Paleorecords of Domesticated and Wild Grapevine in Romania: a Review

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Abstract

This paper reviews the, so far available, paleorecords of *Vitis sylvestris* C.C. Gmel and *Vitis vinifera* L. from Romania. The study takes into consideration the presence of *Vitis* pollen from Holocene peat sediment sequences and archaeological context, but also the presence of macrorests from various archaeological sites that date from Neolithic, Chalcolithic, Bronze Age, and La Tène. Both paleobotanical arguments and archaeological discoveries support the theory that places the beginning of viticulture in Romania a few millennia ago, in Neolithic period. Also, written evidences (works of classical authors, epigraphical sources) confirm, indirectly, the presence of grapevine in La Tène period. Occurrences of *Vitis vinifera* and those of *Vitis sylvestris* manifest independently of the climate oscillations, being present both through colder and more humid episodes, as well as through drier and warmer events. Probably prehistoric communities have made a constant and deliberate effort, all along the Holocene, to maintain grapevine crops.

Keywords *Vitis* · Carpological remains · Pollen · Holocene · Romania

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Introduction

Grapes, also known as *Vitis vinifera* L. (Vitaceae family), are one of the most important fruits in the world, being used in nutrition (as fresh and / or dry fruits) and winemaking (Gerrath et al. 2004), but also with medicinal purposes (Yadav et al. 2009; Fernández-Marín et al. 2012; Doshi et al. 2015; Cui et al. 2018), in the perfume production (Gashkova 2009) and other industries (Sowmya et al. 2015; Ping et al. 2018; Zhang et al. 2018). Even if we talk about *Vitis vinifera* ssp. *sylvestris* (syn. *Vitis sylvestris* C.C. Gmel, wild grapevine), or *Vitis vinifera* ssp. *vinifera* (domesticated grapevine), grapes represented a contribution to the alimentary needs of people for thousands of years (Kislev et al. 1992; Jeraj et al. 2009; Antolin and Jacomet 2015; Ucchesu et al. 2017). *Vitis vinifera* L. is the only species in the Vitaceae family that gained an important economic interest over the time (Terral et al. 2010). Today, as it was in the past, grapes are grown for their fruits, that are used fresh and / or dry, but especially for winemaking, a beverage with economical, cultural and simbolic value.

Regarding wine's origins and how it could have been obtained by prehistoric communities, the subject is still of high interest. It has to be noted that, in certain Mediterranean areas, such as Northern Greece (e. g. Dikili Tash site), wine was, at first, obtained from wild vines, fact that could prove that viticulture was not a prerequisite for the production of wine. Also, the archaeobotanical evidence from this region has led to the suggestion that there was a transitional phase during which the grape pips were neither wild, nor domesticated in their entirety (Renfrew 1995; Valamoti et al. 2007; Valamoti et al. 2015). The finds from Dikili Tash (charred grape pips and wine pressings) represent the earliest evidence (second half of the Vth millennium BC) for the use of grape juice and/or wine in the Aegean and the eastern Mediterranean in general, during the Neolithic period (Valamoti et al. 2007; Valamoti et al. 2015; Garnier and Valamoti 2016). The answers that concerns the beginnings of winemaking and viticulture have to be sought in the history of the civilisations that populated the Earth a few millenia ago. Besides, Patrick E. McGovern said that „the origins of winemaking and viniculture are shrouded in the mists of human prehistory” (McGovern et al. 1997). After the last Ice Age, the Neolithic period of the Near East (ca. 10,000–4500 BC) was a hotbed of experimentation, especially in the mountainous region extending from the Taurus Mountains of Southeastern Anatolia through the South Caucasus and northern Mesopotamia to the Zagros Mountains of northwestern Iran (McGovern et al. 2017). The Near Eastern uplands have been described as the „world center” of the Eurasian grape (Vavilov 1926), based on where the wild plant thrived and achieved the greatest genetic diversity (McGovern et al. 2017).

As the climate moderated and precipitation levels increased, especially between 6200 and 4200 BC (Davis et al. 2003; Marsicek et al. 2018; Zhang et al. 2018a), the communities began to establish permanent settlements. This type of habitation allowed the recently domesticated plants like barley (*Hordeum vulgare*), emmer wheat (*Triticum dicoccum*), vetch (*Vicia ervilia*), pea (*Pisum sativum*), lentil (*Lens culinaris*), flax (*Linum usitatissimum*) and chickpeas (*Cicer arietinum*) to be efficiently grown, harvested and stored (Zohary and Hopf 2000; Bar-Yosef 2016). The invention of the fired-clay pots at the beginning of the VIIth millenium BC had, also, profound implications in the processes of making, serving / consuming and storing of food and beverages (McGovern et al. 2017).

In the international context, the archaeological data (McGovern 2003) places the beginning of cultivation of *Vitis vinifera* ssp. *vinifera* 6000–8000 years ago, in the Near East, from its wild progenitor, *Vitis vinifera* ssp. *sylvestris*. The results of recent genetic analysis suggest a multilocality of genetic selection in the process of grapevine domestication (Samorini 2019). Most of the cultivars of the Iberian Peninsula show chlorotypes that are compatible with wild vine populations originating in the western Mediterranean region (Arroyo-García et al. 2006). Sardinia (Italy) could represent a secondary grapevine domestication centre (following the discovery of a large quantity of grape pips preserved in waterlogged contexts at the Sa Osa site, dating in the Bronze Age) (Ucchesu et al. 2015a; Ucchesu et al. 2015b). Also, the analysis of vine seeds found in the Neolithic horizons of the Serratura Cave (Salerno) could confirm a domestication of the wild vine in southern Italy, independent of the Caucasian one (Gismondi et al. 2016). The first evidence of grapevine domestication is attested at the beginning of the climate amelioration specific for the Holocene in South Caucasus, at around 8.000 BP, during the Early Neolithic (Roberts 1998; Arroyo-García et al. 2006; Jalabadze et al. 2010; Kvavadze et al. 2010b; McGovern et al. 2017; Kvavadze et al. 2019). For instance, paleoenvironmental reconstructions of the Georgian Neolithic show a landscape dominated by thermophilic species and the existence of a increased humidity (Kvavadze et al. 2010a; 2014). Grapevine domestication evidences expanded later towards south, to the western region of the Fertile Crescent, Jordan Valley and Egypt, before 3000 BC (Olmo 1995; McGovern 2003).

Among the earliest recordings of the *Vitis* species around the world are the ones from the archaeological sites of: Ohalo II, Israel (there were discovered two seeds of *Vitis vinifera* ssp. *sylvestris* – $19,800 \pm 360$ – $15,550 \pm 130$ BC, Kislev et al. 1992), Jiahu, China. The samples confirmed the presence of grape beans and also of a fermented beverage made out of rice, grapes, hawthorn and honey – 7000 BC (McGovern et al. 1997) at Shulaveris Gora and Gadachrili Gora, Georgia. There was identified vine pollen for the period between 5900 and 5000 BC (McGovern et al. 2017) in Hajji Firuz Tepe, Iran (the analysis showed that there existed a product made out of grapes and the resin of turpentine tree – 5400–5000 BC, McGovern et al. 1997) and Areni, Armenia (it was discovered a grape-pressing rig – 4223–3790 BC, Barnard et al. 2011).

Recent evidence from the probable areas of earliest grapevine domestication (the Mediterranean and neighbouring regions) show the existence of a correlation between peaks of viticulture and winemaking activities and favourable environmental conditions, such as that observed during the Bronze Age in Transcaucasia and the Near East (Rothman 2005; Batiuk 2013; Sagona 2014; Kvavadze et al. 2020). Similar phenomena have been documented in modern day vineyards, pollen production being heavily influenced by climate factors (Kvavadze et al. 2010a).

Studies in Hungary have shown that the earliest seed remains of *Vitis sylvestris* were found at Tiszapolgár (5300 BC). Remains of *Vitis vinifera* were discovered at Sopron (1300 BC), thus dating the origins of grape cultivation to the Late Bronze Age. Also, the earliest wine residue dates back to 700 B.C. (Fehérvárcsurgó), which places the beginnings of wine making in the Iron Age (Szabó et al. 2007; Güner et al. 2009).

For the region of Bulgaria, we have to mention the pips of *Vitis sylvestris*, discovered in the Early Bronze Age tell-site of Madretz (Nova Zagora). The author of the anthracological and carpological analysis considered this discovery, along with the

remains of *Prunus avium*, *P. domestica* L. ssp. *institia* (L.), *Cornus mas* L., *Sambucus ebulus* L. and the acorns of *Quercus*, a confirmation of the use of these plants in alimentation (Popova 2005).

Nowadays, the wild progenitor of *Vitis vinifera* ssp. *sylvestris* (syn.: *V. sylvestris*) coexists with the domesticated species *V. vinifera* ssp. *vinifera* (syn. *V. vinifera*) in Eurasia and northern Africa (This et al. 2006).

In this paper, we present a review of the palaeobotanical discoveries of the domesticated and wild grapevine in the Romanian territory. Using data from literature, we provide an overview of *Vitis* presence during Holocene period. Palaeobotanical discoveries that concern *Vitis* species are limited, but they are of extraordinary importance. They can be used to correlate the apparition, the development and the spread of this taxon with aspects that involve the evolution of prehistoric societies, concerning also the palaeoenvironmental and palaeoclimatic conditions in the Holocene era. This can contribute not only to the knowledge on aspects like the process of domestication of grapevine or the apparition of viticulture, but also in understanding the development of the wine-making in the Carpato-Danubiano-Pontic space.

Palaeobotanical Findings of *Vitis* in Romania

Evidence of *Vitis* in Archaeological Context

Both *Vitis sylvestris* and *Vitis vinifera* are recorded in 10 archaeological sites that date from Neolithic, Chalcolithic, Bronze Age, and La Tène (Table 1, Fig. 1). We have to mention that, 25–30 years ago, analysis under an optical microscope did not allow the distinction between the pollen from the wild species from the domesticated ones (Bottema and Woldring 1990). Therefore in the published pollen diagrams the mention is made only for *Vitis* genera and not for the species. Nevertheless, technological and methodological advances during the last 15 years have allowed the identification of distinctive features of *Vitis vinifera* pollen grains, allowing for its documentation in an entire series of recent publications (Turner and Brown 2004; Babaev et al. 2009; Shatilova et al. 2011; Bitadze et al. 2011; Connor 2011; Chichinadze et al. 2012, 2017, 2019; Langgut et al. 2013; McGovern et al. 2017; Maghradze et al. 2018, Maghradze et al. 2019; Kvavadze et al. 2007, Kvavadze et al. 2008, Kvavadze et al. 2013, Kvavadze et al. 2015, Kvavadze et al. 2019, Kvavadze et al. 2020). The earliest pollen evidence of *Vitis* belongs to the Pleistocene era (Cârciumaru 1985), but no absolute chronology is available. *Vitis* pollen was identified in the sediment samples that were collected from the **Bugiuleşti** settlement (Vâlcea County), which was relatively dated to Lower Paleolithic (the Upper Villafranchian) (Cârciumaru 1985).

Vitis pollen and/or macro-remains have also been identified in archaeological sites throughout the middle and late Holocene (Neolithic, Chalcolithic, Bronze Age and Iron Age).

The tell site from **Hârşova** (Constanţa County), that belongs to Gumelniţa culture and dates in the second half of Vth millenium BC, has provided a wealth of data since the beginning of the archaeological excavations in 1961. The absolute chronology of the site has been built on a series of five radiocarbon dates with a range from 5574 ± 64 to 4666 ± 55 BP (Bem 2000–2001). At the end of the XXth century, in a rectangular area

Table 1 Recordings of *Vitis vinifera* and *Vitis sylvestris* remains in archaeological contexts of Romania

M a p code	Site / RAN code	Chronology	Culture	Material	Taxa	Archaeological context	References
a	Bugulești, Vâlcea	1.7 mil yr (relative dating)	unspecified	pollen	<i>Vitis</i>	unspecified	Cărciumaru 1985
b	Hârșova, Constanța / 60,810.02	Second half of the V th mil. BC	Gumelnița A2	seeds	<i>Vitis vinifera</i>	area of household waste; dwelling	Chabal 1995; Monah 1999; Monah 2000; Tomescu 2005; Monah 2007
c	Hârșova, Constanța	Second half of the V th mil. BC	Gumelnița A2; Boian	charcoal	<i>Vitis sylvestris</i>	cultural layer	Chabal 1995
d	Căscioarele- Ostrovul, Călărași / 101,733.02	Second half of the V th millennium BC	Gumelnița A2	Seeds	<i>Vitis vinifera</i>	dwelling	Cărciumaru 1996
e	Borodușani - Popină Ialomița / 92,998.01	4550–3950 BC	Gumelnița A2	charcoal	<i>Vitis vinifera</i>	cultural layer	Tomescu 2003; Popovici et al. 2015
f	Borodușani Popină Ialomița / 92,998.01	4550–3950 BC	Gumelnița A2	carpological remains mineralised seeds	<i>Vitis vinifera</i> / <i>sylvestris</i>	unspecified	Hovsepian 2008
g	Sultana, Mălu Roșu, Călărași / 104,216.03	4460–4472 BC	Gumelnița A2	macrorests	<i>Vitis vinifera</i>	dwelling	Bălășescu et al. 2015
h	Poduri, Dealul Ghindaru, Bacău / 24,640.01	4450–4050 BC	Cucuteni A2	seeds	<i>Vitis vinifera</i>	large pot	Golea et al. 2014
i	Drăgușeni, Ostrov, Botoșani / 37,182.02	Late Chalcolithic (relative dating)	Cucuteni (unspecified phase)	pollen	<i>Vitis</i>	dwelling	Monah 2004; Monah and Monah 2005; Monah and Monah 2008
j	Cărlomănești, Buzău / 50,148.01	Middle of II nd millennium BC	Monteoru	pollen	<i>Vitis</i>	unspecified	Cărciumaru 1985
k	Piscul Crăsani, Ialomița / 92,934.01	II nd – I st centuries BC	geto-dacians	seeds	<i>Vitis vinifera</i>	waste pit	Cărciumaru 1996
l	Brad, Bacău 23,662.01	I st century BC – I st century AD	dacians	seeds	<i>Vitis vinifera</i>	fibula	Cărciumaru 1985

of ca. 55 m² destined for the household waste (*Complex no. 521*), were discovered about 650 stratigraphical units, from which 257 contained coprolites, all of them being clustered in 118 sequences that were incorporated in a coherent stratigraphical column. This complex dates in the A₂ phase of Gumelniţa culture and represents a special area designed for the household waste, being placed outside the used buildings, although it was formed on the ruins of a former dwelling (Monah 1999). There were collected seeds, fruits, inflorescences and charcoal fragments. In the third stratigraphical unit, that included six species, were identified 15 seeds from domesticated grapevine, *Vitis vinifera* and one pip of *Sambucus nigra*. The measurements took on the seeds emphasized the existence of two groups with different sizes: four had 6 mm length and 2 mm width and the other eleven had 5–6 mm length and 2–3 mm width. Felicia Monah (Monah 1999) thought that the recording of two dimensional groups of *Vitis vinifera* seeds can signal the presence of two types of grapevine. Previously, the anthracological analyses made by L. Chabal (Chabal 1995) had shown the presence of the species *Vitis sylvestris* in the area. Considering the fact that the region provides the optimal conditions for its development, researchers have accepted the idea of the dietary usage of *Vitis* fruits, both fresh and preserved (Monah 2000). This hypothesis was supported also by the discovery, in 2000's archaeological campaign, of three *Vitis vinifera* pips, that belong either to the Complex no. 720, either to the dwelling no. 48, both being dated in the same phase A₂ of Gumelniţa culture (Monah 2007). Also, the analysis of the stratigraphical units that contained coprolites, revealed *Vitis* pollen (Tomescu 2005). It is important to notice that, regarding biometric criteria, more sophisticated calculations have been proposed in different studies (Jacquat and Martinoli 1999; Bouby et al. 2013) and nowadays, digital image analysis is used to distinguish the wild from cultivated grapes (Terral et al. 2010).

The site at **Căscioarele, Ostrovel** (Călăraşi County) includes a Neolithic complex with overlaid settlements from the transition period between Boian and Gumelniţa cultures, also Gumelniţa and Cernavodă I, and its absolute chronology has been established on a series of 22 radiocarbon dates ranging from 5980 ± 120 to 5400 ± 100 BP (Bem 2000–2001). In 1965's excavations were discovered 27 non-carbonised seeds of *Vitis vinifera*. They were found in a layer that belonged to Gumelniţa culture, phase A₂. Although, the seeds were assigned to the domesticated grapevine, there are reservations regarding their cultural framing (Cărciumaru 1996).

Borduşani – Popină (Ialomiţa County) is one of the few Romanian archaeological sites where the multidisciplinary studies include anthracology, palynology, mammalogy, ichthyology, malacology, herpetology, sedimentology and micromorphology. It belongs also to Gumelniţa A₂ phase (4550–3950 BC) and includes two tell-settlements, round and oval shaped, with heights of 8 and 15.4 m. The stratigraphical unit 1070 represented the only charcoal sample of paleoecologic interest exhaustively collected and analyzed. Besides poplar / willow (*Populus-Salix*), elm (*Ulmus*) and dogwood (*Cornus*), there were discovered charcoal fragments of wild grapevine (*Vitis sylvestris*). Out of the 72 fragments, only three belonged to *Vitis* species, representing only 4.2% of the whole (Tomescu 2003). In 2014 remains of *Sambucus nigra* were uncovered, thought to be residues of alimentary products derived from the harvested plants (Popovici et al. 2015). The carpological analyses revealed the presence of *Vitis vinifera* macrorests (Hovsepyan 2008), and also of *Vitis vinifera* / *Vitis sylvestris* mineralized seeds, identified in cultural sediments (Bălăşescu et al. 2015).

Fig. 1 Recordings of *Vitis*, *Vitis vinifera*, and *Vitis sylvestris* in archaeological sites and natural sequences of Romania: (a) - Bugiulești, Vâlcea; (b, c) - Hârșova, Constanța; (d) - Căscioarele, Ostrovel, Călărași; (e, f) - Bordușani, Popină, Ialomița; (g) - Sultana, *Malu Roșu*, Călărași; (h) - Poduri, *Dealul Ghindaru*, Bacău; (i) - Drăgușeni, *Ostrov*, Botoșani; (j) - Cărlomănești, Buzău; (k) - Piscul Crăsani, Ialomița; (l) - Brad, Bacău; (m) - Poiana Știol, Rodna Mountains, Bistrița Năsăud; (n) - Gărgălau, Rodna Mountains, Bistrița Năsăud; (o) - Bisoca, Buzău Subcarpathians, Buzău; (p) - Ponor, Apuseni Mountains, Cluj; (q) - Mohoș, Harghita Mountains, Harghita; (r) - Avrig, Făgăraș Mountains, Sibiu; s - Iaz, Plopiș, Apuseni Mountains, Sălaj; (t) – Lacul Știucii, Cluj; (u) – Molhașul Mare, Apuseni Mountains, Bihor

Sultana – *Malu Roșu* (Călărași County) site (4460–4472 BC) is one of the most important settlements of Gumelnița culture, including a tell and a necropolis. The living area comprises all three phases of Gumelnița culture (A₁, A₂, and B₁), and also later traces of dwellings (Cernavodă I and Tei cultures, La Tène period and graves from migration period). The necropolis has a different stratigraphy, only the first two Gumelnița phases and graves from Vidra and Spanțov phases of Boian culture being identified. The vegetal macrorests discovered and analysed come from two of the Gumelnița dwellings (dwelling no. 5 – phase A₂ and dwelling no. 2 – phase B₁). The samples from the dwelling no. 5 (dating from 4460 to 4472 BC) provided macrorests of *Vitis vinifera*, indicating the possibility of this species being used as food. Most likely, this fruit was known to the chalcolithic communities of Sultana - *Malu Roșu* tell site, but we cannot say if it was also cultivated (Golea et al. 2014).

Poduri – *Dealul Ghindaru* (Bacău County) tell site contains a series of settlements from Precucuteni and Cucuteni cultures, followed by a mixed level Monteoru-Costișa. Its absolute chronology is documented through a series of 13 radiocarbon dates covering a time span from 5820 ± 50 to 5350 ± 80 BP (Bem 2000–2001). From the Cucuteni A₂ layer were collected three pips of grape (Monah and Monah 2005). Two of them were discovered in 1995, by analysing 10 g of vegetal macrorests, strongly

carbonized and mixed with charcoals. Only one of them was found whole. Later, was discovered the third pip, during 2000's excavations. It was found, together with other macrorests in a large sized pot, near a grinder and a hearth (Monah and Monah 2005). These three samples represent the first record of grapevine in the tell of Poduri.

Since this settlement is contemporary with the previous ones, that belong to Gumelnița A₂, and in the Republic of Moldavia, at Ruseştii Noi I (in the Precucuteni III settlement) and also in the Cucuteni B site of Varvarovka XV, were discovered *Vitis vinifera* pips, we can say that the Neolithic and Chalcolithic communities knew the grape and, probably, the winemaking (Monah and Monah 2008).

The palynological analysis of the Cucutenian settlement from **Drăguşeni - Ostrov** (Botoşani County), has signaled, at ca. 1.10–1.20 m depth, pollen from *Vitis*. The layer belonging to Cucuteni culture was identified until 0.60 m depth, so the author of the chart did not include the record in the list (Cârciumaru 1996).

The settlement at **Cârlomăneşti** (Buzău County) was inhabited in the Middle Bronze Age (Monteoru culture) and also in La Tène period. In the layer Monteoru II_a, the pollen diagram of the E2d western wall's profile, displayed by Marin Cârciumaru, shows the presence of *Vitis* pollen (Cârciumaru 1996).

The Geto-Dacian fortress (centuries II – I BC) of **Piscul Crăsani** (Ialomiţa County) has provided many materials that became the subject of carpological analysis. Among these are the 35 seeds of *Vitis vinifera*, discovered in 1987, that represented, at the time, the earliest evidences of the beginning of viticulture in Romania. Their dimensions were of 5–6.7 mm length and 3.1–4 mm width (Cârciumaru 1996).

In the Vth section dug at **Brad** (Bacău County) in the Dacian settlement (centuries I BC – I AD), at 1.9–2 m depth, in 1969 were discovered, on a fibula, glued with sediment, 6 seeds of *Vitis vinifera*. They were of 5–6 mm length and 3–3.3 mm width (Cârciumaru 1996).

Paleorecords of *Vitis* in Natural Sedimentary Sequences

The analysis of sedimentary sequences collected from different Quaternary stations showed the presence of *Vitis* pollen (Tanţău et al. 2003; Tanţău et al. 2011a; Tanţău et al. 2011b; Tanţău et al. 2014a; Grindean et al. 2015) (Table 2, Fig. 1). The natural sequences were dated using absolute chronology.

In **Rodna Mountains**, at **Poiana Ştiol** (1540 m a.s.l.), was identified pollen of *Vitis* in sediments that date before 9220 ± 45 BP. The presence of this taxon in Poiana Ştiol's Preboreal period is not unique. *Vitis* pollen was recorded in other samples too. For the Boreal age, in this sequence, there is no trace of *Vitis* pollen, although it reappears in the sediments of the Atlantic period. The most recent recording in the pollen diagram at Poiana Ştiol is in the Subboreal period (before 4210 ± 35 BP (Tanţău et al. 2011b).

Vitis pollen was identified also in a natural sequence from a peat bog in **Rodna Mountains (Gărgălău)**, dating at the beginning of the Atlantic period, ca. 9000 BP ($9000-7690 \pm 50$ BP) (Tanţău et al. 2014a).

In a sediment sequence collected from **Bisoca, Buzău Subcarpathians** (890 m a.s.l.) was identified *Vitis* pollen dating back to 8100 ± 45 BP, the Boreal age (Tanţău et al. 2009).

Also, *Vitis* pollen was recorded in a natural sequence collected from the **Apuseni Mountains (Ponor)**, dating between 7400 and 5830 cal BP (Grindean et al. 2015).

For the Atlantic period (ca. 6660 ± 250 BP), *Vitis* pollen was found in a natural sequence from **Harghita Mountains (Mohoş 1)** (Tanţău et al. 2003). The pollen analysis showed also the presence of human activities between 6660 ± 250 BP and 6230 ± 240 BP (Tanţău et al. 2003). This can be related to some Neolithic and Chalcolithic settlements near Mohoş, (Cavruc 1998; Maxim 1999; Tanţău et al. 2003): Albiş - *Grădina lui Csiszér* (Székely 2000, 2002, Székely 2004), Brăduţ - *Dealul cu cioturi, Dealul Rotund, Muntele de Piatră* (Maxim 1999; Székely 1996, 1997, 1998, 1999, 2008, 2009), Malnaş-Băi - *Platoul Nisipos, Lunca, Cariera de bazalt, Cariera Podeiu* (Maxim 1999; Berecki 2015, 2018), Peteni, Turia - *Judeţ, Balász-Telke* (Bordi 2001; Istrate 2003, 2005) and Zoltan - *Nisipărie, Mestecăniş, Dealul Bisericii* (Kavruc 1997, 1999, 2001; Beldiman 2002).

Other mentions of *Vitis* pollen come from a sedimentary sequence collected at **Avrig – Făgăraş Mountains** (Tanţău et al. 2011a). The pollen from this taxon was identified in different layers that correspond, chronologically, to: 3800–2870 cal BP; 2870–2250 cal BP; 720–570 cal BP.

Grains of *Vitis* pollen were also preserved in a natural sequence taken from **Iaz - Munţii Plopişului** (Grindean et al. 2014; Grindean et al. 2016). This taxon's presence is also recorded since ca. 5450–4500 cal BP (Grindean et al. 2014, Table 2). If in the Neolithic and Chalcolithic periods, *Vitis* pollen appears periodically but is an insignificant presence, in the Bronze Age was signaled its constant presence and also a larger proportion, concurrent with other taxa that suggest anthropical activity (Grindean et al. 2016). For Hallstatt and La Tène periods, the diagram of the sedimentary sequence collected at Iaz shows a slightly lower presence of viticulture, but still constant. The Roman period records an important increase of the relative abundance of *Vitis* pollen, suggesting a continuous preoccupation for vineyards and, implicitly, a development of trading. In the post-roman and medieval periods, plant cultivation and shepherding become more important than viticulture (Grindean et al. 2016). The recordings of the natural sequence collected at this site can be related with the existence in its vicinity of prehistoric sites, the Neolithic, Chalcolithic and Bronze Age settlements from: Plopiş (*arina, Perimetru, Cucleu*), Valcău de Jos (*Şighileu, Roata lui Kincses*), Sub Cetate (*Cetate*) şi Pietroasa (*Pietre*) (Maxim 1999; Luca and Gudea 2010).

Vitis pollen was identified, also, in the sedimentary sequence from **Lacul Ştiucii** (Feurdean et al. 2015). Regarding the chronological framing of this discovery, it appears between 700 cal. yr. BP and 200 cal. yr. BP and, also, between 200 cal. yr. BP – present.

Finally, recordings of *Vitis* pollen come from **Molhaşul Mare** – 1224 m a.s.l. (Feurdean and Willis 2008). In this case, the pollen belonging to *Vitis* species, appears scattered after 1000 cal. yr. BP.

Archaeological Evidences of Viticulture

Some of the main archaeological discoveries that can be related with the presence of *Vitis vinifera* are the curved knives, with different sizes and the edge on the concave side. Most of them are similar regarding the shape to the sickles. Since they couldn't be used for food preparation, the archaeologists considered them to be billhooks (Comşa 1982). Billhooks appeared in the romanian territory in the Bronze Age (Florescu 1964).

Table 2 Recordings of *Vitis* pollen in natural sequences of Romania

Map code	Site	Altitude	Chronology	Reference
m	Poiana Ştiol (Rodna Mountains, Bistriţa-Năsăud)	1540 m	> 9220 ± 45 cal BP 9220 ± 45–8660 ± 60 cal BP 7840 ± 45–5990 ± 40 cal BP 5990 ± 40–4870 ± 55 cal BP 4870 ± 55–4210 ± 35 cal BP	Tanţău et al. 2011b
n	Gărgălău (Rodna Mountains, Bistriţa-Năsăud)	1810 m	9000–7690 ± 50 cal BP	Tanţău et al. 2014a
o	Bisoca (Buzău Subcarpathians, Buzău)	890 m	8100 ± 45 cal BP	Tanţău et al. 2009
p	Ponor (Apuseni Mountains, Cluj)	1050 m	7400–5830 cal BP	Grindean et al. 2015
q	Mohoş (Munţii Harghita, Harghita County)	1050 m	6660 ± 250 cal BP	Tanţău et al. 2003
r	Avrig (Făgăraş Mountains, Sibiu)	400 m	3800–2870 cal BP 2870–2250 cal BP 720–570 cal BP	Tanţău et al. 2011a
s	Iaz (Plopiş, Apuseni Mountains, Sălaj County)	300 m	5450–4500 cal BP 4500–2400 cal BP 2400–1770 cal BP 1770–730 cal BP	Grindean et al. 2014
t	Lacul Ştiucii (Transylvanian Plain, Cluj County)	239 m	700–200 cal BP 200 cal BP - present	Feurdean et al. 2015
u	Molhaşul Mare (Apuseni Mountains, Bihor County)	1224 m	1000 cal BP - present	Feurdean and Willis 2008

This meant that their presence could be the evidence of viticulture (Ichim 1984; Haheu and Bratco 2012). The larger billhooks were probably used for cutting the shoots and, sometimes, for pruning fruit trees (Comşa 1982).

In the works of some classical authors (Plato, Strabo, Ovid, Polybius, Herodotus) we can find numerous references about wine in Roman Dacia (centuries II–III). For example, Strabo narrates the moment when Burebista persuaded the Getae to cut down the vine and to live without wine (*Boerebistas a Getan, on setting himself in authority over the tribe, restored the people, who had been reduced to an evil plight by numerous wars, and raised them to such a height through training, sobriety, and obedience to his commands [...] The following is an indication of their complete obedience: they were persuaded to cut down their vines and to live without wine*) (Strabo 1974, VII, 3.11). Plato described in his *Dialogues* a ritual in which *Thracians, both men and women, drink unmixed wine, which they also pour on their garments, and this they think a happy and glorious institution* (Plato 2010). In this context, the presence of billhooks can suggest viticulture: e.g. the billhooks from Vlădiceni – *Schit* (Vaslui County), Teliţa,

Table 3 Recordings of *Vitis vinifera* and *Vitis sylvestris* in archaeological sites and natural sequences of Romania in correlation with probable paleoenvironmental conditions. Sites: b, c - Hârșova, Constanța; d - Căscioarele, Ostrovel, Călărași; e, f - Bordușani, Popină, Ialomița; g - Sultana, Malu Roșu, Călărași; h - Poduri, Dealul Ghindaru, Bacău; j - Cărlomănești, Buzău; k - Piscul Crăsani, Ialomița; l - Brad, Bacău; m - Poiana Știol, Rodna Mountains, Bistrița Năsăud; n - Gărgălău, Rodna Mountains, Bistrița Năsăud; o - Bisoca, Buzău Subcarpathians, Buzău; p - Ponor, Apuseni Mountains, Cluj; q - Mohoș, Harghita Mountains, Harghita; r - Avrig, Făgăraș Mountains, Sibiu; s - Iaz, Plopiș, Apuseni Mountains, Sălaj.

Yrs.cal. BP	South Romania				North Romania				Cultural period	Climate phase
	Temp.	Precip.	Vitis occurrence	Site	Temp.	Precip.	Vitis occurrence	Site		
1500	cool		V. Vinifera	k	cool	humid	V. vinifera	l	Iron Age / Dacians	Subatlantic
2000										
2500										
3000	cooling	humid	V. Vinifera/ V. sylvestris	j/ r	cool	humid			Middle & Late Bronze Age	Subboreal
3500										
4000										
4500										
5000							V. sylvestris	m, s		
5500										
6000	warm		V. vinifera/ V. sylvestris	b, c, d, e, f, g / f	warm	humid	V. vinifera	h	Late Neolithic	Atlantic
6500										
7000										
7500										
8000							V. sylvestris	m, p, q		
8500			V. sylvestris	o			V. sylvestris	m, n		
9000	dry				warm	humid				Boreal
9500										
10000										
										Preboreal

(Tulcea County), Bucureşti, Piatra-Neamţ – *Bâtca Doamnei* (Neamţ County) (Comşa 1982), Tăvădăreşti (Bacău County) etc. Vineyards existed near Roman cities also, fact proven by the billhooks discovered at Ulpia Traiana, Drobeta, Apulum, Dacia Porolissensis etc. (Regep and Tutilă 2010; Farcaş and Pop 2017). It should be noted that the curved knives, used for harvesting the grapes were called by the romans *falcula vineatica*, and the billhook *falx vineatica* (Lascu 1965). This can be related with the dacian weapons, called *falx* and represented on Trajan's Column and Tropaeum Traiani at (Regep and Tutilă 2010).

Two of the most important discoveries regarding Roman Dacia's viticulture come from Potaissa: *cella vinaria* (a partly underground room, of rectangular shape with 7.82 m length and 2.96 m width, used as cellar, for wine storage) and a winepress made out of hard limestone (Regep and Tutilă 2010). Also, I. C. Teodorescu specifies that, in the Dacian settlements at Popeşti, were discovered impressions from cultivated vine, *Vitis vinifera sativa* (Teodorescu 1964).

Viticulture in Roman Dacia is also proven by some epigraphical mentions, among which is also an epitaph from Sucidava. The headstone contains the will of an individual that, in order to make sure that his grave will be taken care of and the sacrifices will be regularly performed, gives to the one that will fulfill this task, two acres (*iugera*) of cultivated grapevine and the right to use a home (Regep and Tutilă 2010).

Evidences of viticulture are also present on the waxed tablet from Alburnus Maior (it mentions two types of wine existing in Dacia: *merum* and *vinum*), the inscriptions that attest the existence of wine merchants, the romanian terminology regarding viticulture (of latin origin), the decorative motives that show grapevines and grape bunches (mostly illustrated on funerary headstones, but also on some pots with Dionysiac scenes etc.) (Regep and Tutilă 2010).

Current Ecological Background and Palaeoenvironmental Conditions

Vitis sylvestris (the wild grapevine) is a very vigorous creeper, with exfoliating rhytidome, that peels on longitudinal strips; the marrow of the sprouts is interrupted at the knots; it has discontinuous tendrils (two consecutive knots with tendrils or inflorescences and the third one without); it has polygamous-dioecious flowers, with small, sour berries (5–7 mm diameter) and seeds with short rostrum. It can be found sporadic in forests, up until 1500–1800 m altitude, and blooms in June (Ştefan & Oprea 2007). *Vitis vinifera* (cultivated grapevine) is a less strong creeper, with flowers generally hermaphrodite; the fruits are sweet berries, larger than 7 mm in diameter, and the seeds have a visible rostrum. It is found only in crops, formed from the wild grapevine, and blooms in May–June (Ştefan & Oprea 2007). The macroscopic morphometric differences between *Vitis sylvestris* and *Vitis vinifera* seeds are well illustrated by Forni (2012, Fig. 4), and the morphometry of pollen grains is exemplified by Kvavadze (2016, Fig. 14) for *Vitis vinifera* and by Gallardo et al. (2009, Figs. 3–4) for *Vitis sylvestris*.

The growth and development of grapevine is influenced not only by the superior levels of the soil, but also by the geological characteristics of the region. This species has requirements that allow its growth on soils that could not be used for other crops (Bucur 2011). There have been recorded successful cases of viticulture on steep slopes,

characterized by eroded, sandy, clay soils, on sandy soils along rivers, even on sand beaches (e.g., on the narrow strip of sand between Dniester's shore and the Black Sea, in Belgorod-Dnestrovsk district, near Odesa; in Absheron Peninsula, in Azerbaijan etc.). Also, there are known small areas with rocky soils (coarse) in Moldavia region, in the uplands of Crimea, Switzerland and Germany, where the majority of high quality grapes are grown. For most of the breeds, the best harvests are obtained on light soils, well heated and profoundly drained, rich in nutritive substances (Babeş 2011). Statistically speaking, most of the sites presented above are defined by the presence of mollisols (gray soils, chernozem, cambic chernozem and argillic soil), after that being sites on undeveloped, truncated or sloppy soils. This is a characteristic specific for many Romanian Chalcolithic settlements. The explanation for these choices is based on the fact that chernozems and gray soils are included in the category of soils with best properties, being rich in humus and nutritive elements. These can be found, usually, in relatively wet areas, that can assure water supplies for the crops and are also very good for growing barley and wheat, for example, or for pasture (Ştefan 1980). Due to the high number of nutritional substances and the possibility of additional water supply, the terrains with protosols or alluviums are, usually, good surfaces for agriculture. Also, the high level of groundwaters and overflows, allow the alluviums to assure a good water supply for the plants (Ştefan, 1980).

Both species of *Vitis* have similar ecological requirements. *Vitis vinifera* domesticated cultivars are known to thrive in climates where the annual mean temperature varies between 10 and 20 °C (Sawicki et al. 2016), the growing season temperatures average 13–21 °C (Jones 2016), and may withstand exposure to freezing temperatures ranging from −14 to −26 °C (Jackson 2000). The requirements for growing degree days range between 850 GDD and 2700 GDD (Keller 2020), and for water availability between 300 to 800 mm (Jackson 2000). Current *Vitis sylvestris* varieties from Central and South Eastern Europe, and Caucasus are present in environments characterized by average annual temperatures varying from 9 to 13.4 °C, GDD values between 2750 and 4500, and average annual rainfall levels between 300 and 2800 mm (Chkhartishvili and Maghradze 2012; Melyan and Gasparyan 2012; Popa et al. 2009; Savin 2012; Butorac et al. 2018).

From the point of view of palaeoenvironmental conditions, the presence of both species of *Vitis* seems to not have been influenced by the general climatic oscillations specific for the middle and late periods of the Holocene. Reconstructions of the temperature evolution for the northern hemisphere (Marsicek et al. 2018; Wanner et al. 2011; Zhang et al. 2018a) in general, and temperature and pluvial regimes focused on Central-Eastern Europe indicate that, at millennial scale, starting from 6000 yrs. cal BP there is a warmer and more humid climate than today (Barber et al. 2004; Davis et al. 2003; Mauri et al. 2015; Russo and Cubasch 2016) with a cold event at approximately 4000 yrs. cal BP.

A similar general evolution may be observed for the territory of Romania, but a finer grained analysis alludes to the presence of some regional characteristics distributed to the north and south of the 46°N parallel.

For southern Romania, indications on the evolution of climate during the Holocene come from $\delta^{18}\text{O}$ analysis of two speleothems (Constantin et al. 2007; Drăguşin et al. 2014), from pollen analysis from two locations situated west (Tanţău et al. 2009) and east (Tanţău et al. 2014b) of the Carpathians, and from the analysis of a chironomids

assemblage (Tóth et al. 2015). The general trends exhibit warm and humid conditions up to 5200 yrs. cal BP, a cold and humid event at around 4200 yrs. cal BP, a subsequent climatic amelioration peaking at 3300 yrs. cal BP followed by a cooler episode until 1500 yrs. cal BP. For this region, *Vitis sylvestris* presence is attested both throughout the Holocene climate optimum (Chabal 1995; Tanţău et al. 2009; Bălăşescu et al. 2015) characterized by a warmer and more humid climate than today, as well as through the colder and more humid than today episode between 3300 and 1500 yrs. cal BP (Tanţău et al. 2011a). The same can be said about *Vitis vinifera*, attested during the climatic optimum in the late Neolithic settlements of Gumelniţa culture (; Chabal 1995; Cărciumaru 1996; Tomescu 2003; Golea et al. 2014), and also during the cold and humid climate of the Iron Age, in the Dacian settlements (Cărciumaru 1996; Cărciumaru 1987). Despite the climate variations, the inferred reconstructions of the GDD values (range between 1600 and 1800) and mean temperatures of coldest month (range between -15 to 7 °C) and warmest month (range between 10 and 25 °C) for the time frames when *Vitis* is attested seem to fall within the suitability range wild grapevine, while the low summer temperatures during the Iron Age may have affected the productivity of *Vitis vinifera* cultivars (Barber et al. 2004, Tóth et al. 2015).

More abundant and diverse data are available for the north of Romania, reconstructions of the climate being advanced from data based on pollen (Fărcaş et al. 2013; Feurdean et al. 2008, 2015, 2016; Tanţău et al. 2011b), plant macrofossils (Gałka et al. 2017; Gałka et al. 2016) and testate amoebae and *Chironomidae* (Diaconu et al. 2017) $\delta^{18}\text{O}$ analyses of speleothems (Onac et al. 2002; Tămaş et al. 2005; Perşoiu et al. 2017), and geomorphological and sedimentological analyses (Chiriloaei et al. 2012). Due to the larger number of studies and increased variety of data sources, there is also increased variability in the palaeoenvironment reconstructions. Still, the overall Holocene general trend is similar to the climate evolution in the south, with probably colder winters and cooler summers. Throughout the entire timeframe, the mean annual temperature oscillates around 7 °C, mean coldest month temperatures around -1 °C, mean warmest month temperatures around 16 °C, and mean annual precipitations around 900 mm. For this region, *Vitis sylvestris* is present in natural sequences starting with the early Holocene (at ~ 9000 cal. Yrs. BP) (Tanţău et al. 2011b) through middle and late Holocene (Tanţău et al. 2003; Tanţău et al. 2014a; Grindean et al. 2014, 2015), and evidence of the domesticated grapevine originates from Cucuteni late Neolithic (Monah and Monah 2005) and Iron Age Dacians sites (Cărciumaru 1987). As we can see, for the northern regions of Romania, at least from the point of view of mean annual temperatures, which during both the Neolithic and the Iron Age, reach lows of 6 °C and never go above 10 °C, the conditions are not ideal for the cultivation of *Vitis vinifera* and do not fit the current ecological conditions observed for the wild grapevine populations present in the area.

Given these data, we observe that the archaeological occurrences of *Vitis vinifera* and those of *Vitis sylvestris* manifest independently of the climate oscillations, being present both through colder as well as through warmer events (Table 3). We may therefore assume a constant and deliberate effort of the human communities, throughout mid and late Holocene, to maintain the *Vitis vinifera* crops. The wine could have been produced not only for personal consumption, but it most likely had an economical, cultural and symbolic value. We may connect this persistence to the production of fermented drinks, which may have held a special ritual value throughout the prehistory

of Eurasia (Guerra-Doce 2015). This point of view may be supported by additional information of the production of fermented drinks from *Coriandrum sativum* and *Sambucus nigra* (Monah 2004). At the site of Poduri, in one of dwellings, within a painted amphora, were discovered 248 fruits of coriander (*Coriandrum sativum*). Near the pot, on the bottom of a wooden container, that was probably a barrel, was discovered a mix of coriander fruits and elderberries (Monah 2004). These species were discovered before in this site: in 1982, in the ca. 200 g of vegetal material collected from an adobe chest in the Precucuteni III level, were discovered 30 g of kernels mixed with coriander fruits and charcoals (Monah and Monah 2008). Felicia Monah (Monah and Monah 2008) thought, at the time, that the discovery made in the Precucuteni III level could suggest the usage of coriander for flavouring cereal broths. In the cucutenian level A₂, researched in 1990, was also found a coriander fruit (Monah and Monah 2008). This type of discoveries from the Cucuteni A₂ layer were also recorded in 2000, when were found many fragments that came from coriander fruits, nucules of elderberries etc. In Cucuteni B₁ phase, were discovered, during 1900 and 2000's campaigns, two nucules of elderberry, next to 61 g coriander fruits and 63 g of elderberry fruits. Taking into considerations these discoveries, the assumption that these communities knew and produced the fermented beverage made out of elderberries and coriander, becomes plausible.

Conclusion

Although the first recordings of *Vitis* in Romania date back to the Pleistocene period, we have to bear in mind that for this single case we have no results concerning the absolute dating and the archaeological context is not very clear.

Paleobotanical evidences of domesticated and wild grapevine (*Vitis* pollen and macrorests from *Vitis vinifera* and *Vitis sylvestris*) exist since the beginning of Holocene period in different regions of Romania and at different elevations. The communities of Chalcolithic period and of the Bronze Age seem to have known and used the grapes of both species of *Vitis*. The presence of grapevine is recorded for the Chalcolithic period also by the impressions left on the ceramics (in the Cucuteni-Trypillia settlements of Ruseştii Noi I and Varvareuca VIII, in the Republic of Moldavia). After that, this taxon appears in the Late Bronze Age, in the settlements of Belozerk culture: impressions on ceramics in the archaeological site of Etulia (Bratco and Haheu 2015).

As it was mentioned before, as a general trend we can observe that the warm event in the north was shorter lived and of lower amplitude than in the south. It was noticed that the archaeological occurrences of *Vitis vinifera* and those of *Vitis sylvestris* manifest independently of the climate oscillations. They are present both through colder and more humid episodes, as well as through drier and warmer events which leads us to believe that the two species of *Vitis* held some degree of importance to the prehistoric human communities which justified the maintenance of *Vitis vinifera* crops. Despite the intrinsic aspect in pollen identification by optical microscopy of wild from cultivated grapevines, the occurrence of *Vitis* pollen since Neolithic period (ca. 6660 ± 250 BP) and its high proportion during the Bronze Age in the natural sequences may imply the onset of viticulture in Carpato-Danubiano-Pontic space.

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