



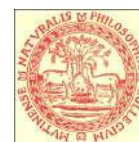
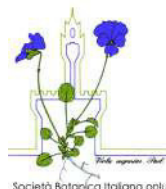
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Could seed image analysis be helpful in the archaeobotanical studies? The case of *Vitis vinifera* L.

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Introduction

Application of computer vision techniques in archaeological plant remains, proved to be an effective tool for the identification of both charred and waterlogged seeds (Terral et al. 2010; Bouby et al. 2013; Orrù et al. 2013; Pagnoux et al. 2015; Ucchesu et al. 2015, 2016, 2017; Sabato et al. 2017).

Plant remains can give important information about the relationship between human and plants in the past, related to diet, plant domestication and origins of agriculture (Zohary et al. 2012). In some cases, identification of remains is not easy because of the alteration of the morphology seed shape. Moreover, since the archaeological seeds of many domesticated plants are morphologically very similar to those of wild ancestors, it is very difficult to distinguish them (Hillman et al. 1993). For example, the seeds of *Vitis vinifera* L. ssp. *sylvestris* (C.C. Gmel.) Hegi and *Vitis vinifera* L. ssp. *vinifera* are highly similar (Zohary et al. 2012). In this study, the results about image analysis applied on waterlogged and charred grapevine seeds found in the archaeological sites of Sa Osa (Cabras, Sardinia) and Monte Meana (Santadi, Sardinia), respectively dated to the 12th- 10th century BC and to the 3rd – 2nd century BC (2017–1751 BC), are presented.

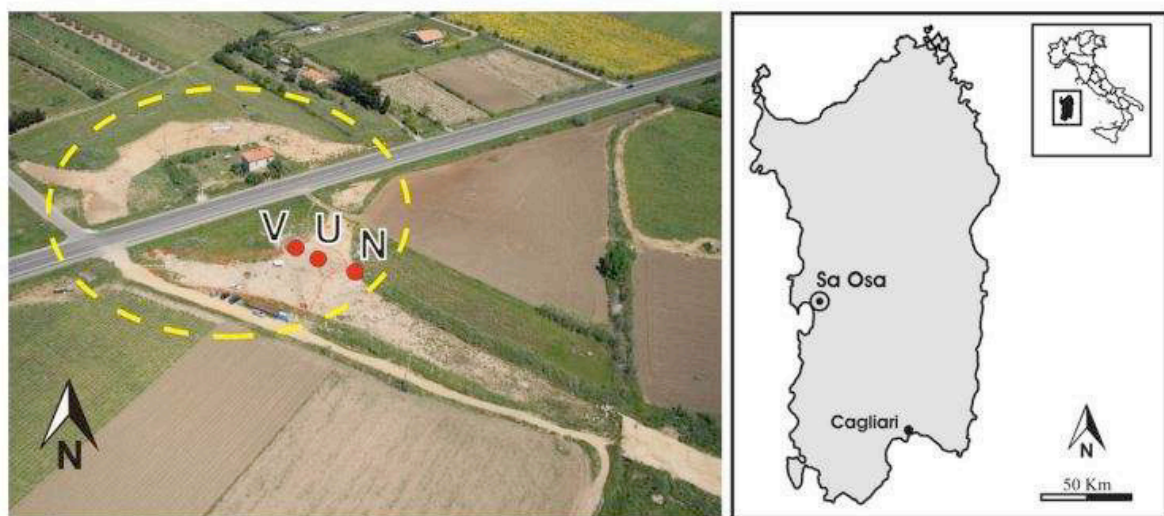


Figure 1 - Sa Osa wells, and location map of the site in Sardinia.

Materials and Methods

A total of 2009 waterlogged pips from the wells N, U and V of Sa Osa settlement were analysed (Fig. 1). Moreover, 8 charred grape seeds in a layer containing other biological remains and a pottery, were studied from Monte Meana found (Fig. 2; Ucchesu et al. 2016).

Modern grape samples consist of 13 accessions of *V. vinifera* L. ssp. *sylvestris* and 41 cultivars of *V. vinifera* L. ssp. *vinifera*, both collected from Sardinia.

Digital images of the modern and archaeological samples were acquired using a flatbed scanner (Epson Perfection V550) with a digital resolution of 400 dpi for a scanning area not exceeding 1024×1024 pixels. The images were processed using the software package ImageJ v. 1.49. To increase the number of discriminant parameters a further 80 Elliptic Fourier Descriptors (EFDs), descriptive of the seed contour shape, were computed using the open source SHAPE software (Iwata and Ukai 2002).

Statistical analysis was performed with the SPSS software package release 16.0 (SPSS 2006), applying the same stepwise Linear Discriminant Analysis (LDA) as described by Grillo et al. (2012). A cross-validation procedure was applied to test the performance of the classifiers, as reported by Venora et al. (2007).

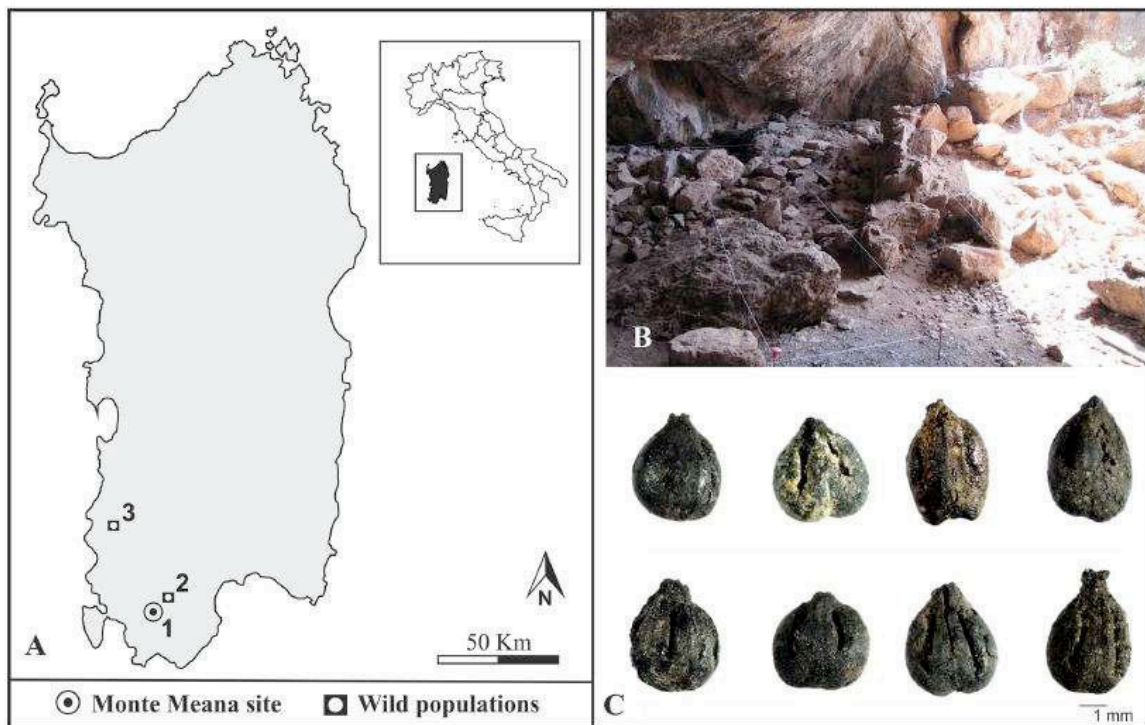


Figure 2 - A: Location of the Monte Meana cave (1) and populations of *V. vinifera* subsp. *sylvestris* from Santadi (2) and Fluminimaggiore (3); B: Archaeological area of Monte Meana; C: Archaeological charred grape seeds discovered.

Results and Discussion

Archaeological samples were compared with modern wild and cultivated accessions. The archaeological pips from Well N were identified as *V. vinifera* ssp. *vinifera* in 95.3 % of the cases, while those from Well U were equally distributed between *V. vinifera* ssp. *vinifera* and *V. vinifera* ssp. *sylvestris*. Pips from Well V were identified as *V. vinifera* ssp. *sylvestris* in 66.3% of the cases. The results of the comparison of charred grape seeds showed 81.3% of similarity among archaeological seeds of Monte Meana and wild grapes. Moreover, statistical analyses

showed that the archaeological seeds were similar to wild grape seeds grown near the archaeological site, reaching the 75% of correct identification.

Conclusions

The discovery of many grape pips preserved in waterlogged contexts at the site of Sa Osa allowed investigating the domestication status of grapes during the Bronze Age in Sardinia. Considering the high scientific and cultural value of plant remains, and the availability of a new, accurate, reliable and above all non-destructive technology able to morphologically investigate, characterize and compare archaeological remains, we wanted to prove the usefulness of seed image analysis in archaeobotanical studies.

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References

- BOUBY, L., FIGUEIRAL, I., BOUCHETTE, A., ROVIRA, N., IVORRA, S., LACOMBE, T., PASTOR, T., PICQ, S., MARINVAL, P., TERRAL, J. 2013: Bioarchaeological insights into the process of domestication of grapevine (*Vitis vinifera* L.) during Roman times in Southern France. *PLoS One* 8, e63195.
- GRILLO, O., DRAPER, D., VENORA, G., MARTÍNEZ-LABORDE, J. B. 2012: Seed image analysis and taxonomy of *Diplotaxis* DC. (Brassicaceae, Brassicaceae). *Systematics and Biodiversity* 10, 57-70.
- HILLMAN, G., WALES, S., MCLAREN, F., BUTLER, A. 1993: Identifying problematic remains of ancient plant foods: a comparison of the role of chemical, histological and morphological criteria. *World Archaeology* 25, 94-121.
- IWATA, H., UKAI, Y. 2002: SHAPE a computer program package for quantitative evaluation of biological shapes based on Elliptic Fourier Descriptors. *Journal of Heredity* 93, 384-385.
- ORRÙ, M., GRILLO, O., LOVICU, G., VENORA, G., BACCHETTA, G. 2013: Morphological characterisation of *Vitis vinifera* L. seeds by image analysis and comparison with archaeological remains. *Vegetation History and Archaeobotany* 22, 231-242.
- PAGNOUX, C., BOUBY, L., IVORRA, S., PETIT, C., VALAMOTI, S. M., PASTOR, T., PICQ, S., TERRAL, J. F. 2015: Inferring the agrobiodiversity of *Vitis vinifera* L. (grapevine) in ancient Greece by comparative shape analysis of archaeological and modern seeds. *Vegetation History and Archaeobotany* 24, 75-84.
- SABATO, D., ESTERAS, C., GRILLO, PEÑA-CHOCARRO, L., LEIDA, C., UCCHESU, M., USAI, A., BACCHETTA, G., PICÓ, B. 2017: Molecular and morphological characterisation of the oldest *Cucumis melo* L. seeds found in the Western Mediterranean Basin. *Archaeological and Anthropological Sciences* DOI:10.1007/s12520-017-0560-z.
- SPSS. 2006: Application guide (Prentice Hall: Upper Saddle River, NJ, USA). Base 16.0.
- TERRAL, J. F., TABARD, E., BOUBY, L., IVORRA, S., PASTOR, T., FIGUEIRAL, I., PICQ, S., CHEVANCE, J. B., JUNG, C., FABRE, L., TARDY, C., COMPAN, M., BACILIERI, R., LACOMBE, T., THIS, P. 2010: Evolution and history of grapevine (*Vitis vinifera*) under domestication: new morphometric perspectives to understand seed domestication syndrome and reveal origins of ancient European cultivars. *Annali di Botanica* 105, 443-455.

UCCHESU, M., ORRÙ, M., GRILLO, O., VENORA, G., USAI, A., SERRELI, P., BACCHETTA, G. 2015: Earliest evidence of a primitive cultivar of *Vitis vinifera* L. during the Bronze Age in Sardinia (Italy). *Vegetation History and Archaeobotany* 24, 587-600.

UCCHESU, M., ORRÙ, M., GRILLO, O., VENORA, G., PAGLIETTI, G., ARDU, A., BACCHETTA, G. 2016: Predictive Method for Correct Identification of Archaeological Charred Grape Seeds: Support for Advances in Knowledge of Grape Domestication Process. *PloS one* 11, e0149814.

UCCHESU, M., SARIGU, M., DEL VAIS, C., SANNA, I., D'HALLEWIN, G., GRILLO, O., BACCHETTA, G. 2017: First finds of *Prunus domestica* L. in Italy from the Phoenician and Punic periods (6th–2nd centuries BC). *Vegetation History and Archaeobotany* 26, 539-549.

VENORA, G., GRILLO, O., SHAHIN, M. A., SYMONS, S. J. 2007: Identification of Sicilian landraces and Canadian cultivars of lentil using image analysis system. *Food Research International* 40, 161-166.

ZOHARY, D., HOPF, M., WEISS, E. 2012: Domestication of plants in the old world. The origin and spread of cultivated plants in West Asia, Europe and the Nile valley. Oxford University Press, Oxford.