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To cite this version:

Laurent Bouby, Jazmín Ramos-Madrigal, Anne Kathrine Wiborg Runge, Thierry Lacombe, Vincent Bonhomme, et al.. Investigating the grape varieties cultivated by the Romans in Southern Gaul through geometric morphometrics and palaeogenomics. A. Making Wine in Western-Mediterranean B. Production and the Trade of Amphorae: Some New Data from Italy: Panel 3.5. Heidelberg, Propylaeum, 2020 (Archaeology and Economy in the Ancient World – Proceedings of the 19th International Congress of Classical Archaeology, Cologne/Bonn 2018, Vol. 9), 2020. halshs-03201893

HAL Id: halshs-03201893

https://shs.hal.science/halshs-03201893v1

Submitted on 26 Apr 2021

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Investigating the grape varieties cultivated by the Romans in Southern Gaul through geometric morphometrics and palaeogenomics

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Grape cultivation was a highly important and lucrative activity in the Mediterranean areas of Roman Gaul, especially during the 1st and 2nd c. AD (Brun 2005). Many aspects of wine production are nowadays well documented by archaeology. However, still little is known about the cultivated grape itself. Yet, grape cultivar is, together with soil, climate and human practices, one of the main factor for the quality of wine. Thousands of grape cultivars are described today, displaying a tremendous diversity for many phenotypic characteristics. But very few is known about the history of these cultivars and even less about their ancestors from Classical times. Latin writers, such as Columella and Pliny the Elder, reported about the already remarkable diversity of cultivated grapes in their times, giving the names of the most famous types, providing extensive information about their productivity, hardiness, adaptation to soil and climate conditions, areas of origin (Tchernia 1986). Several types are described as typical of the territory of Gaul (*Allobrogica*, *Caburnica*, etc.) but it is impossible to draw any relationship between the named ancient types and existing modern cultivars.
The archaeological excavations recently carried out on Roman sites in Languedoc provided significant numbers of well-preserved grape pips, due to waterlogged conditions prevailing in some deposits, especially in wells. Most of these sites were more or less involved in wine production and in many cases the recovered pips, together with pedicels and berry skins, belonged to wine making residues (Figueiral *et al*. 2010). Consequently, the pips almost certainly came from locally cultivated grapes. We then decided to use the pips as a proxy to try to characterize the grape types cultivated in Southern Roman Gaul, combining two approaches: geometric morphometrics and palaeogenomics[1]. Together or separately, these analyses were carried out on samples from seven Roman sites in Languedoc (200 BC - AD 400). The shape of ancient pips was quantitatively described using outline analysis, namely elliptic Fourier transforms performed on dorsal and lateral seed outlines. Ancient pips shapes can then be characterized by comparison with modern pips using Discriminant and data analysis methods. This method is able to discriminate pips from wild or domesticated grapevines and, among them, 14 morphotypes composed of various cultivars (Terral *et al*. 2010). A new palaeogenomic approach, based on targeted-high-throughput sequencing of ten thousand Single Nucleotide Polymorphisms, explored identities and genetic relationships of grape cultivars across times, by assembling a dataset of ancient and modern samples. Individually collected archaeological pips from waterlogged contexts were analysed in a dedicated ancient DNA clean laboratory (Ramos-Madrigal *et al*. submitted).
The combined results from these independent approaches are congruent and prove the cultivation of an important grape diversity, not only on a regional scale but also at the level of each individual farming site. Numerous morphotypes and several genotypes can be recognized on the majority of the sites. In general the grapes cultivated in Gallia Narbonensis during the Roman period were quite different from the varieties cultivated today. First, morphometrics show that pip shapes similar to those of modern wild grapes are very common on every site. However, ancient DNA suggests that all archaeological pips are genetically closer to modern domesticated grapevine than to its wild relative. The wild morphotype then most probably represents a part of the ancient cultivated diversity of grapes, with no modern equivalent, rather than collected wild grapes (Bouby *et al*. 2013).

[1] This project is supported by the French National Agency of Research (VINICULTURE project – ANR-16-CE27-0013), by the Danish Council for Independent Research (10-081390) and the Danish National Research Foundation (DNRF94).

Then, palaeogenomics identify no specific match between archaeological pips and any modern variety, but parental relationships exist in some cases with varieties regarded today as typical of the northern Alpine regions. The morphotypes acknowledged by morphometry include modern cultivars from various French wine regions. However, many pips are similar in shape to 'Mondeuse blanche', a white wine cultivar characteristic of the Savoie region, in the French Alps.
These results show that drastic changes affected the diversity of the grapes cultivated in Southern France between the antiquity and the present time. We still have to trace the origins of the ancient cultivated grape types and to determine how and when they have been replaced by new varieties.

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