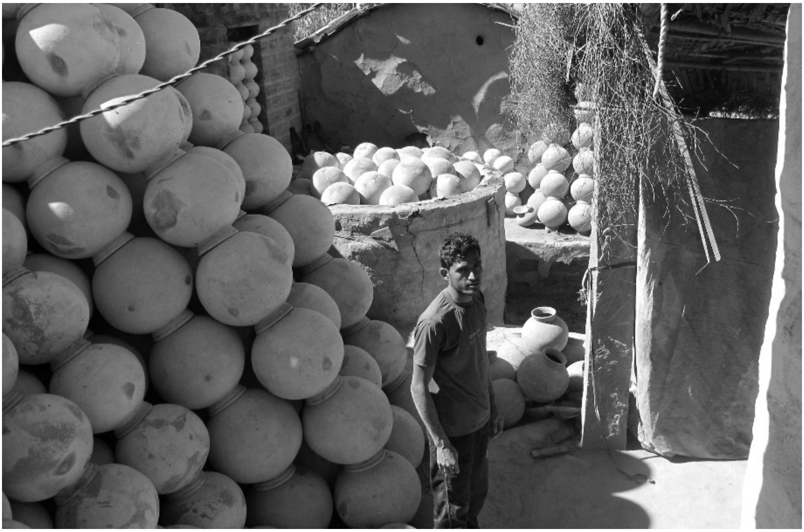

Figure 2-2: Heaps of fired water jars waiting to be loaded and taken away by middlemen.

In each village, most of the studied potters are family related. In Sar, SLI and GAN are brothers. In Banar, SAF and RMJ are brothers; AGA is the father of GUL; NUR is the father of RAM and the grandfather of SKA. In Salawas, CHA is the father of FAZ and SAD; in Rudakali, ANW is the father of RAZ, USI and INS. In Pachpadra, HIR is the father of HAS and LAL. In Mokalsar, ALI and FIR are brothers.

The jars under study were selected randomly from heaps of jars, each heap corresponding to the production of a well-identified potter (Fig. 2-2). The jars stored by each potter were waiting to be loaded and taken away by middlemen. They match a production over a few weeks.

Jar size (liter)	Potter	Age	Annual rate of production	Village	Group	*n*
15	AGA	68	3200	Banar	Muslim	20
15	CHA	55	4800	Salawas	Muslim	30
15	GAN	50	4800	Sar	Muslim	30
15	GUL	45	4800	Banar	Muslim	20
15	NUR	70	3600	Banar	Muslim	20
15	SLI	25	4800	Sar	Muslim	29
15	SKA	19	4800	Banar	Muslim	22
20	ALI	22	4800	Mokalsar	Muslim	30
20	ANW	50	3200	Rudakali	Muslim	30
20	BAB	28	4000	Rudakali	Muslim	30
20	BLA	65	4000	Banar	Hindu	31
20	FAZ	28	4000	Salawas	Muslim	31
20	FIR	25	4800	Mokalsar	Muslim	30
20	HAS	17	3200	Pachpadra	Hindu	20
20	HIR	60	3200	Pachpadra	Hindu	20
20	IMA	19	4800	Salawas	Muslim	30
20	INS	29	4000	Rudakali	Muslim	30
20	LAL	25	3200	Pachpadra	Hindu	20
20	RAM	45	6000	Banar	Muslim	21
20	RAZ	25	600	Rudakali	Muslim	31
20	RMJ	26	4800	Banar	Muslim	30
20	SAD	26	6400	Salawas	Muslim	29
20	SAF	30	3200	Banar	Muslim	30
20	SAM	37	4800	Rudakali	Muslim	31
20	USI	27	4800	Rudakali	Muslim	31

Table 2-1: The body of data distributed per jar capacity, potter (alphabetical order), potters' age, the rate of production, village and religious community. The last column indicates the number of jars studied per potter.

Analytical methodology

Data acquisition

In order to construct systematic morphological comparisons, all pots have been photographed with a Canon camera from a few meters distance in a way that shows their silhouette in front of a blue curtain (see Fig. 2-3).

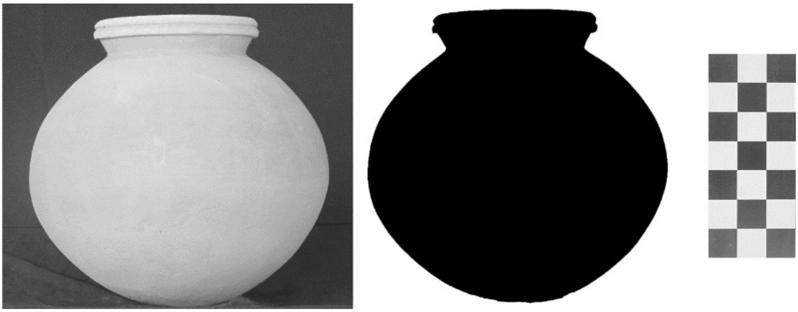

Figure 2-3: Example of the images that were used for profile extraction.

A standard scale was pictured with the exact same conditions together with every pot. The images of the jars were transferred into black and white pictures, from which the pixelized silhouette profiles were extracted automatically, and their absolute size was fixed according to the pixelized picture of the scale. Fig. 2-3 shows an example of one jar as pictured in front of the blue screen (left) and as a black and white image (right), together with the standard scale that was used with all images.

Analysis of the absolute dimensions

An analysis of the CVs of the absolute dimensions (Rim Diameter and Maximum Diameter – abbreviated RD and MD respectively) has been conducted in order to verify the CVs obtained depending on the rate of production and potters' intention to make standardized jars that sell by their size. Distribution of the absolute dimensions has also been examined in order to assess its value for highlighting inter-individual variability.

Analysis of the profiles

During the last decade, many papers have shown the significant advantage of automatic classification based on mathematical representations of ceramic profiles (Gilboa et al. 2004; Karasik and Smilansky 2008, 2011; Adan-Bayewitz et al. 2009; Sergi et al. 2012). The method which was used in those papers was published in detail in Karasik and Smilansky (2011), and we have decided to use it in the analysis of the current assemblage. Briefly, we can say that the profiles of the jars are considered as planar curves, that is further represented by three mathematical functions – Radius, Tangent and Curvature.

Each of these representations has the one-to-one correlation with the original profile, though, it emphasizes features of different scales. The only difference that we have introduced in the current analysis is that we have decided to ignore the bottom of the jars and to concentrate on their upper part which holds the most significant morphological information about the jars.

Fig. 2-4 shows how the upper part of one profile (left) is represented by the three mathematical functions, Radius (top-right), Tangent (middle-right) and Curvature (bottom-right). The classification starts by measuring the distances between any pair of jars in terms of the corresponding mathematical representations and summarizing them in a distance matrix. Statistical techniques such as *Principal Component Analysis* and *Cluster Analysis* are used to reveal the inner structure of the assemblage and its sub-grouping.

The results provide hierarchical grouping within the assemblage, and it is conveniently displayed by a *'cluster tree'* or plotted in the plane of the two leading PCA (Karasik and Smilansky 2011).

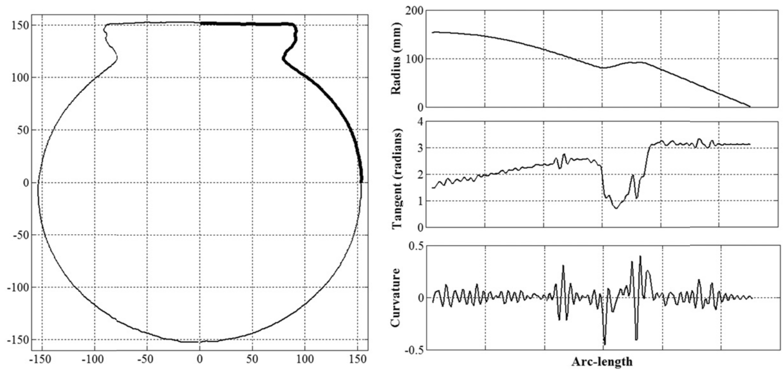

Figure 2-4: An example of a silhouette profile and the corresponding three mathematical representations.

Results

As described above, the water jars documented in the pictures include two distinct categories of products regarding capacities – 15- *versus* 20-liter jars (Table 2-1). Therefore, we have analyzed each of them separately. The first group (15 liters) includes 171 jars produced by 7 potters. The second group (20 liters) includes 505 jars produced by 18 potters.

Absolute dimensions of the water jars

Coefficients of Variation

When considering the CVs of the jar assemblages (respectively all the 15- and 20- liter jars), results are in line with published previous results according to which high rates of production develop high motor skills enabling the potters to produce standardized vessels whose CVs values for RD and MD are inferior to 3 percent despite a cumulative effect (Longacre et al. 1988; Roux 2003), corresponding here to a few week production per potter.

More precisely, the CVs of the RDs and the MDs of both the 15- and 20 liter jars are inferior to 3 percent, except for 4 cases whose CV values of the RD are in the range of 3.01-3.89 percent (Tables 2-2 and 2-3).

15-l jars	**Mean MD**	**Std. MD**	**CV MD**	**Mean RD**	**Std. RD**	**CV RD**	***n***
AGA	311.77	5.65	1.81	170.65	3.82	2.24	20
CHA	324.47	4.66	1.43	170.96	3.79	2.22	30
GAN	326.51	7.45	2.28	174.45	3.81	2.18	30
GUL	323.45	5.03	1.55	165.25	2.80	1.69	20
NUR	306.27	4.76	1.55	167.64	2.68	1.60	20
SKA	323.59	6.86	2.12	176.59	5.32	3.01	22
SLI	340.40	4.09	1.20	174.22	3.13	1.80	29
Total	323.79	11.42	3.52	171.78	5.08	2.96	171

Table 2-2: Mean (in mm), standard deviation and CVs (in percent) of Maximum Diameter (MD) and Rim diameter (RD) of the 15-liter jars distributed per potter.

20-l jars	Mean MD	Std. MD	CV MD	Mean RD	Std. RD	CV RD	*n*
ALI	373.46	3.04	0.81	178.88	2.12	1.18	30
ANW	377.27	3.63	0.96	183.94	2.64	1.43	30
BAB	380.48	3.94	1.03	188.86	3.95	2.09	30
BLA	377.73	4.55	1.2	179.18	4.57	2.55	31
FAZ	376.39	3.98	1.05	182.69	4.74	2.59	31
FIR	373.05	4.31	1.15	191.87	2.56	1.33	30
HAS	394.08	8.83	2.24	189.05	7.36	3.89	20
HIR	383.69	3.92	1.02	196.65	4.71	2.39	20
IMA	364.85	8.31	2.27	177.9	3.81	2.14	30
INS	377.3	7.35	1.94	180.32	4.41	2.44	30
LAL	381.65	5.64	1.48	190.96	5.84	3.06	20
RAM	377.26	3.35	0.88	184.94	3.78	2.04	21
RAZ	369.09	7.19	1.94	181.32	3.29	1.81	31
RMG	380.56	4.52	1.18	188.07	2.92	1.55	30
SAD	376.66	3.52	0.93	174.58	3.26	1.86	29
SAF	369.61	5.33	1.44	181.8	4.91	2.7	30
SAM	376.9	4.52	1.2	176.8	3.73	2.11	31
USI	385.16	3.14	0.81	186.48	5.98	3.21	31
Total	376.98	7.96	2.11	183.62	6.93	3.77	505

Table 2-3: Mean (in mm), standard deviation and CVs (in percent) of maximum diameter (MD) and rim diameter (RD) of the 20-liter jars distributed per potter.

For the 15-liter jars, the total CV values are of 3.52 percent for the MD and 2.96 percent for the RD; for the 20-liter jars, the total CV values are of 2.11 percent for the MD and 3.77 percent for the RD. The high rate of production amounts here to 4000-6000 jars a year, knowing that potters produce nowadays a single type of jar which is a rather exceptional case, ethnographic situations usually reporting situations where the rates of production of vessels include the manufacturing of different morpho-functional types.

Let us also specify that in most of the cases, the CVs of the MDs and RDs are inferior to 1.3 percent, the CV for length measurement derived for the Weber fraction and considered as the limit of human ability to perceive the difference in size (Eerkens and Bettinger 2001). This shows again (Roux 2003) that it is possible to attain such a low variability without automation or use of an independent standard and contrarily to what the CV derived for the Weber fraction suggested.

Distribution of the dimensions

The distribution of the absolute dimensions of the 15- and 20- liter jars shows values whose range is partly due, in both cases, to two potters who tend to make jars either smaller or bigger than the average (Figs. 2-5 and 2-6).

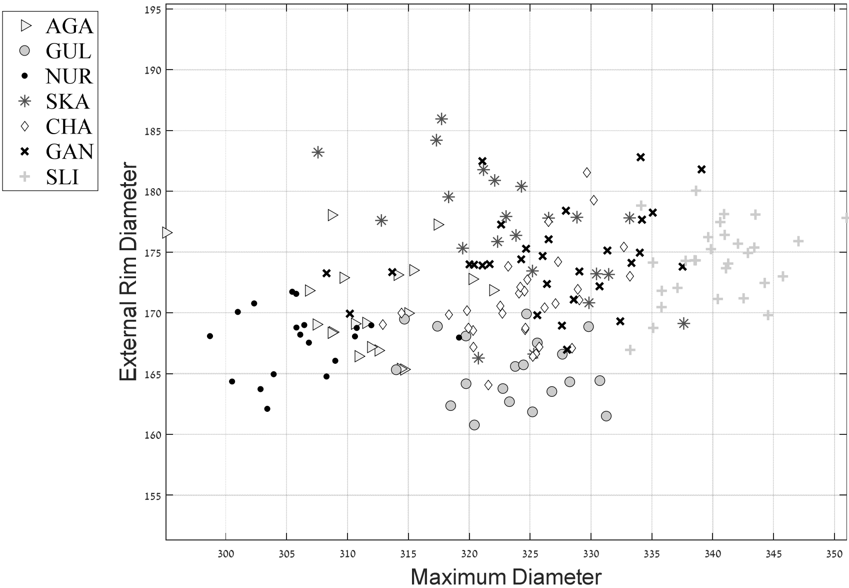

Figure 2-5: Distribution of the maximum diameters and the rim diameters of the 15-liter jars. The centers of the ellipses are at the mean of the distributions, and the dimensions to each side are the standard deviations.

These potters are either old (this is the case of NUR for the 15-liter jars) or young (for the 15-liter jars, SLI is 25 years old; for the 20-liter jars, IMA is 19 and HAS is 17). Except for them, the values of the absolute dimensions are grouped within a group whose variability is in the range of 3 cm both for the MD and the RD. For the 15-liter jars, the two potters whose jars show the absolute dimensions with the widest range (also measured by the highest CVs) are SKA and GAN. SKA is a 19 years old potter, whereas GAN is a fifty years old potter still making a wide range of morphological pots, contrarily to most of the other potters. For the 20-liter jars, the two potters who made the jars with the absolute dimensions showing the widest range of values are IMA and HAS (also measured by high CVs), the two young potters whose production tends to be either too small or too big.

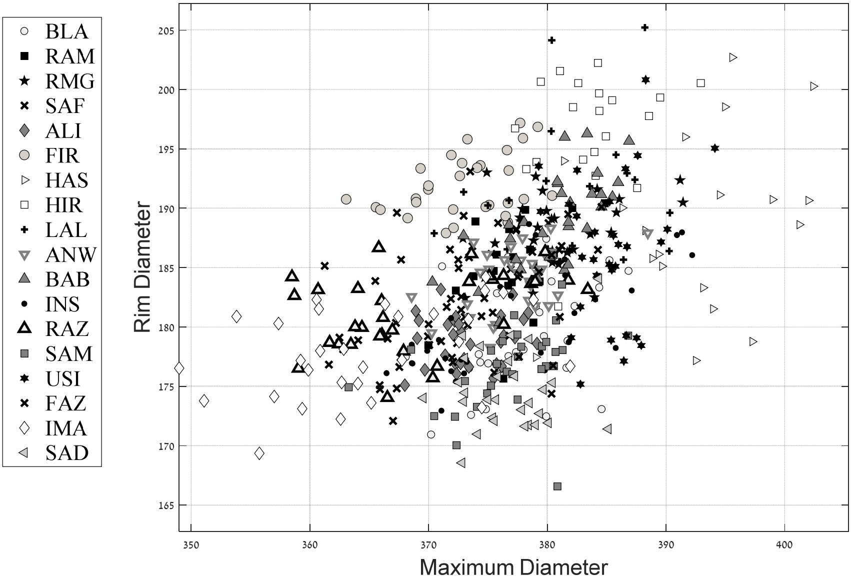

Figure 2-6: Distribution of the maximum diameters and the rim diameters of the 20-liter jars. The centers of the ellipses are at the mean of the distributions, and the dimensions to each side are the standard deviations.

In order to test whether dimensions vary depending on potters' productions, *ANOVA*s were conducted. Results show significant differences between the series of vessels produced by the different potters in both the rim diameter and the maximum diameter (15 liters: Maximum Diameter, F=88.77, p=0.00; Rim Diameter F=25.4, p=0.00; 20 liters: Maximum Diameter, F=41.05, p=0.00; Rim Diameter, F=50.94, p=0.00)

Profiles of the water jars

Fifteen-liter jars

Using *cluster analysis* which is based on the distance matrix of the corresponding profiles, we have defined, for the 15-liter jars 2 main branches and six sub-branches as can be seen in the *cluster-tree* (Fig. 2-7).

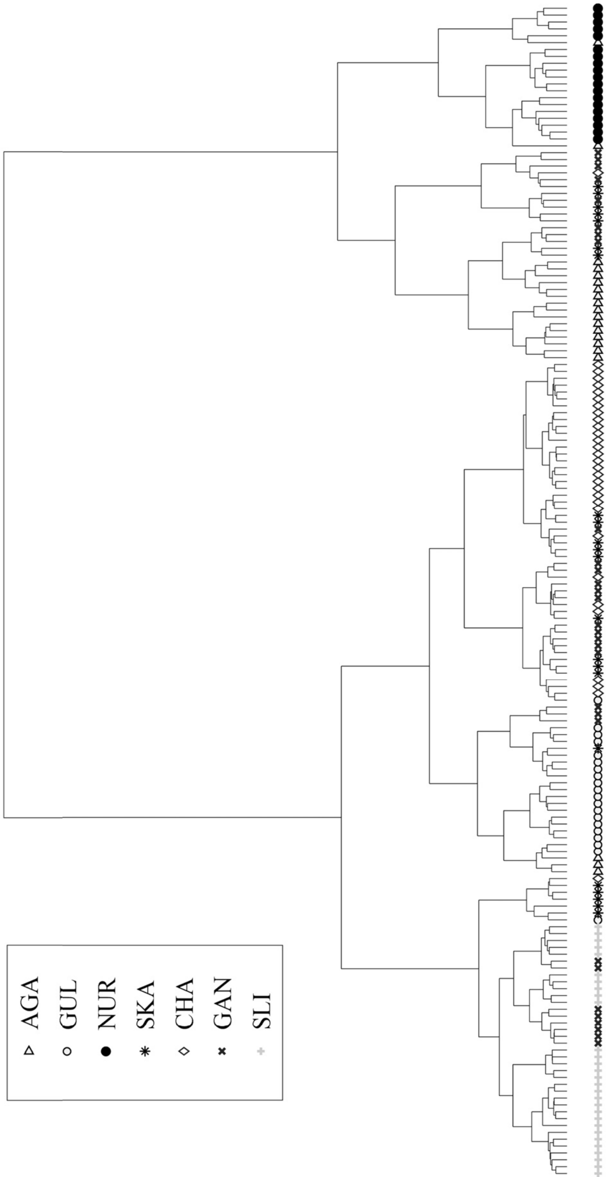

Figure 2-7: *Cluster tree* for the 15-liter jars.

Every line at the bottom of the tree corresponds to a single jar. The potters' identities are denoted with a unique color and symbol. Jars with similar morphological characteristics are clustered close to each other. On the other hand, jars that were classified into faraway branches have significant differences between them. The cluster tree shows a clear correlation between the products of the potters and the branch on which they were clustered. Thus, all of the jars that were produced by NUR classify into branch 2-c. Similarly, the jars of SLI and GUL are grouped on branches 1-a, and 1-b respectively. Most of the jars that were manufactured by CHA are sorted together into 1-c, except for two examples that are classified with other groups (1-b and 2-b). The potter AGA has three outliers that are classified far from the rest of his products (on 1-b instead of 2-a). Only two potters, SKA and GAN, have vessels scattered between almost all the different branches (1-a, 1-b, 1-c, 2-a, 2-b).

Twenty-liter jars

We applied the same procedure of cluster analysis for the 20 liter jars to produce a *cluster tree* (Fig. 2-8). This time we have defined 3 main branches with a total of 10 sub-branches, as can be seen in the Fig. 2-8. However, the larger amount of potters increased the complexity and the variability of the assemblage. Therefore, individual variability and distributions are harder to detect in the view of the tree, and only very evident trends can be established. For instance, branch '2-e' clusters only jars of ALI. Similarly, most of the jars of FIR and HIR group together on branch 3.

In order to understand better the structure of the *cluster-tree*, we summarized the distribution of the products of each potter according to the 10 sub-branches. Each column in Fig. 2-9 displays the distribution of the jars of one potter on the *cluster-tree*. The ten rows of the Fig. 2-9 correspond to the ten sub-branches, and the black bars show the relative portion of the products of each potter in the specific group.

The sum of all black bars per column is set and equals to the height of one rubric. If a potter produces very uniform and unique shape of jars, then one should expect to see in his column a single black bar that fills up precisely one rubric. In such a case, the corresponding row and column should be empty. For instance, the potter ALI has the most uniform products, as can be seen in his column with a black bar in the row of 2-e that signify for about 90% of his jars, and another small bar in the row of branch 3 for the rest of the jars. Moreover, there are no other jars grouped together with ALI's on the branch 2-e, as can be observed from the emptiness of row 2-e.

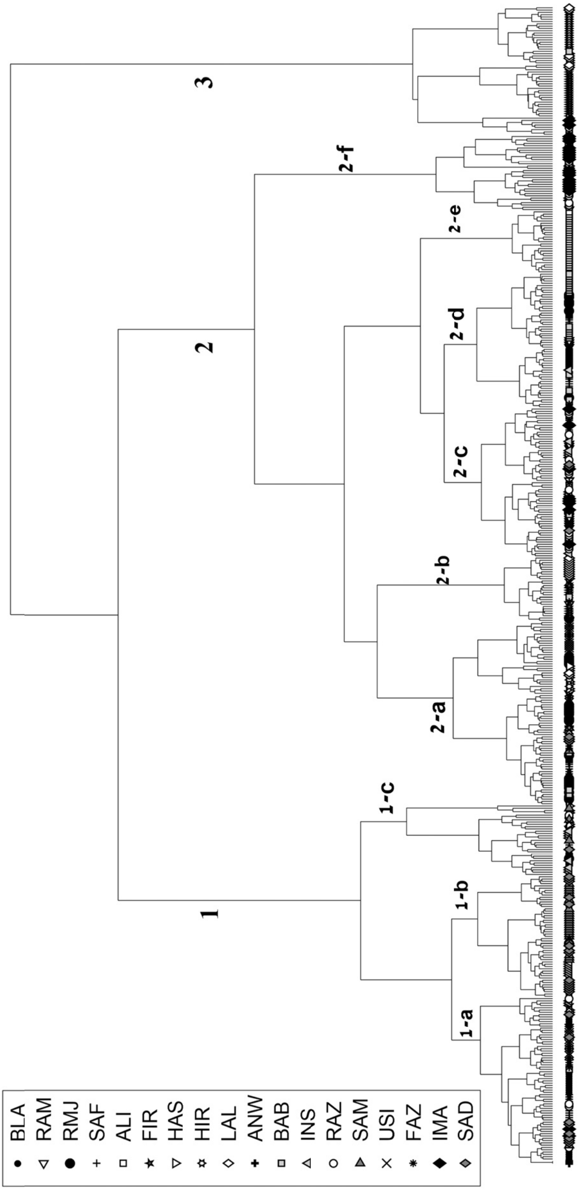

Figure 2-8: *Cluster tree* for the 20-liter jars.

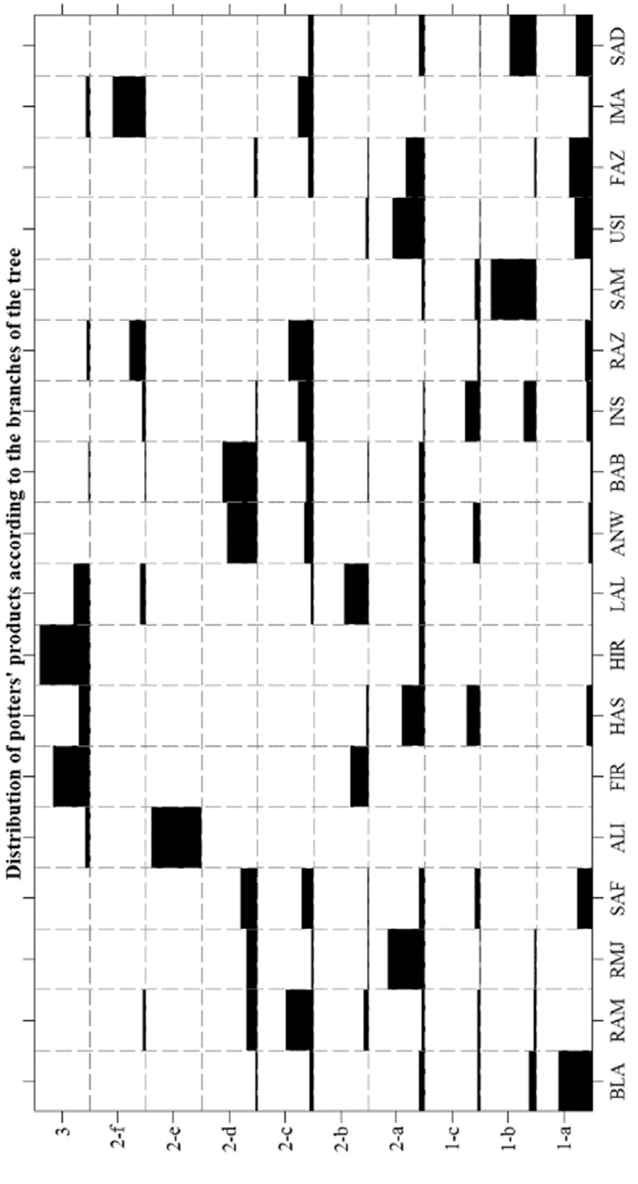

Figure 2-9: Distribution of the 20-liter jars of each potter (columns) according to the branches of the *cluster-tree* (rows)

The potter HIR has the similar distribution in his column, with most of the jars in branch 3 and very few in branch 2-a. However, the many small bars in row 3 indicate that there are other jars on branch 3 in addition to HIR's. There are eleven potters for whom more than 50 percent of their products cluster together – BLA, RAM, RMJ, ALI, FIR, HIR, ANW, BAB, SAM, USI, and IMA. The distribution of the other seven potters' jars is much more spread and testifies to their less uniform production and larger intra-individual variability.

Discussion

The overall picture that comes out from our analysis is that assessing the number of individuals from the variability of standardized ceramic assemblages should be possible given both low intra-individual variability and significant inter-individual variability.

Intra-individual variability is well expressed by both the CVs of the absolute dimensions and the distribution of the jar profiles according to the branches of the cluster-tree. Inter-individual variability is well detected by the *ANOVA*s. However, it is better expressed by the cluster analysis which shows clear trends as far as sub-branches and the grouping of productions are concerned.

For the 15 liters, the highest intra-individual variability, as expressed by both the CVs and the cluster tree, is found with two potters among whom one is young (19) and in this regard not fully experienced. The other is in his fifties and involved in the manufacture of both water jars and a wide range of morpho-functional vessels (sold to peasants living in the vicinity of the village). For the 20 liters, the highest CVs are also found with young potters (17 and 19). The distribution of the jars on the *cluster-tree* shows however that one of these young potters, IMA, has 50 percent of his products clustered together, witnessing, therefore, a tendency to less intra-individual variability than the other potter, HAS. Moreover, the distribution of the jars on the *cluster-tr*ee is quite scattered for 7 potters (out of 18). Even though most of these potters are less than 30 years old, the correlation between intra-individual variability and age is not systematic, the two potters showing the lowest intra-variability of the jar profiles, ALI and FIR, being respectively 22 and 25. In the context of a standardized production, we may conclude that low intra-individual variability (between 0.81 and 3.89 percent) can, however, entail different patterns, clustered *versus* scattered, not necessarily related directly to experience.

As a direct consequence of this difference in intra-individual variability pattern, inter-individual variability is not always clearly detectable. Thus, the range of distribution of the absolute dimensions shows that the very large majority of the jars gather together within a group whose variability is in the range of 3 cm. However, when considering the profiles, the results are much more promising. The fact that most of the potters could be identified with mainly one branch on the *cluster-trees* proves that their motor-habits are different and unique. Moreover, when considering the sub-branches of the *cluster-trees*, the classification of the15-liter jars could distinguish clearly 5 potters' productions. The results are not so clear with the 20-liter jars given the higher number of potters, even though the *cluster-tree* succeeded to classify the ensemble of jars within 10 sub-branches.

These results are even more promising when considering that the assemblage is extremely uniform and that many of the potters have family connections. Further researches have now to be developed. In particular, 3D data could help to highlight inter-individual variability better. Indeed, recent publications have shown the great potential of 3D documentation for automatic pottery classification (Gilboa et al. 2004; Karasik and Smilansky 2008, 2011; Adan-Bayewitz et al. 2009; Sergi et al. 2012). Accurate 3D models of the objects can be obtained even without purchasing a sophisticated 3D scanner. Several free softwares enable 3D reconstructions from a set of 2D images, taken from different directions (for instance *123D Catch* or *Agisoft*). Using their technique of photogrammetry, one can create accurate 3D models of almost any object. Such models are much more accurate and can ignore the bias which is introduced by the distortion of the lenses and its single view. In this regard, 3D data could help to assess individual productions better and therefore the number of potters involved in the manufacturing of standardized ceramic assemblages.

Conclusion

The production of standardized jars in the Jodhpur region is a case in point to analyze how to detect inter-individual variability and therefore how to assess the number of potters at the origin of uniform ceramic assemblages. Our results show that inter-individual variability can be detected and quantified even with 2D images of jar silhouette. Still, the results are not perfect, and there are many overlapping distributions of potters and uncertainties in regards of individual identification. But the profiles are a better proxy than absolute dimensions to highlight motor-habits and distinguish between potters. In the future, this promising direction of research of individual variability will be pursued using 3D models enabling us to get more accurate data.

Acknowledgments

This study has been funded by the ANR (French National Agency for Research) within the framework of the program CULT (Metamorphosis of societies-«Emergences and evolution of cultures and cultural phenomena»), project DIFFCERAM (Dynamics of spreading of ceramic techniques and style: actualist comparative data and agent-based modeling). In Jodhpur, the support of the Rupayan Sansthan was invaluable. We want to thank Kuldeep Kothari warmly for his help in sorting out all the logistic problems as well as Lakshman Diwakar for his assistance in the photography of the water jars.

References

Adan-Bayewitz, D., Karasik, A., Smilansky, U., Asaro, F., Giauque, R. D. and Lavidor, R. 2009, Differentiation of ceramic chemical element composition and vessel morphology at a pottery production center in Roman Galilee, *Journal of Archaeological Science* 36 (11), 2517–2530.

Arnold, D. E. 2000, Does the standardization of ceramic pastes really mean specialization?, *Journal of Archaeological Method and Theory* 7 (4), 333–376.

Arnold, D. and Nieves, A. L. 1992, Factors affecting ceramic standardization, In G. J. BeyIii & C. A. Pool (eds.), *Ceramic Production and Distribution: An Integrated Approach*, 113–214, Boulder, Colorado: Westview Press.

Baldi, J. S. 2015, *Aux Portes de La Cité : Systèmes Céramiques et Organisation Sociale En Mésopotamie Du Nord Aux 5ème et 4ème Millénaires*, PhD thesis, Paris I.

Benco, N. L. 1988, Morphological standardization: an approach to the study of craft specialization, In C. Kolb & L. Lackey (eds.), *A Pot for All Reasons: Ceramic Ecology Revisited*, 57–72, Philadelphia: Temple University.

Blackman, M. J., Stein, G. J. and Vandiver, P. B. 1993, The standardization hypothesis and ceramic mass production: technological, compositional and metric indexes of craft specialization at Tell Leilan, Syria, *American Antiquity* 58 (1), 60–80.

Boileau, M. C. 2005, *Production et Distribution Des Céramiques Au IIIème Millénaire En Syrie Du Nord-Est*, Paris: Editions Epistèmes et Editions de la Maison des sciences de l'homme.

Costin, C. L. 1991, Craft specialization: Issues in defining, documenting and explaining the organization of production, In M. B. Schiffer (ed.), *Archaeological Method and Theory*, 1–56, Tucson: The University of Arizona Press.

—. 2001, Craft Production Systems, In G. M. Feinman & T. D. Price (eds.), *Archaeology at the Millennium*, 273–327, Springer US.

Costin, C. L. and Hagstrum, M. B. 1995, Standardization, labor investment, skill, and the organization of ceramic production in late prehispanic highland Peru, *American Antiquity* 60 (4), 619–39.

Eerkens, J. W. and Bettinger, R. L. 2001, Techniques for assessing standardization in artifact assemblages: can we scale material variability?, *American Antiquity* 66, 493–504.

Gilboa, A., Karasik, A., Sharon, I. and Smilansky, U. 2004, Towards computerized typology and classification of ceramics, *Journal of Archaeological Science* 31 (6), 681–94.

Karasik, A. and Smilansky, U. 2008, 3D scanning technology as a standard archaeological tool for pottery analysis: practice and theory, *Journal of Archaeological Science* 35 (5), 1148–1168.

Karasik, A. and Smilansky, U. 2011, Computerized morphological classification of ceramics, *Journal of Archaeological Science* 38 (10), 2644–2657.

Kvamme, K. L., Stark, M. T. and Longacre, W. A. 1996, Alternative procedures for assessing standardization in ceramic assemblages, *American Antiquity* 61 (1), 116–126.

Longacre, W. A., Kvamme, K. L. and Kobayashi, M. 1988, Southwestern pottery standardization: an ethnoarchaeological view from the Philippines, *Kiva* 53, 101–112.

Ramón, G. 2011, The swallow potters: seasonal migratory styles in the Andes, In S. Scarcella (ed.), *Archaeological Ceramics: A Review of Current Research*, British Archaeological Reports, Oxford: Archaeopress.

Rice, P. 1991, Specialization, standardization and diversity: a retrospective, In R. L. Bishop & F. W. Lange (eds.), *The Ceramic Legacy of Anna O. Shepard*, Boulder, 257–279, Colorado: University Press of Colorado.

Roux, V. 2003, Ceramic standardization and intensity of production: quantifying degrees of specialization, *American Antiquity* 68, 768–782.

—. 2008, Evolutionary trajectories of technological traits and cultural transmission: a qualitative approach to the emergence and disappearance of the ceramic wheel-fashioning technique in the southern Levant during the fifth to the third millenia BC, In M. Stark, B. Bowser & L. Horne (eds.), *Cultural Transmission and Material Culture. Breaking Down Boundaries*, 82–104, Tucson: Arizona University Press.

—. 2015, Standardization of ceramic assemblages: Transmission mechanisms and diffusion of morpho-functional traits across social boundaries, *Journal of Anthropological Archaeology* 40, 1–9.

Sergi, O., Karasik, A., Gadot, Y. and Lipschits, O. 2012, The Royal Judahite Storage Jar: A Computer-Generated Typology and Its Archaeological and Historical Implications, *Tel Aviv* 39 (1), 64–92.