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Hellenistic grape and olive diversity: A case study from rural estates in Greece

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ABSTRACT

Grapevine and olive are thought to have been intensively cultivated during the Hellenistic period, as part of an agrarian system which included agricultural choices specializing in the production of their secondary products. The discovery of large assemblages of carbonized grapes and olives at three sites in Pieria, Macedonia, Greece, provides a unique opportunity to advance our understanding of grape and olive cultivation, the production of wine and olive oil, and their position in the agricultural regimes in this region of Greece. In this paper, we report on morphometric analyses performed on these assemblages to distinguish wild and domesticated subspecies, and to identify ancient morphotypes that may correspond to the wild form or other varieties of olives and grapes. The comparison of olive and grape assemblages from three different sites, geographically close but different in terms of size and architecture, shows a wide range of cultivated types of both olive and grapevine, as well as possible local selection processes, especially for the grapevine.

1. Introduction

Both grapevine and olive, the most representative fruit trees of Greece, are thought to have been widely and intensively cultivated during the Hellenistic period, as part of an agrarian system which also includes agricultural choices specializing in the production of their secondary products. This hypothesis has been primarily based on indirect but plentiful evidence: installations for the production of olive oil and wine, storage and transport vessels, written evidence and iconography. Archaeobotanical remains of the 1st millennium Greece, although increasing in number, are still scarce (for a review, see Douché, Tsirtsi and Margaritis, 2021). The discovery of large assemblages of carbonized grapes and olives at three sites in Pieria, Macedonia, Greece, has advanced our understanding of grape and olive cultivation, production of wine and olive oil, and their position in the agricultural regimes in this region of Greece (Margaritis and Jones, 2006; Margaritis, 2015, 2016). In this paper, we report on morphometric analyses performed on these assemblages to distinguish wild and domesticated subspecies, and to identify ancient morphotypes,

that may correspond to the wild form or other varieties of olives and grapes. The shape of the seeds or stones, for respectively grape and olive, is hardly influenced by environmental parameters, in contrast to the size of the seed or stone, and thus offers more accurate criteria to study past diversity (Terral et al., 2010). Analyses based on metric indices have shown the efficiency of these parameters to distinguish wild and domesticated grape (Mangafa and Kotsakis, 1996; Jacquat and Martinoli, 1999; Bouby et al., 2013). Furthermore, shape criteria allow us to go beyond the wild-domesticated dichotomy through the identification of groups of varieties (grape: Terral et al., 2010; Orru et al., 2013; Pagnoux et al., 2015; Uccesu et al., 2015; Bouby et al., 2018; olive: Terral et al., 2004; Newton et al., 2006, 2014; Bourgeon et al., 2018; grape and olive: Pagnoux, 2016).

A first morphometric study was conducted on some samples from the three sites under study (Pagnoux, 2016); new samples have been added in this paper, in an attempt to reconstruct agrarian practices and cultivated diversity of grapevine and olive on the basis of more representative data. The comparison of olive and grape assemblages from three different sites, geographically located in the same area, is expected to shed light on a possible influence of the type and status of each site on the cultivated varieties and agrarian practices.

2. Materials and methods

2.1. The sites

The grape seeds and olive stones included in this study derive from three sites: Komboloi, Platania and Douvari, located in the area of Pieria in Macedonia at the lowlands of Mt Olympus, in a very fertile strip of land. Douvari is located 900 m north of Komboloi while Platania is located further south; they are all contemporarily dated from the end of the 4th century to the beginning of the 3rd century BCE (Fig. 1). The excavation at Douvari revealed a farmhouse of 350 m² although a major part is still unexcavated (Fig. 2). The archaeological material recovered consisted of transportation and cooking vessels; an important find is a fragmentary large wine strainer made of clay, similar to one found at Komboloi with incised letters on its rim (Poulaki, 2003; Mourati et al., forthcoming). The three archaeobotanical samples included in this paper derive from the destruction layer of the main room in an area with traces of fire.

The excavation at the site of Komboloi revealed a country house and a storage area (pitheon) in a complex covering 1350 m² (Fig. 3). Many structures, such as hearths, roofed stoas, and a carefully constructed well, along with many pithoi located in roofed areas, were found outside the complex, indicating that these functioned as external activity areas (Mourati et al., forthcoming; Mourati, 2014). The main building of the complex is a four-sided building encompassing 812 m² with an interior courtyard and stoas along its periphery. The main rooms of the house seem to have been in the north and east wings, with the north being the richest in finds (Poulaki, 2003; Mourati, 2014). Twenty-two pithoi of various sizes were found in the pitheon area of which many were very large indeed, reaching a depth of three metres with an estimated volume of 2.200–2.300 L. On the basis of experimental work, it has been suggested that the great quantities of grape remains found in the bottom of two pithoi represent stored wine (Margaritis and Jones, 2006, Margaritis, 2016).

A basement was excavated on the eastern side of the house, indicating the presence of a tower, a common feature in other farmhouses around Greece (Morris & Papadopoulos, 2005). There was strong evidence of burnt material on the floor, burnt tiles, nails, plaster fragments, charred beams, agricultural tools and fragments of at least three pithoi. An interesting find was a pithos with two holes lined with lead pierced through the neck, perhaps to allow the contents to be siphoned off (Mourati, 2014).

The third site, Platania, has two habitation phases (Poulaki, 2003; Gerofoka, 2015). The initial habitation phase consists of a large building, c. 2408 m² (Fig. 4). Displaying the architecture of a typical Greek country house, like the living quarters of Komboloi, the building was situated around an open central courtyard surrounded by stoas at the east and north part. Five rooms form the north wing of the building while another four have been located in the eastern part. At the north-east corner of the building, a large storage area was located and ten pithoi were preserved in situ. The second phase is dated c. 280–275BCE. During the later phase, the house was transformed into a long and square 7 × 51 m structure (Poulaki, 2003), containing six rooms of similar sizes.

The deep foundations and the walls armoured with buttresses indicate that the building had a second floor (Poulaki, 2003). A well in the courtyard was constructed during the first habitation phase and it was re-used as a rubbish pit in the second phase. All cultural material deposited in the fill, such as domestic pottery, large fragments of pithoi and abundant charred materials belong to the second phase.

2.2. Archaeobotanical material

The material on which morphometric analyses have performed is summarized in Table 1 and it includes 792 grapes pips and 311 olive stones. Grape remains derive from all three sites, while olive stones derive only from Platania.

A total of 285 grape pips come from Douvari. Sample D1 consists of large quantities of grape pips, with a small fraction of these represented only by cotyledons, suggesting exposure to high temperatures (Margaritis and Jones, 2006). D2 is also composed of grape pips in combination with few fruit stalks and fragments of resin associated with the fragments of a large pithos (Fig. 2), suggesting that the grape remains had accumulated at the bottom of the pithos but later were scattered among the fragments during the destruction (Margaritis, 2006). D3 also contains charred grape pips in smaller quantities than the previous samples and comes from another area of the room, also associated with a small pithos.

The first sample of Komboloi (K1) derives from the bottom of one of the pithoi of the pitheon of the north wing and consists of 100 pips. The second sample of grape pips (K2, n = 98) derives from the area around the pithos found in the basement (Fig. 3). It most likely represents the contents of the vessel, which would have been wine (Margaritis and Jones, 2006).

The archaeobotanical samples PL1, 2 and 3 from Platania consist solely of grape remains. They belong to the first habitation phase and derive from the east wing of the building. PL1 comes from the floor of Room I and is not associated with any pottery while PL2 and PL3 originate from Room

II. PL2 was sampled among the broken fragments of a small pithos, and therefore could be interpreted as by-products of wine (Margaritis, 2006; Margaritis and Jones, 2006). PL3 also originates from the same room as PL2 but is not located in its vicinity and most likely represents a separate concentration of grape pips (Fig. 4). Samples PL4 and PL5 consist of both olive stones and grape pips and most likely represent domestic refuse. They also belong to the first habitation phase and originate from a shallow pit located in the courtyard of the building (Margaritis and Jones, 2008a; 2008b).

Samples PL6 and PL7 consist solely of olive remains, are dated to the second habitation phase and derive from Room V and VII of the the north wing of the building (Fig. 5).

2.3. Morphometric analyses

Morphometric analyses were carried out using Momocs v. 1.3.0 (<https://github.com/MomX/Momocs/>; Bonhomme et al., 2014) in the R environment (v. 4.0.2) (R Development Core Team 2020). The shapes of the grape pips have been described using outline analysis based on the elliptical Fourier transforms (EFT), as developed and improved by previous studies (Terral et al., 2010; Pagnoux et al., 2015; for a complete description of the method, see Bouby et al., 2018). Each seed was eventually described by 48 coefficients (24 each for dorsal and lateral view) which were used as quantitative variables in the statistical analyses.

The analysis of shape variation among the olive stones is based on the analysis of their open outline, following a method developed and improved in previous studies (Terral et al., 2004; Newton et al., 2006, 2014; for a complete description of the method, see Bourgeon et al., 2018).

The outlines (four per stone: two for the lateral side and two for the dorsal side) were adjusted using a third order orthogonal (Legendre's) polynomial regression, which offers a good compromise between the accuracy of the shape description and the risk of including error due to irregularities on the stone surface (Terral et al., 2004). Each stone is described by 16 quantitative coefficients (four coefficients for each stone half, eight for each view), which were used for statistical analyses.

2.4. Statistical analyses

Principal component analyses (PCA) were carried out on archaeological samples of grape pips and olive stones to determine the differences between the samples.

Previous studies have revealed that morphometric analyses based on EFT for the grape and orthogonal polynomial regression for the olive allow discrimination of both compartments (wild and domesticated) as well as groups of varieties (parental and eco-geographical groups) (Terral et al., 2004, 2010; Newton et al., 2006, 2014; Pagnoux et al., 2015). Archaeological elements were therefore compared to modern reference sets, which aim to be representative of the modern diversity of wild and cultivated grapevine and olive. The grapevine collection includes 281 cultivars and 82 wild individuals (Bouby et al., 2021). As shown by previous studies, carbonization

causes a distortion of the pips (Smith and Jones, 1990; Mangafa and Kotsakis, 1996), but recent investigations on the effect of carbonization have shown that experimentally charred grape pips, despite distortion, are well classified in their groups of origin (Ucchesu et al., 2016; Bouby et al., 2018). While the analyses conducted by Bouby et al. (2018) revealed that experimentally charred grape pips are well classified not only at the scale of the wild and domesticated compartments, but also at the cultivar level, the authors nonetheless recommend characterization at the cultivar level only using the largest and best preserved samples. In light of these results, carbonized grape pips may be compared to the uncarbonized reference collection.

The collection of modern olive stones represents 54 cultivars and 14 wild populations. Within this reference collection, varieties and wild populations have been hierarchically clustered using UPGMA on the morphological distance matrix between wild populations and cultivated varieties. Ten morphotypes were therefore identified (Pagnoux, 2016; Bourgeon et al., 2018).

Archaeological grape pips were classified as wild or cultivated by using a first linear discriminant analysis (LDA) on balanced samples: 2430 modern pips of varieties were randomly selected within the domesticated pips of the reference collection, while all its 2430 wild pips were included.

Then, the archaeological grape pips classified as domesticated types by this first analysis have been assigned to cultivars through a second LDA on all pips of the modern domesticated types grape, provided they come from samples of at least 50 pips. Olive stones were assigned to the 10 morphotypes highlighted by the cluster analysis of the reference collection. A predictive LDA was carried out on balance samples: 30 stones of each morphotypes of the reference collection were randomly selected. The classification of archaeological olive stones as well as grape pips is considered reliable when the posterior probability of attribution to the given class is higher than or equal to 0.75.

3. Results

3.1. Grape seeds

After a first PCA showing that sample PL1 from Platania was different from all the other samples, it has been treated as supplementary individual (Fig. 6).

The PC1-PC2 biplot of a second PCA shows four clusters. Both samples from Komboloi are clearly clustered and distinct from the samples from Douvari and Platania. A second cluster consists of three of the four samples from Platania (PL2, PL3 and PL4), while PL5, the last sample from this site is close to two samples from Douvari. D1 differs from D2 and D3 although they derive from the same site.

According to the first wild/domesticated level-LDA, grape pips from Douvari are mostly classified as wild (more than 50% for D1 and D3 and 39% for the last one, Douvari D2; Table 2). Grape pips from Komboloi are mostly classified as domesticated (55%). At Platania, pips from samples PL2,

PL3 and PL5 are mainly assigned to the domesticated type (respectively 47%, 63% and 48%), while pips from samples PL1 and PL4 are mostly assigned to the wild type (42% and 43%).

Three hundred and four pips from samples containing more than 50 pips are therefore classified as domesticated types. Among them, 151 are allocated to a modern cultivar with a probability higher than or equal to 0.75. The allocated archaeological grape seeds match with 47 modern cultivars. Archaeological pips are mainly classified as ‘Jahafi’ (Syria; n =21), ‘Bzvanura’ (Georgia; n =14), ‘Mavrostypho’ (Cyclades; n =10) and ‘Marathefico’ (Cyprus; n =7). Several grape seeds are classified to other cultivars mainly from Greece, Georgia and Turkey, but also from France, Armenia and Azerbaijan (Table 3). These other cultivar-types are not detected in more than six grape seeds. All samples are characterized by a wide diversity and a clear pattern can hardly be distinguished. A high proportion of grape seeds from each site is allocated to morphotypes from Greece, Turkey and the Caucasus. Several grape seeds from Platania are allocated to varieties regarded as typical from Western Europe, while Maghreb and Near East cultivar-types seem numerous at Komboloi, but this is explained by the high number of pips from this site classified as ‘Jahafi’, a cultivar from Syria (Fig. 7).

3.2. Olive stones

The PCA does not reveal any clear structuration among the samples. One hundred and thirty-eight of the 311 archaeological olive stones (44%) have been classified as a morphotype with a posterior probability ≥ 0.75 . Most of the olive stones are classified as morphotype 5.3, and all samples contain stones allocated to this morphotype (table 4). This cluster has a strong geographical coherence and consists of Greek and Croatian cultivars (Bourgeon et al., 2018). Twenty-one archaeological stones are classified as the MT2 defined by several wild populations and one cultivar from the Iberian Peninsula (Bourgeon et al., 2018).

Few olive stones are allocated to the other morphotypes, and these are not as frequent as the MT5.3 and MT2. Six stones are classified as MT5.1, coming from all the samples except one. This cluster consists mostly of western Mediterranean cultivars whereas plastid DNA data reveal that their distant origin would be eastern (Besnard et al., 2013). Six stones from one single sample (PL7) are assigned to MT5.2. This morphotype is constituted by varieties from various areas of the Mediterranean (Bourgeon et al., 2018). Less than 5 individuals are allocated to MT1, MT3 and MT4. No olive stone was assigned to MT 6 to MT10, which consists of one or two cultivars each.

4. Discussion

The grape samples from the three sites are characterised by a wide diversity, including wild-type and many domesticated-types. Most of the grape seeds are assigned to domesticated-types considered to be typical of Greece, the Balkans and the Caucasus. According to Negrul (1946) and his proles, which are geographical groups based on ampelographic criteria, these cultivars belong to the proles pontica. Varieties belonging to this group are supposed to share “ancestral” features and their fruits may be used for wine making or direct consumption (Negrul, 1946; Levadoux,

1956). This pattern is similar to the one observed for Georgia from the Late Bronze Age uninterruptedly to the Medieval period (Bouby et al., 2021), and that observed in Prehistoric Greece (Pagnoux, 2016; Pagnoux et al., 2021). These domesticated-types may correspond to the first selected varieties in a geographical area expanding from the Caucasus to Greece.

In addition to the wide diversity identified among grape samples, there is a diverse pattern both between sites and also within sites. A selection of varieties at the site scale depending on the use of the grape (domestic consumption or wine trade, for example), and the use of seeding in propagating grapevine may explain this characteristic. Seeding may have been more widely adopted as a selection and adaptation practice than one may have supposed on the basis of the Latin agronomic literature or modern selection methods (Bouby et al., 2013; Bouby, 2014). Grapevines growing from seeding may evolve in “variety- populations”, i.e. varieties with common features but not identical (Levadoux, 1956; Bisson, 2009). Pliny the Elder refers to “sister varieties” (Natural History 14, 21–24) which may reflect these types growing from seeding (Bouby, 2014; Pagnoux, 2016). Furthermore, Cato refers to a grapevine type named *miscellae* (Cato, *De agricultura* 6, 4), “mixed”, which may also be grapevines growing from grape seeds (Bouby et al., 2013, Bouby, 2014, Pagnoux, 2016).

On the other hand, grapevine growing from seeds may show common features with the wild plant, including the shape of the grape seeds. Some archaeological pips morphologically close to the wild-type could therefore be outcomes of seeding. This could explain the relatively high proportion of seeds classified as “wild” in our assemblages. Although gathering of grape berries in the wild on true wild grapevines cannot be excluded, the high proportion of grape seeds allocated to this type cannot be provided by this activity alone, even though wild-type are reported on many archaeological sites from France and Greece until the Roman period (Bouby et al., 2013, 2021; Terral et al., 2010). It could be suggested that this type represents “low-selected” varieties: grapevines which already underwent selection but involving no change in seed morphology, in the framework of an ongoing domestication process.

Grape seeds close to the wild-type are more numerous at Douvari than at the other sites. This may be related to the status of the site: Platania and Komboloi are large estates and specialized viticulture is attested at Komboloi, while Douvari is a small farmhouse (Poulaki, 2003; Margaritis, 2015, 2016). Selected varieties would have been cultivated in both large farmhouses, which might have targeted specific varieties for wine making. Grapevine grown from seeds could have been kept more regularly at Douvari, whose grape and wine production was not dedicated to commercial use. The wild-type is indeed scarce at Kombloi, but some samples from Platania (PL1 and PL4) contain a high proportion of grape seeds close to this type, while domesticated-types are more numerous in the other samples. This may reflect the use of both cultivated grapevines as a result of grafting and grapevines growing from seeds at Platania, where specialized viticulture is not attested. This diversity of types may indicate that grapevines were cultivated for various purposes at Platania, including possibly wine making as well as fresh and dry fruit consumption.

Regarding the olive, most of the stones are classified as “Greek” morphotype (MT5.3). Among the assemblages from Greece dating from the Bronze Age to the Hellenistic period, it is the most frequent and the most abundant type (Pagnoux, 2016). It is worth noting that this type is scarce in

Western Europe (Bourgeon et al., 2018): it probably reflects varieties selected and cultivated in the Aegean, and the presence of this type at Platania is not surprising.

Few stones are allocated to MT5.1, a group consisting mostly of western Mediterranean cultivars whose distant origin is thought to be eastern (Besnard et al., 2013). They may reflect varieties from the Near East, introduced as early as the Bronze Age, since this type is attested in earlier sites (Pagnoux, 2016).

MT2 is characterized by a symmetric shape and clusters several modern wild populations. The stones allocated to this type may correspond to feral or wild individuals transplanted and cultivated: ethnographical studies show that wild olive trees can be integrated into agrosystems, as it is the case in Morocco (Aumeeruddy-Thomas et al., 2014; Moukhli, 2017). This morphotype could also represent varieties close to the wild olive tree and selected for special purposes. Ancient sources mention an olive type, different enough from the common cultivated olive to receive another name and perhaps closer to the wild olive tree, whose fruits were used for fragrant oil making (Theophrastus *On odours* 15, *Enquiry into plants* II, 2, 12; Brun, 2000, 2003; Pagnoux, 2016).

At Platania, these different morphotypes are represented in three samples (PL4, PL5 and PL6) deriving from different contexts and from both habitation phases. It may reflect a choice towards a wide diversity of olive varieties aiming to ensure sufficient annual yield, by limiting the impact of pest attack or unfavourable climatic conditions, reducing the effect of irregular fruiting, and ensuring optimal cross-pollination. PL7 is slightly different from the other samples with more individuals allocated to MT2 and MT5.2 and fewer to MT5.3 and MT5.1, to which many olive stones of the other samples were allocated. It may reflect olives cultivated for different purposes, perhaps for the production of olive oil for medicinal or cosmetic use as the affiliation to MT2 of some of the olive stones could suggest.

5. Conclusion

Given the presence of these various types, viticulture and oleiculture in Hellenistic Pieria were characterized by a wide diversity of olive and grape varieties and cultivation practices, including probably vegetative propagation but also seeding. Local selection leading to local features could be supposed especially for the grapevine, although the identified domesticated-types share features with the types observed in other areas at the same period. This study provides insights to the development of varieties in the course of the development of a specialised viticulture oriented towards the wine trade. The diversity of olive varieties was the main characteristic of oleiculture, possibly to ensure regular production but also due to the search for varieties suitable for various uses: direct consumption, oil for culinary use as well as for perfume production or medicinal use.

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FIGURES

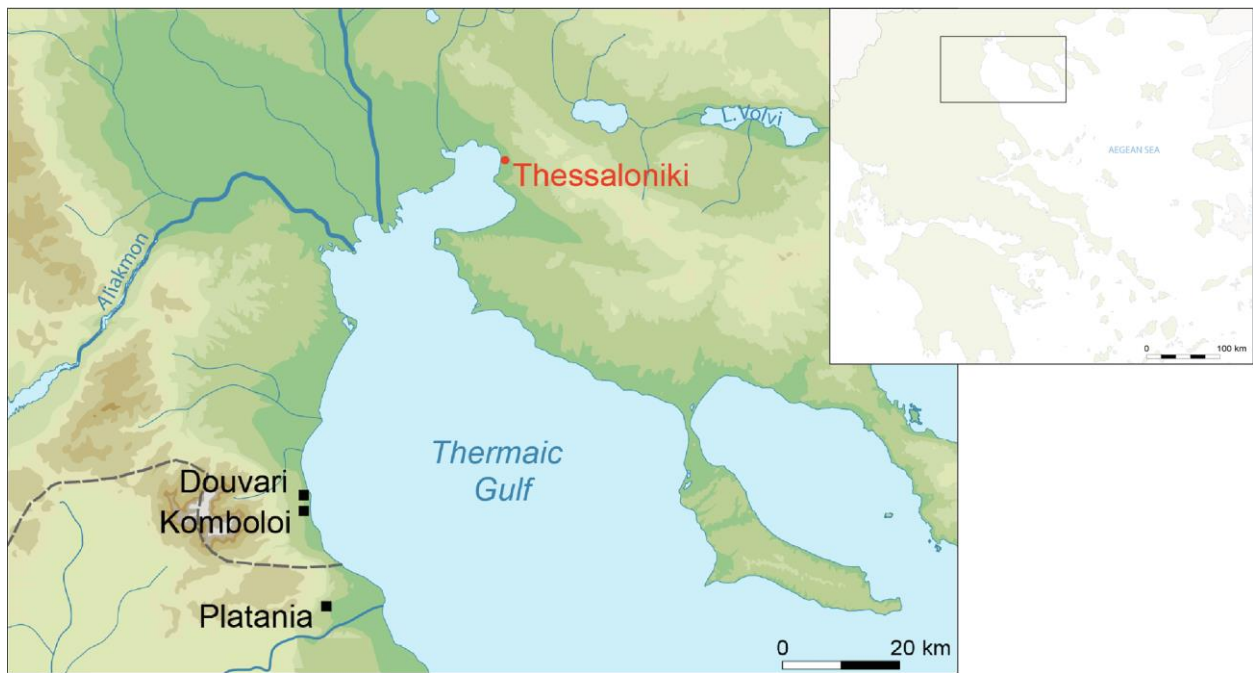


Fig. 1. Map showing the sites.

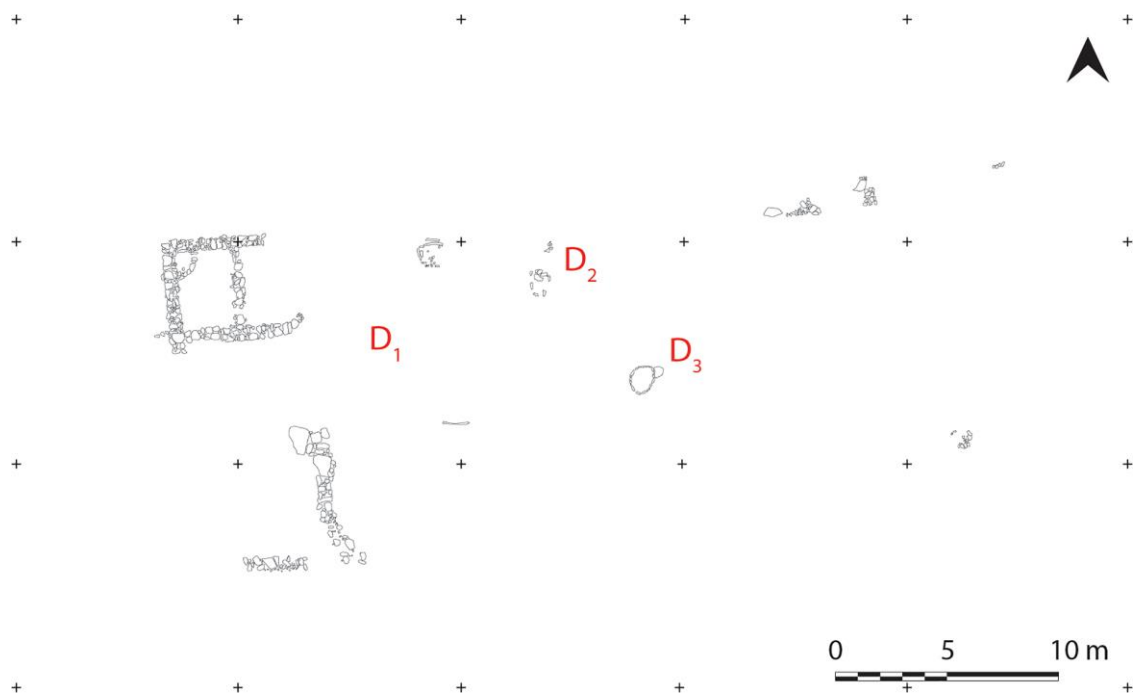


Fig. 2. Site of Douvari with location of samples (courtesy Greek Ministry of Culture).



Fig. 3. The site of Komboloi with location of samples (courtesy Greek Ministry of Culture).

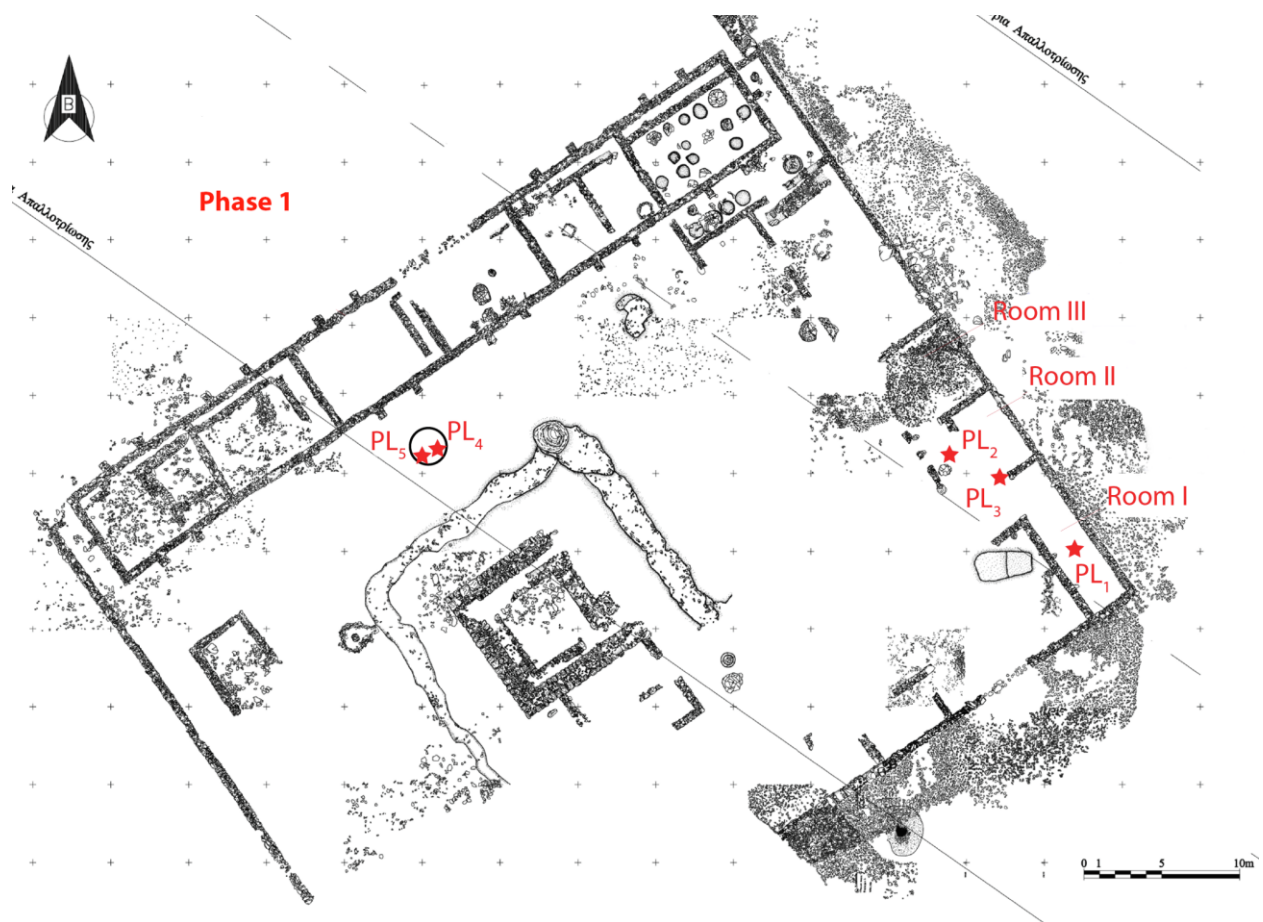


Fig. 4. The site of Platania-1st Habitation phase with location of samples (courtesy Greek Ministry of Culture).

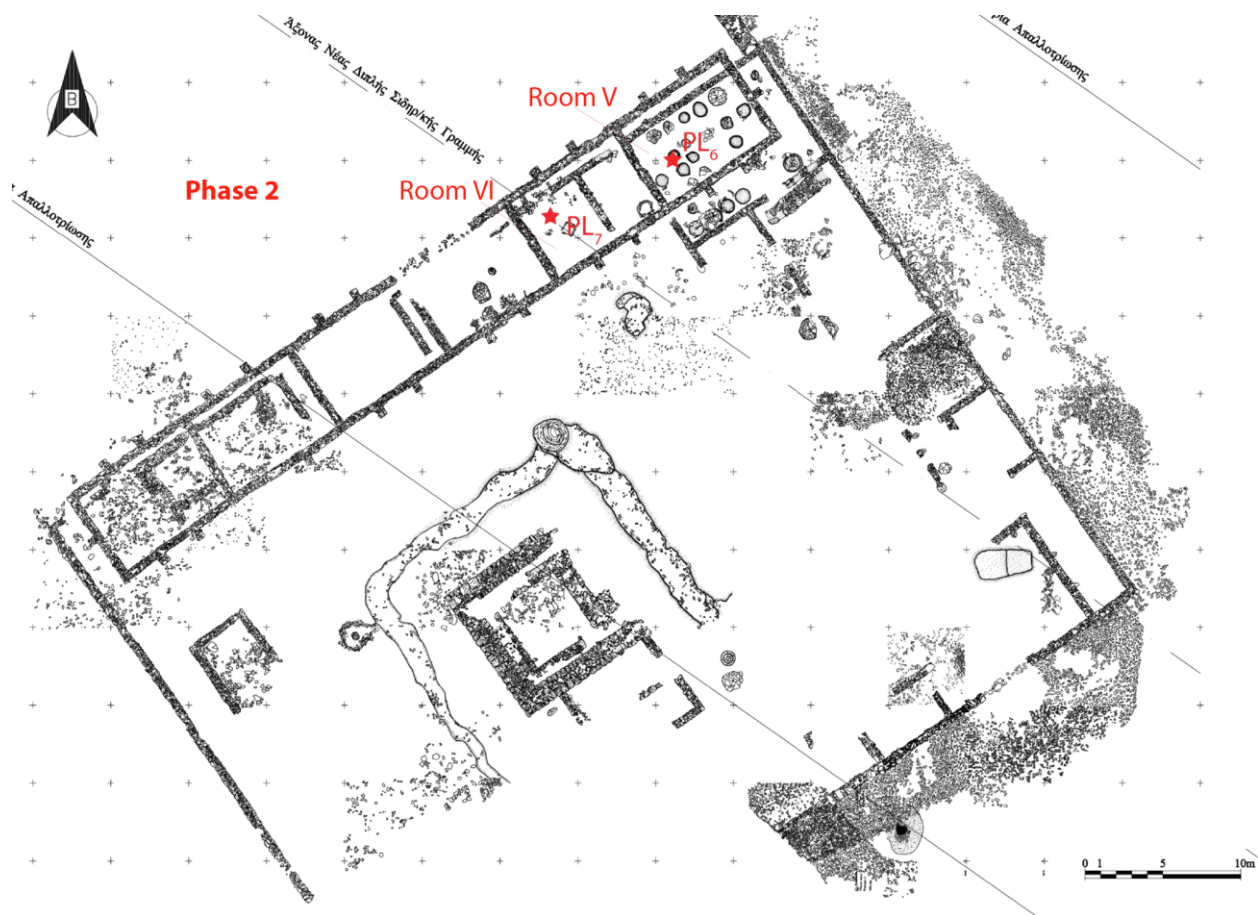


Fig. 5. The site of Platania-2nd Habitation Phase with location of samples (courtesy Greek Ministry of Culture).

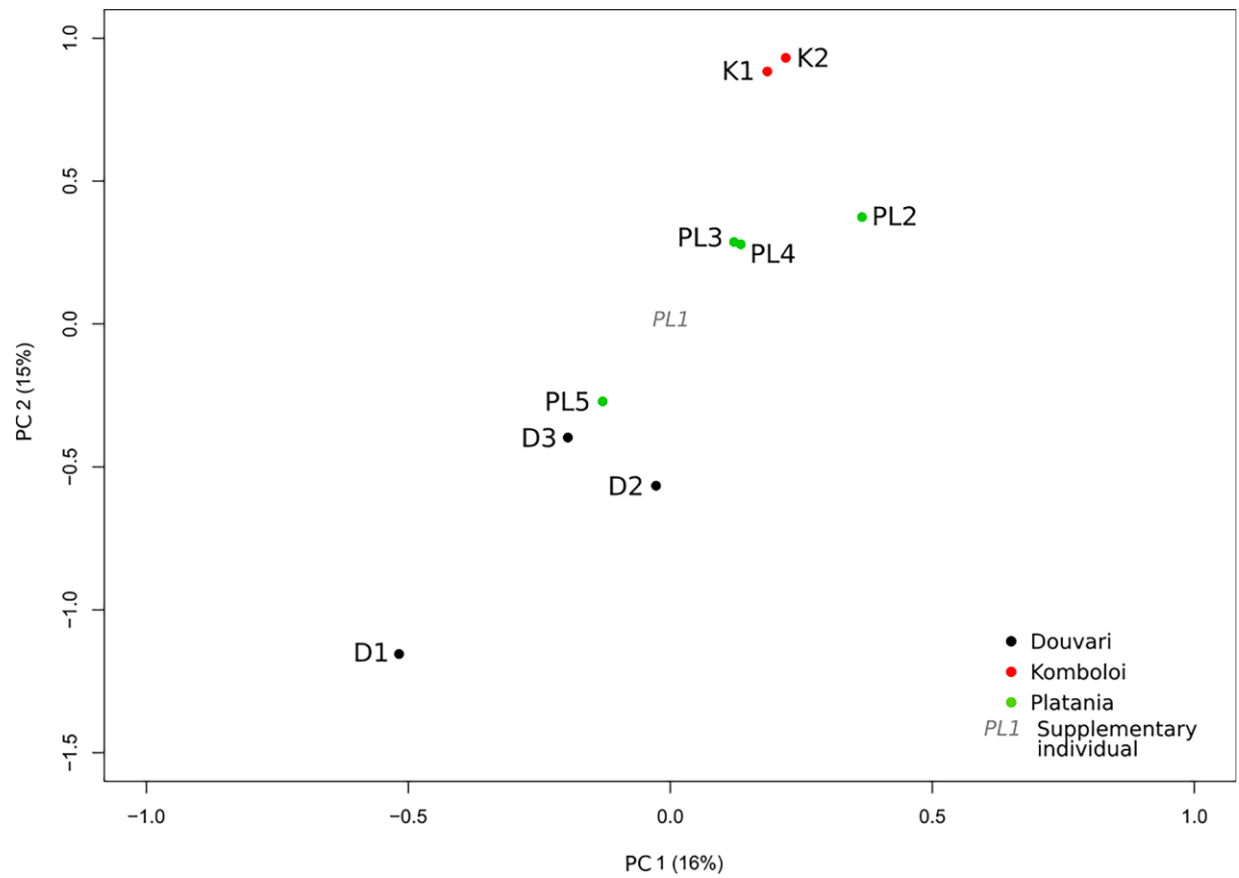


Fig. 6. Principal Component Analysis performed on the shape descriptors of the grape pips, biplot of axes 1 and 2. Each point represent the centroid of an assemblage.

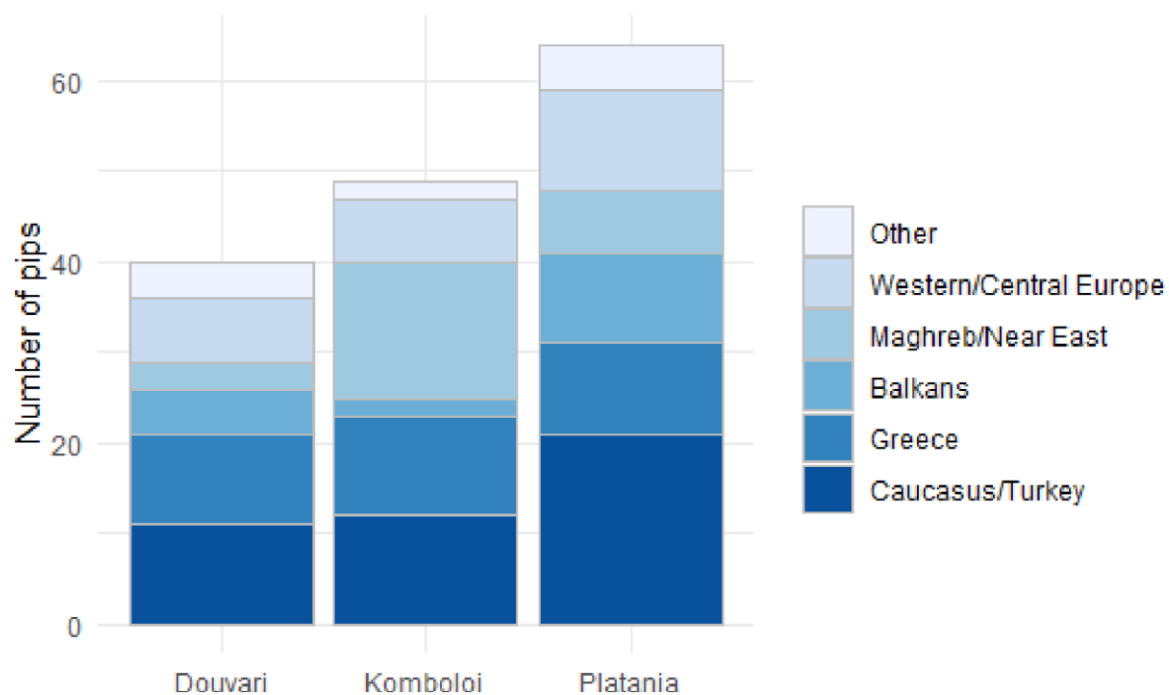


Fig. 7. Distribution of the grape pips classified as cultivars, according to the geographical group of the identified cultivars.