

Clustering the past: the use of multivariate analysis to understand cultural dynamics

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Introduction

Cultural evolution [1] provides a set of methods that can be used for the interpretation of the change processes, focused on the production of olive oil amphorae (called Dressel 20) during the Roman Empire.

Specifically we want to identify changes on the pattern productions and if these changes were produced by economical and political reasons [2]. As hypothesis, we think that making techniques processes were transmitted by vertical transmission based on the learning production techniques from master to disciple instead of horizontal transmission where this learning is done by workers with the same level. If this hypothesis is validated amphorae made in nearby workshops should share more traits than amphorae made from farthest workshops.

Materials and Methods

Dataset

We analysed a sample of 413 amphorae from 4 different workshops to explore the dynamic of changes. These workshops were selected from different sites of *Baetican* province in order to detect if morphometric distance was correlated with spatial distance (**fig.1**). A database was created using a sample of 90 amphorae from each workshops. 8 measures mostly focused on the rim were taken from each amphorae.

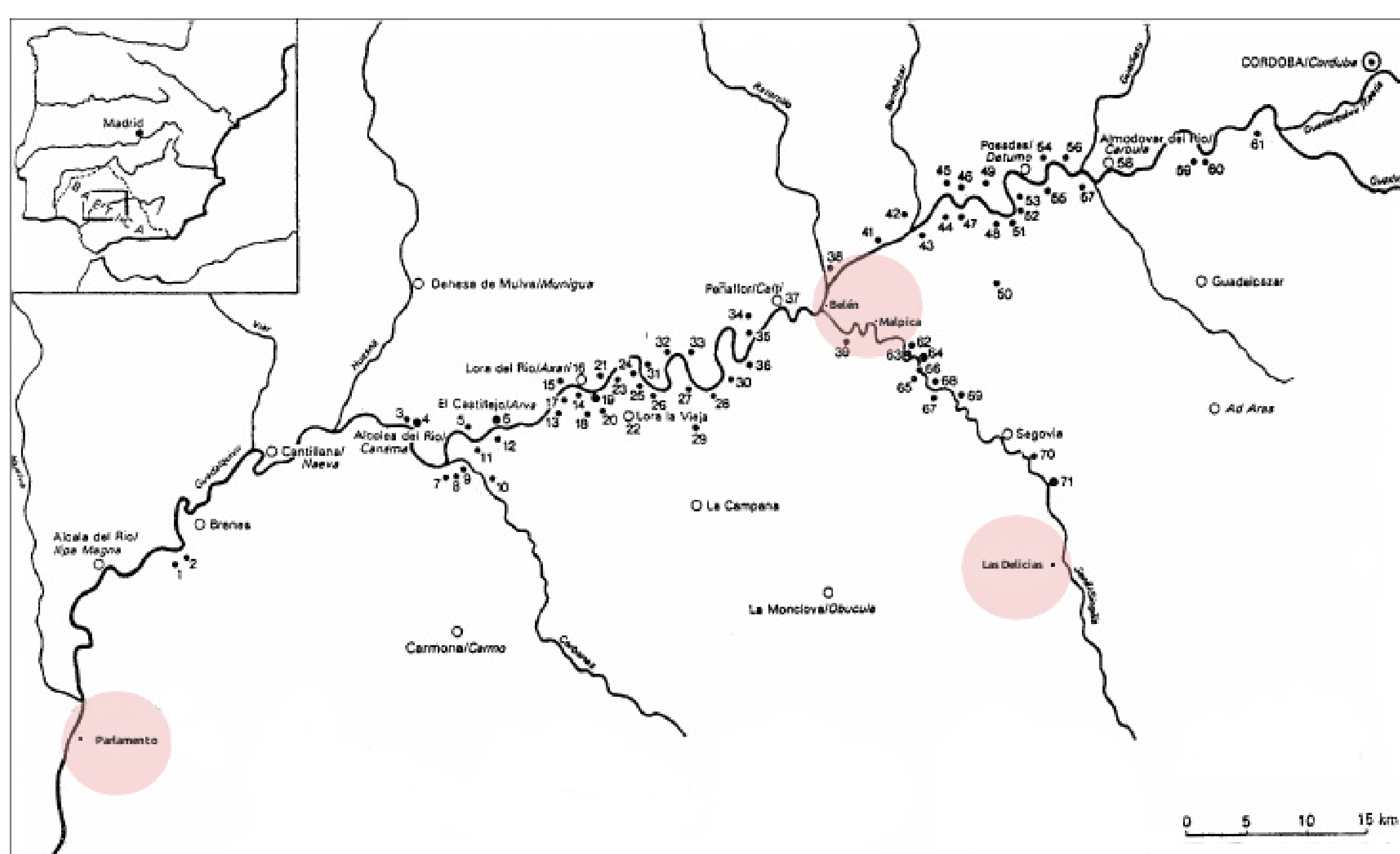


Figure 1: Dressel 20 production was distributed along the rivers Guadalquivir and Genil. The workshops analyzed in this study are located within the red circles

Methods

Principal Component Analysis (PCA) allowed us to simplify the analysis by grouping the variance of the dataset. Clustering was used to explore these metrical observations [3] with the 8 measurements as variables.

Clustering

Several multivariate methods were used such as PCA and Discriminant Analysis (DA) to quantify the differences on the pattern production among workshops [4]. The first two principal components were chosen to see the significant differences among workshops. **Figure 2** shows the workshops with a minor space such Belén and Malpica share more pottery traits than the rest: Parlamento and Las Delicias.

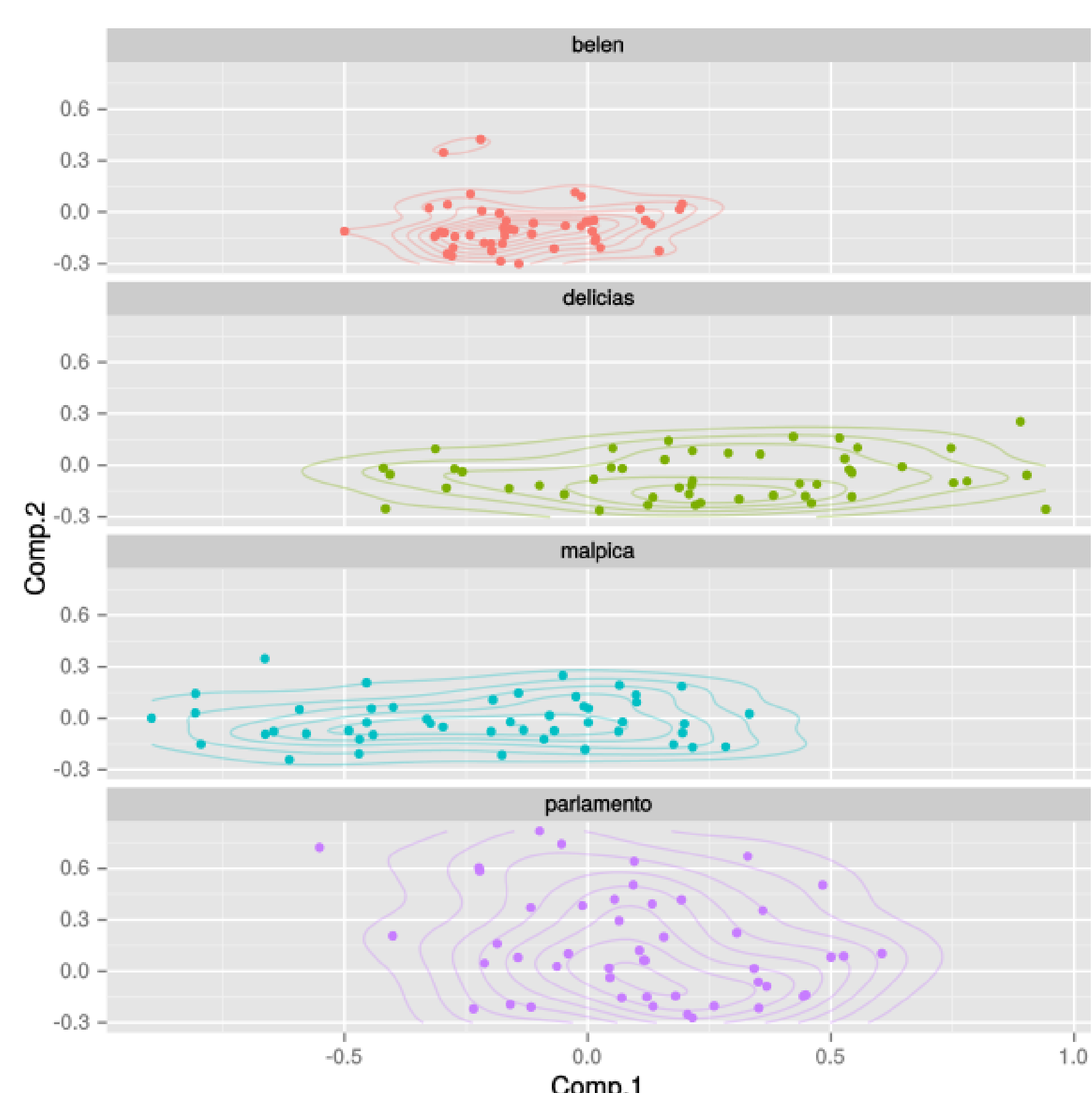


Figure 2: First and Second Principal Components for the analysed sample

Confusion Matrix & Distance metrics

Once defined the component, we used DA to generate a Confusion Matrix to able of quantifying the degree of confusion among workshops. The results of Confusion Matrix showed than workshops with more troubles to be distinguished such as Malpica and Belén shared a minor spatial distance than the rest. Therefore similar amphorae production are correlated with the spatial distance between them.

	BELEN	DELICIAS	MALPICA	PARLAMENTO
BELEN	37	10	18	8
DELICIAS	4	32	8	14
MALPICA	5	3	18	6
PARLAMENTO	2	3	4	20

Table 1: Confusion Matrix. Accuracy: 55,73 %. P-Value: < 0.01.

As shown in the Confusion Matrix (**table 1**), most correct guesses were located in the diagonal of the table. We compared morphometric and spatial distance by performing peer-to-peer analysis between all workshops. We calculated the geographical distance between each site and the distance among pottery measures, calculated using the previous results. **Figure 3** shows that the pottery distance is correlated with the spatial distance of workshops.

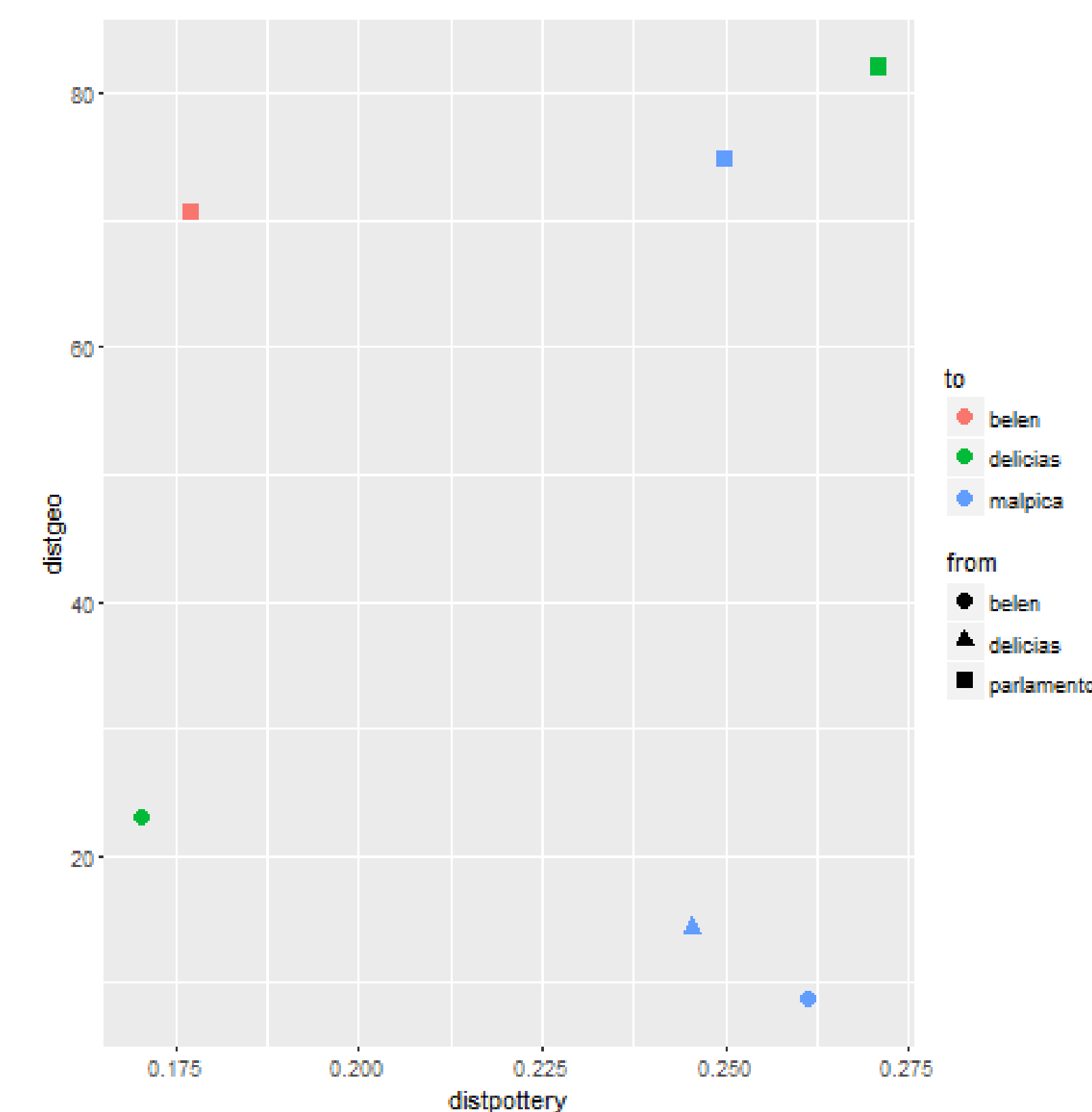


Figure 3: Distance metrics calculated among different workshops.

Concluding Remarks

Differences among pottery workshops were identified using PCA and Discriminant Analysis. As results, amphorae made in nearby workshops with a minor spacial distance, such as Malpica and Belén, share more traits than amphorae made in pottery workshops farther as Parlamento. It could suggest that the pottery techniques were learned from master to disciple instead of workers with the same level.

References

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