RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

On the origin and cultivation of grapevine in Bohemia, Moravia, and Slovakia

K otázce původu a pěstování révy vinné na území Čech, Moravy a Slovenska

Michaela Látková

The study addresses the history of grape cultivation and viticulture in Czech-Slovak territory and examines the related economic and ecological aspects in individual historical periods – from the first finds of grapevine to the Early Middle Ages, when wine was an important liturgical symbol associated with Christianisation, to the high medieval and modern periods, when viticulture became an important economic sector. The paper discusses methods of identifying archaeobotanical grapevine finds, which had been problematic due to morphological changes caused by diagenetic processes. Although the accuracy of morphometric methods is low when coupled with the macroscopic assessment of finds, they can be effective for distinguishing between cultivated forms of grapevine and their wild counterparts. Despite the difficulties in classifying the finds, archaeobotanical studies are an important source of information on the history of viticulture and grapevine cultivation in the region.

grapevine – archaeobotany – Mikulčice – Early Middle Ages – morphology

Studie se zabývá problematikou historie pěstování vinné révy a vinohradnictví v česko-slovenském prostoru, zkoumá ekonomické a ekologické aspekty v jednotlivých historických obdobích – od prvních nálezů révy přes období raného středověku, kdy se víno stalo důležitým liturgickým symbolem spojeným s christianizací, až po vrcholně středověké a novověké období, kdy se vinařství stalo významným hospodářským odvětvím. Článek diskutuje metody identifikace archeobotanických nálezů révy, které byly problematické kvůli morfologickým změnám způsobeným diagenetickými procesy. Přesnost morfometrických metod se ukázala být nízká, ale ve spojení s vizuálním hodnocením nálezů mohou být efektivní způsobem, jak odlišit pěstované formy révy od divoké. Navzdory obtížím při klasifikaci nálezů jsou archeobotanické studie důležitým zdrojem informací o historii vinohradnictví a pěstování révy v regionu.

vinná réva – archeobotanika – Mikulčice – raný středověk – morfologie

Introduction

The common grapevine (*Vitis vinifera*), which is native to the Levant (*Zohary – Spiegel-Roy 1975*; *van Zeist 1991*), ranks among the oldest domesticated and cultivated crops in the world (along with other species such as olives, dates, figs, and pomegranates). Grapes have a high content of sugar (15–25%), vitamins, and minerals (*Hajnalová 2001*, 64), which probably explains their popularity with the first farmers once the species was domesticated. In addition to fresh fruit, grapevine is also the source for highly storable raisins, grape juice and, naturally, the traditional product – wine. From a botanical perspective, two subspecies of *Vitis vinifera* are usually distinguished: *Vitis vinifera subsp. vinifera* (cultivated grape) and *Vitis vinifera subsp. sylvestris* (wild grape). They are often referred to in the literature

https://doi.org/10.35686/AR.2024.245

as *Vitis vinifera* (for cultivated grapevine) and *Vitis sylvestris* (for wild grapevine) and we will also adhere to these names and their use in this article. The specific genes of the wild form of grapevine are found in the genotypes of the current cultivated forms of *Vitis vinifera subsp. vinifera*, where they were inherited during the domestication process from *Vitis vinifera subsp. sylvestris* (C. C. Gmelin). Before establishing a vineyard, the land must be prepared for up to two years. The first harvest can be expected after three years, but better results are usually achieved only after five years of growth. During this entire period, intensive care must be given to the vineyard, including demanding tasks such as ploughing, pruning, tying, fertilising, and watering. Vineyard locations on sunny southern slopes are preferred, while unsuitable habitats include northern slopes, shallow soils with insufficient nutrients, areas with high water tables, farmyards (contaminated by chicken droppings) and manure pits.

Vitis vinifera sensu stricto (*s.s.*), known as grapevine, is a cultivated form of grapevine and is closely related to wild grapevine, *Vitis sylvestris sensu stricto*, which occurs in various forms in many parts of Europe. Spontaneous crossbreds between the two species are fertile (*Webb 1968*). Today, wild grapevine is spread between the 38th parallel north and the 49th parallel north (*Arnold et al. 2017*, 1).

In the natural world, wild grapevine is found from the coast of the Atlantic Ocean through Southern Europe, the Black and Caspian Sea regions to the western Himalayas and Tajikistan. It stretches all the way to Central Europe along the Danube and Rhine rivers (*Hajnalová 2001*, 65). The wild grapevine, morphologically and genetically very similar to the cultivated form, is not currently found in the Czech Republic (*Maděra – Martinková 2002*, 484), but in Slovakia its occurrence has been proven in the Danube and Nitra River regions (*Látková et al. 2019*). Wild grapevine was identified in the territory of Slovakia in 2018 on the basis of morphological and ampelographic characteristics; a total of 325 individuals were found at 13 sites in the Morava, Hron, Ipeľ, Váh, Laborec, and Latorica river basins (*Pospíšilová – Šimora 2019*). In some cases, grape cultivars can spread from controlled habitats, and reverted individuals can be mistaken for wild forms. Factors that can affect the spread include pip dispersal by animals, the influence of wind or situations in which vineyards are left untended and vines spread uncontrollably (*Zecca et al. 2010*, 558). The transformation of grapes into an alcoholic beverage – wine – is an extremely complex process requiring a variety of skills depending on whether the wine is made from imported grapes, produced locally from gathered wild grapes, or from grapes that are cultivated locally. This may be influenced by the economic and social requirements of a given community, or may itself influence these factors. According to archaeological evidence, local cultivation and wine production appear to be related to agricultural specialisation and a higher level of social organisation. However, it is important to first determine whether the fossilised archaeological material comes from wild or domesticated plants, and whether there is archaeological evidence suggesting local cultivation of some of these forms. The fruit of wild grapevine is typically more acidic than that of its cultivated relative, *Vitis vinifera*. Nevertheless, wild grapes are suitable for human consumption and can be used to make wine, albeit of lower quality. Archaeobotanical finds make clear that the fruits of wild grape vine were collected long before its domestication (*Renfrew 1973*, 73).

In this context, recent archaeological excavations in Greece (*Valamoti et al. 2020*; *Pagnoux et al. 2021*) are important sources of information. These discoveries provided hard archaeobotanical data that proved to be important in discussing the contribution of

local wild forms of grapevine to the process of domestication outside the primary domestication area, i.e. 'parallel domestication'. It is also important to note that cultivated forms of grapevine are not necessary for making wine; this previously held belief was disproved long ago by finds from the Dikili Tash site in northern Greece (*Valamoti 2015*; *Valamoti et al. 2015*; *Miller 2008*). Finds of grape pips from Dikili Tash are the earliest evidence of the use of grape juice or wine in the eastern Mediterranean during the Neolithic period (second half of the 5th millennium BC).

Various methodological and scientific approaches are used in an attempt to answer questions concerning the origin, character, and possibility of grape cultivation. In older literature, it is generally held that the culture of drinking wine and growing grapes reached the territory of Central Europe under the influence of the Roman Empire (*Kolník 1971*, 519; *Beranová 2000*, 106) because in the first four centuries AD the borders of the Roman Empire were in close proximity to the territory of Slovakia and the Czech Republic. Ancient written sources support this notion, as in 276–282 AD, Roman Emperor Probus issued a decree to plant vineyards in the Roman transalpine colonies, primarily in Austria (*Kraus 2009*, 45). Evidence of wine consumption (especially drinking sets) and dining in the Roman style among the Germanic ruling class is more indicative of the cultural influence of the Roman Empire and Romanisation than the cultivation of grapes itself (*Krekovič 2000*, 48). Similarly, archaeobotanical finds of grape pips from Roman sites seem to suggest the importation or trade of wine as a finished product (*Hajnalová 2001*, 66).

The discovery of evidence of the presence of grapevine in the territory of today's Czech Republic and Slovakia begins in the Early Middle Ages and increases in intensity (*Hajnalová 2001*, 66). The beginnings of viticulture were apparently influenced by the church and Christianisation, as wine was associated with Eucharistic symbols (*Beranová 2000*, 106; *Meduna 2017*). *Meduna* (*2017*, 15) assumes that during the 9th century AD the cultivation of grapevine and the production of wine spread to the region of Bohemia from the southeast, specifically from the Danube Region. The process took place during the period in which Bohemia came under the political influence of the Great Moravian Empire and the Přemyslid ruling dynasty adopted Christianity. At this time, the cultivation of grapes was not primarily economic but more for liturgical purposes. Naturally, it is not ruled out that fruit, juice, or wine were also consumed outside liturgical acts. In the Early and High Middle Ages, grapevine cultivation was associated with the nobility, monasteries, and wealthy burghers from royal cities (*Frolec 1973*). King Charles IV played a significant role in the expansion of viticulture and on 16 February 1358 issued a decree to establish vineyards for Prague and its surroundings (*Kraus 2009*, 83). With a second decree on 12 May 1358, he extended the validity of his original decree to the entire territory and to all clergy and lay persons (*Kraus 2009*, 84). In the 17th and 18th centuries, even ordinary people in the countryside were involved in viticulture (*Frolec 1973*). An interesting discussion in this area is provided by *Tomková* (*2021*), who analyses the relationship between archaeobotanical finds of grapevine and historical sources regarding the establishment of vineyards and wine production. A stark disparity becomes apparent when these two datasets are compared. A considerable number of vineyards are documented in written sources for the period of the Early Middle Ages, but archaeobotanical finds of grapevine are recorded at only a relatively small number of archaeological sites. Only finds from the historic centre of Prague deviate from the described trend (*Tomková 2021*, 322).

'Vineyard knives' are closely related to the issue of the history of grapevine cultivation and viticulture. In the archaeological literature, these finds are often considered evidence of grapevine cultivation (*Měřínský 1972*; *Tejral 2002*; *Beranová – Kubačák 2010*, 136). However, the occurrence of these knives is relatively rare in the Czech and Slovak environments (*Borzová 2005*, 51–52; *Turčan 2012*, 54), and their function is also discussed (*Borzová – Pažinová 2010*). This artefact can be considered multifunctional and could have been used to cut willow twigs, to gather tree shoots and leaves for fodder, but also to prune grapevines (*Borzová – Pažinová 2010*, 182). Therefore, it is not possible to directly connect finds of these knives with the cultivation of grapevine. Evidence of local grapevine cultivation takes the form of a greater concentration of pips, pomace, rachises (evidence of grapevine processing) and conserved wood (carbonised or waterlogged), which indicate the presence of whole plants, not just fruits, which could have been imported (*Hlavatá 2015*).

The oldest archaeobotanical evidence of grapevine in the Czech-Slovak area comes from the Eneolithic site in Hlinsko near Lipník, where the finds were identified by morphometry as *Vitis sylvestris* (*Opravil 1977*, 363; *1985*). Dated to the period of the Maďarovce culture (Early Bronze Age in Slovakia), one grape pip was found at the Trnava-Modranka site and determined as probably *Vitis vinifera* (*Hajnalová 2012*, 86). However, these finds are rare in the region and therefore their dating is questionable without the absolute dating of specific finds.

At the turn of the Bronze Age and the Iron Age, Central Europe was on the outskirts of ancient Mediterranean cultures. The western Hallstatt sphere became a key node for trade with commodities such as wine, bronze, ceramic vessels, and exotic objects. In this period, wine flagons imported from Etruria appear in princely graves as early as the 6th century BC, and from the 5th century they formed a fundamental element in Hallstatt culture. The components of drinking sets (flagons, sieves, ladles, kraters, situlae and others) were used for the consumption of wine in their native northern Italy (*Rebay-Salisbury 2003*). However, pollen and chemical analyses of these finds in Central Europe demonstrate that most of these vessels contained mead, not wine (e.g., Hochdorf: *Stika 1999*; Glauberg: *Rösch 2002*). Only a bronze bottle from a grave in Dürrnberg was shown to have contained spiced wine, which was probably of southern European origin (*Stöllner 1993*; *2002*).

Archaeobotanical finds of grapevine from the Iron Age in Central Europe come from the sites of Stillfried an der March, dated to 992–810 BC (*Köhler-Schneider 2001*, 147–149; *Köhler-Schneider 2003*), Zagersdorf (*Rebay-Salisbury 2002*), and Nußdorf (*Facsar – Jerem 1985*). Finds from Slovakia and from Bohemia and Moravia are missing, with the exception of one find from South Bohemia, specifically from the Zahrádka site (*Šálková et al. 2015*). The occurrence of grape pips in this region began sporadically only in the later Roman Period – Bratislava, Rusovce – Tehelný hon, Nitra, Veľký Cetín, Iža-Leányvár (*Hajnalová 2001*, 66), Zohor, Hurbanovo (*Krčová 2016*) and Stillfried (*Köhler-Schneider 2001*, 147–149; *Köhler-Schneider 2003*).

Grapevine also appears sporadically in archaeobotanical finds from the period from the 6th to the 12th century AD: Nitra (3 sites), Bratislava (2 sites), Mužla-Čenkov (*Hajnalová 2001*, 66), Lovosice (*Čulíková 2008*, 67), Břeclav-Pohansko (*Opravil 1985*, 46–74), Žatec, Ledčice, Libice, Olomouc, Prague (Foundry Yard, Lesser Quarter, Hartig Palace), Přerov, Ústí nad Labem (*Čech et al. 2013*, 26), Mělník (*Bernardová et al. 2010*), Statenice (*Komárková 2005*), unpublished find from Dolánek – Rubín hillfort (*Tomková 2021*). In terms of the occurrence of grape pips, Mikulčice-Valy is an exceptional place among

medieval sites (*Látková et al. 2019*). An extensive assemblage of grape pips – nearly 2,000 finds – was found at this Great Moravian site. The pips come from almost all the investigated parts of the agglomeration and are documented in all states of conservation (*Opravil 1972*; *2000*; *2003*; *Látková 2017*). The legitimacy of this dating is also confirmed by absolute dating of pips retrieved from the defunct riverbed that surrounded the stronghold (*Barta et al. 2014*, 121).

From the 13th century AD, when the cultivation of grapevine became an important economic factor, it is possible to observe a substantial increase in the number of archaeobotanical finds, including pips, rachises, but also pomace. According to *Hajnalová* (*2001*, 67), there are roughly 42 sites with high medieval settlement in Slovakia where these finds are known. Approximately 30 sites are listed from the Czech Republic (*ArboDat database*; *Pokorná et al. 2011*).[1] From this period, we have in particular extensive collections of plant macro-remains from waste pits situated within medieval plots of urban areas (*Rzehak 1909*; *Fietz 1941*; *Kočár et al. 2014*). In addition to archaeobotanical finds, we can also assume the cultivation of grapevine near the royal cities based on extensive written sources (*Dřímal 1965*). However, the only indisputable evidence that confirms the cultivation and processing of grapevine directly on high medieval plots in royal cities is the mass discovery of 67,000 grape pips together with stalks in Brno at the Pekařská Street site (*Kočár et al. 2014*, 143).

The breeding process of grapevine produced many clones that differ from each other in various phenotypic qualities, but also in the overall shape of the pips. For this reason, it is very challenging to identify different grape varieties using archaeobotanical material (*Terral et al. 2010*). Grape pips retain their characteristic shape well, which is recognisable even when the pip shells are heavily damaged. Therefore, some archaeobotanists (*Stummer 1911*; *Mangafa – Kotsakis 1996*; *Terral et al. 2010*; *Bouby et al. 2013*; *Pagnoux et al. 2015*) try to demonstrate and characterise the biodiversity of the genus *Vitis* L. using various, primarily mathematical, methods. The traditional morphometric approach (*Stummer 1911*; *Mangafa – Kotsakis 1996*) tried to differentiate the pips of cultivated and wild grapes. These methods allow distinction based on the measurement of different parts of the pips and the calculation of indices from the measured values. Yet, these methods are often criticised due to morphological changes on the pips during carbonisation and a demonstrated lack of ability to distinguish cultivated cultivars from wild grape vine species (*Logothetis 1970*; *1974*; *Bouby et al. 2013*, 2).

Grape pips were also in the centre of interest of Czecho-Slovak archaeobotanists. *Hajnalová* (*1989*) tried to identify 14 basic morphological groups based on 10 measured features based on an extensive collection from various phases of the settlement of Bratislava in the High Middle Ages (*Hajnalová 1989*, 175). In the Czech environment, *Opravil* (*1963*; *1965*; *1977*; *1980*; *1985*) devoted himself to a more detailed evaluation of grape pips. This author also applied the morphometric approach to archaeobotanical finds from Czech sites (*Opravil 1972*; *1977*; *2000*). Opravil is the only Czech archaeobotanist who critically used the morphometric approach and was able to define the differences between grape pips. He attributed the differences in pip shape to differences in their origin/species (*Vitis vinifera*

[1] There will probably be more sites, given the updated data from the ArboDat database.

versus *Vitis sylvestris*). In the large collection of pips from the Great Moravian site of Mikulčice-Valy (n = 1512), which he collected over roughly 40 years of archaeological and archaeobotanical research, Opravil identified up to 49% of the total number of finds as *Vitis sylvestris* (*Opravil 2000*, 353).

The aim of this study is to discuss the issue of grapevine from the perspective of economy and ecology in individual historical periods. Viticulture was an important part of agriculture and produced a number of commodities such as wine, fresh fruit, grape juice, and raisins, important products for many historical peoples and archaeological cultures. As such, the demanding cultivation of grapevine proves the economic character of the agriculture of the given communities. The second aspect is the ecological nature of wild grapevine, which grows naturally in periodically flooded riparian forests with a humid climate in warmer regions. Therefore, it is not ruled out that wild grapevine occurs in archaeobotanical assemblages from certain regions of Moravia and Slovakia, taking into account its ecological requirements (*Hajnalová 2001*, 65). Considering the factors above, it is clear that for the archaeobotanical research in the Czech Republic and Slovakia, it is very important to define precisely whether archaeobotanical finds of grape pips represent evidence of cultivated fruit or are wild species in nature. It is also necessary to establish their mutual relationship at specific archaeological sites and in different time periods.

Methodology and material

In the field of archaeobotany, there are many methodologies that try to determine whether the find is a cultivated variety or a wild species based on the measurement of individual parts of the pip (e.g. length, width, etc.) and its dimensions (*Stummer 1911*; *Mangafa – Kotsakis 1996*). As part of this study, metric methods were used to identify the finds, which make it possible to distinguish wild from cultivated forms based on the measurement of several parameters of the pips and the calculation of indices (*Hajnalová et al. 2023*). Two morphometric methods were applied on the archaeobotanical finds from all the investigated archaeological sites (*Online Supplementary Material 1*) and also on the recent pips of wild grapevine (*Stummer 1911*; *Mangafa – Kotsakis 1996*). The overall length of the pip (L), the length of the stalk (LS), the distance from the base of the chalaza to the tip of the stalk (PCH) and width were measured (B; *Fig. 1*).

The first method that distinguishes cultivated and wild forms of grape vine is based on the ratio of width to length (B:L*100) of the pip (*Stummer 1911*). Pips with a ‘Stummer index’ value in the range of 76–83 can be considered wild grapevine (*Vitis vinifera subsp. sylvestris*), while values in the interval 44–53 indicate cultivated forms (*Vitis vinifera subsp. vinifera*). The application of this method on carbonised material is heavily criticised (*Logothetis 1970*; *1974*; *Smith – Jones 1990*; *Terral et al. 2010*; *Bouby et al. 2013*; *Pagnoux et al. 2015*).

The authors of the second method (*Mangafa – Kotsakis 1996*, 414) created four formulas that use all the aforementioned dimensions, which eliminates the deviation caused by carbonisation and is therefore also suitable for material conserved in this manner. This method works on a similar principle to the previous one, i.e. based on the calculation of the equation and the index obtained, which can be classified into one of the four groups created by the authors, thus classifying each find of grapevine pip.

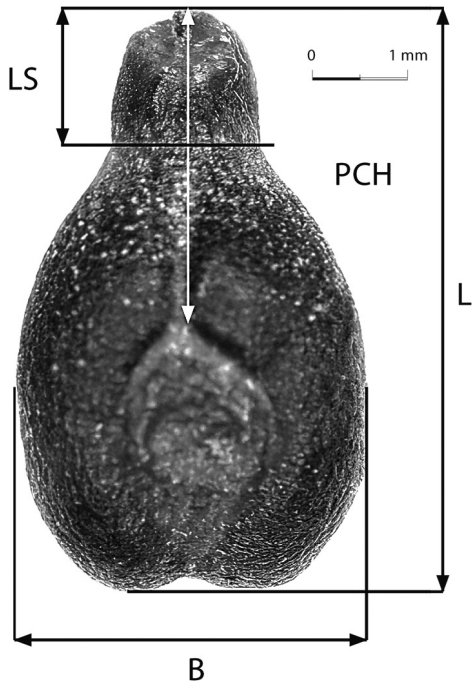


Fig. 1. Grape pip and dimensions measured on the dorsal side. L – overall length; LS – stalk length; PCH – location of chalaza; B – overall width (after *Mangafa – Kotsakis 1996*).

Statistical analyses

The character of grape pips was investigated here using the method of multivariate statistics, specifically detrended correspondence analysis (DCA) and two-step discriminant analysis in the CANOCCO software (*ter Braak 1996*). Various ratios of four dimensions were included in the analysis–pip length (L), pip width (B), the length of the stalk (LS), and the distance of the upper/lower part of the chalaza (PCH).

Archaeobotanical material

The material that was evaluated in this study comes both from earlier excavations processed by E. Opravil and E. Hajnalová, and from current excavations of various sites, which were analysed by M. Látková, M. Hajnalová, J. Hlavatá, and J. Mihályiová. The collected material represents a relatively rich spectrum of archaeological structures in which the pips were found (wells, defunct river beds, waste pits, manure pits, graves, pits of various types, residential features, etc.).

Recent material

The pips of wild grapevine were obtained from living plants at four locations in Slovakia. The pips were collected in September 2015 and flowers in May 2016 in the cadastres of Mužla and in the Veľký les Nature Reservation situated in the cadastre of Úľany nad Žitavou in Slovakia (*Látková et al. 2019*). Herbarium specimens are stored in the herbarium of the Slovak University of Agriculture and in the collection of Eva Hajnalová.

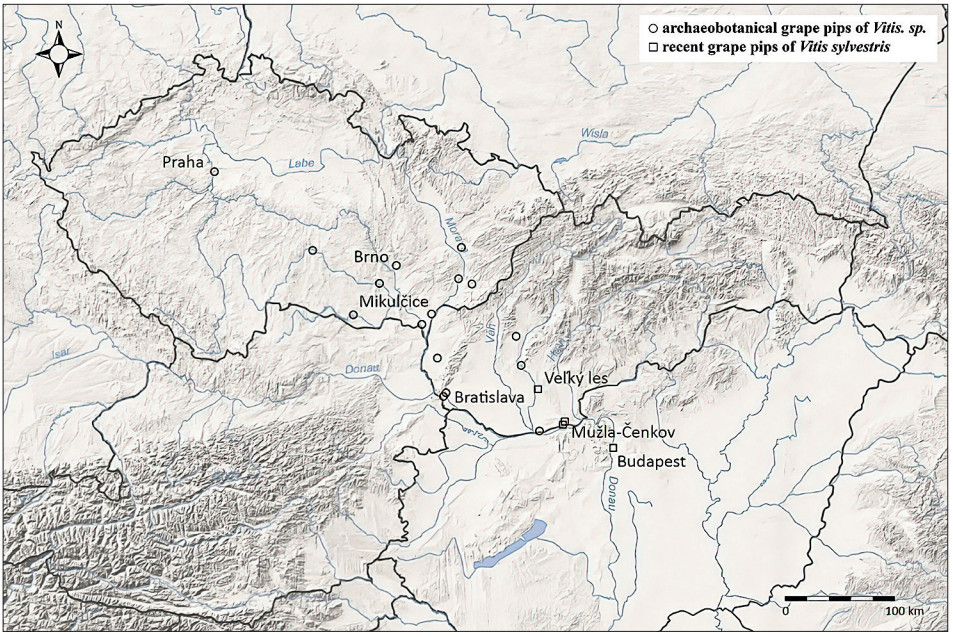


Fig. 2. Map of archaeological sites and places of recent wild grapevine (*Vitis sylvestris s.s.*) occurrence from which grape pips were examined.

Results

Twenty-eight archaeological sites with finds of grape pips in Bohemia, Moravia, and south-western Slovakia were included in the analysis (*Fig. 2*).[2] In most cases, these are standard archaeological sites where plant macro-remains represent waste or by-products of the processing of various crops, i.e. common settlement waste. From a spatial perspective, the dataset includes sites where grapevine cultivation does not have a long history due to unsuitable environmental conditions (e.g. Jihlava, Hulín). Sites dated from the 13th to the 15th century AD were the most numerous, i.e. 16 sites (Prague – Jungmann Square, Týn Courtyard, Ungelt Theatre; Jihlava – Masaryk Square, Brno – Goat Market, Mečová Street, Veselá Street; Uherský Brod – People's House, Soukenická Street, Uherské Hradiště – Hradební Street, Bratislava – Klariská Street, Primacial Square, Jirásek Street, Nálepková Street, Zámočnícka Street, Bridge of the National Uprising). Finds dated to the 16th and 19th century are represented by five sites (Ivančice, Hulín-Nivky, Uherský Brod, Bratislava – Kapitulská and Panenská Street), and finds from the 8th to 9th century AD are also represented by five sites (Mikulčice-Valy, Břeclav-Pohansko, Znojmo – St Hypolite hill-fort, Bojná-Valy I, Malacky-Vinohrádok). Grape pips dated to Roman times come from two sites (Rusovce – Tehelný Hon and Iža-Leányvár). The number of pips at individual

[2] The map does not express the overall state of occurrence of grape pip finds in the territory of Bohemia, Moravia and Slovakia, but documents the sites from which the material evaluated in this study was acquired.

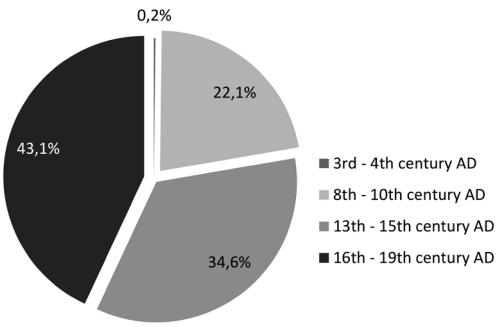


Fig. 3. Representation of grape pips in the dataset according to their chronology (in centuries).

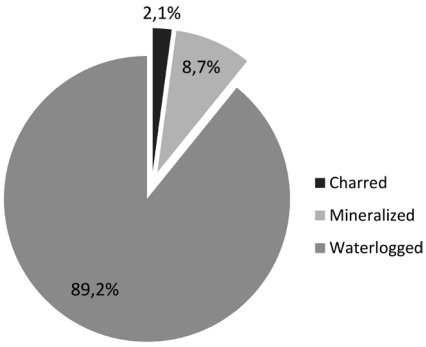


Fig. 4. Representation of grape pips according to the state of conservation.

sites varies significantly. In terms of the number of pips that were suitable for measurement, the largest collections were documented in Mikulčice-Valy (208 finds from the 9th century AD measured) and Ivančice near Brno (143 finds from the 16th–17th century AD measured).

Similar to the number of sites, the number of grape pips analysed is dominated by finds dating from the 13th to the 15th century AD, with a total of 475 finds from this period being examined. A total of 360 well-conserved pips from the period of the 16th to the 19th century AD were measured and evaluated. While 239 pips from the Great Moravian period were analysed, the majority of finds with this dating come from Mikulčice (*Fig. 3*). In terms of percentage, the pips from Mikulčice make up 87% of all Great Moravian finds.

All three types of plant material preservation (carbonised, mineralised, and waterlogged) are represented in the dataset. The most numerous were grape pips conserved by water (*Fig. 4*), which were found at every investigated site. Pips conserved by mineralisation were documented at nine sites. Pips conserved in this way occurred quite rarely among finds, and only in the case of two sites (Bratislava – Primacial Square and Brno – Mečová Street) were all finds conserved exclusively in this manner. Pips conserved by carbonisation were the least frequent in the evaluated group, and material conserved in this way was documented at only three sites (Mikulčice-Valy, Bojná-Valy I and Rusovce – Tehelný Hon). Mikulčice was the only site out of the entire evaluated collection where all three types of conservation of the examined archaeobotanical material (including grapevine) were documented.

The measured values with regard to their method of conservation show considerable variability. Carbonised and mineralised pips can be considered the ‘smallest’ (*Tab. 1*). It is clear from the literature and from archaeobotanical experiments that these types of conservation generally affect a change in size and shape of plant pips and their dispersion (*Smith – Jones 1990*; *Boardman – Jones 1990*). The material conserved in this way has dimensions similar to the measured pips of recent wild grapevine (*Vitis sylvestris s.s.*; cf. the table). The median of the stalk length is the closest to the dimensions of the wild grapevine stalk. However, the other observed dimensions (total length, width, and location of the chalaza) in carbonised and mineralised pips are similar to those of fully grown wild grapevine.

Charred	L	LS	PCH	B
Min	2.66	0.47	1.59	1.85
Median	5	1.15	2.43	2.8
Mode	5.8	1.5	3.5	3
Max	6.1	2	3.5	3.9
Mineralised	**L**	**LS**	**PCH**	**B**
Min	3.77	0.5	1.78	2.48
Median	4.91	0.95	2.51	3
Mode	5.79	0.86	2.29	2.58
Max	5.94	1.52	3.27	4.26
Waterlogged	**L**	**LS**	**PCH**	**B**
Min	3.15	0.39	0.82	1.62
Median	5.41	1.39	3	3.29
Mode	5.74	1.38	2.92	3.24
Max	7.74	2.68	4.95	5.26
Recent VS	**L**	**LS**	**PCH**	**B**
Min	3.63	0.39	1.68	2.52
Median	5.21	1.05	2.65	3.48
Mode	5.44	1.21	2.88	3.33
Max	6.41	1.86	4.63	4.38

Tab. 1. Basic characteristics of input data used in the following analyses with regard to the method of conservation. Key: same as *Fig. 1*.

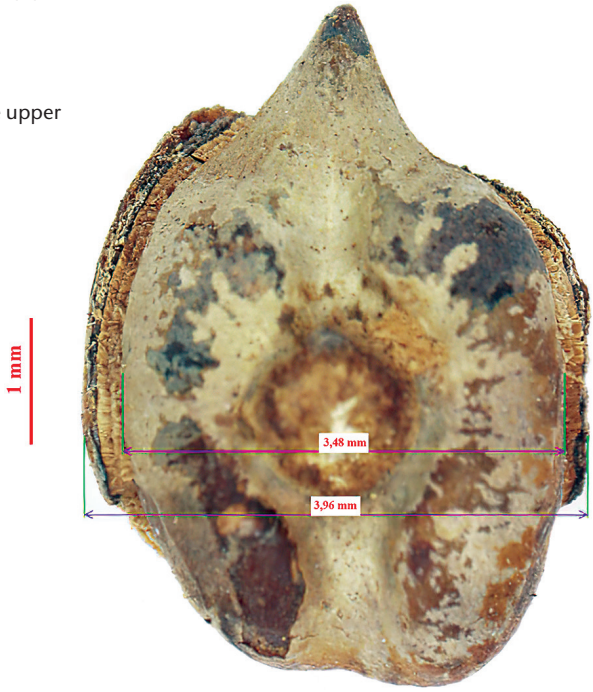
Compared to the other material conserved in another way, the waterlogged pips appeared to be the 'largest' based on the measurements. These finds differed the most from the recent material not only in mean values, but also in maximum and minimum values. Notably, the waterlogged pips collected in this study can be considered smaller with relatively long stalks compared to the recent material, which is also a trait of cultivars.

Although waterlogged material appears to be the most suitable for morphometric analysis, under certain circumstances this conservation process can significantly distort the original shape of the pips. Plant macro-remains are most frequently (but also best) conserved in waste pits from the High Middle Ages (*Rzehak 1909*; *Fietz 1941*; *Kočár et al. 2014*). Waste pits are closed features of a faecal-waste character with specific physical-chemical environmental conditions that preserve plant macro-residues. Although grape pips are well-conserved in various types of sediments due to their hard sclerenchymatous tissues, their shells can corrode under certain circumstances. The epidermis of grape pips consists of four layers that have a different thickness depending on the specific part of the pip (*Fig. 5*). Empirical observations of archaeobotanical material damaged in this way show that it is usually the thickest on the stalk (*Fig. 6*). An example illustrating the width of the pip with the casings and the width of only the sclerenchymatous tissue comes from a waste pit in Bratislava – Zámočnicka Street (15th–16th century AD). The difference in width between the two measurements is 0.48 mm, and there is also a gradual increase towards the stalk. Such a large difference in measurements could result in misinterpretation in the morphometric approach in grape pip analysis, with the cultivated cultivars being considered wild grapevine. Morphometric methods cannot be applied to pips affected by shell corrosion due to the relatively large deviations from the original size. Pips that were damaged in this manner were excluded from further analyses.

It became clear during the initial evaluation of the collected material that there are significant differences in the shape and size of the grape pips between the individual sites.

Fig. 5. Detail of damaged shell of grape pip.

Fig. 6. Damaged grape pip missing the upper layer of shell in several places.



These differences were observed not only between archaeobotanical and recent material, but also between finds from archaeological sites from different time horizons. By analysing the basic dimensions of the pips using multivariate statistics, it was possible to search for trends, dependencies, and the arrangement of data in a relatively robust set. All wild

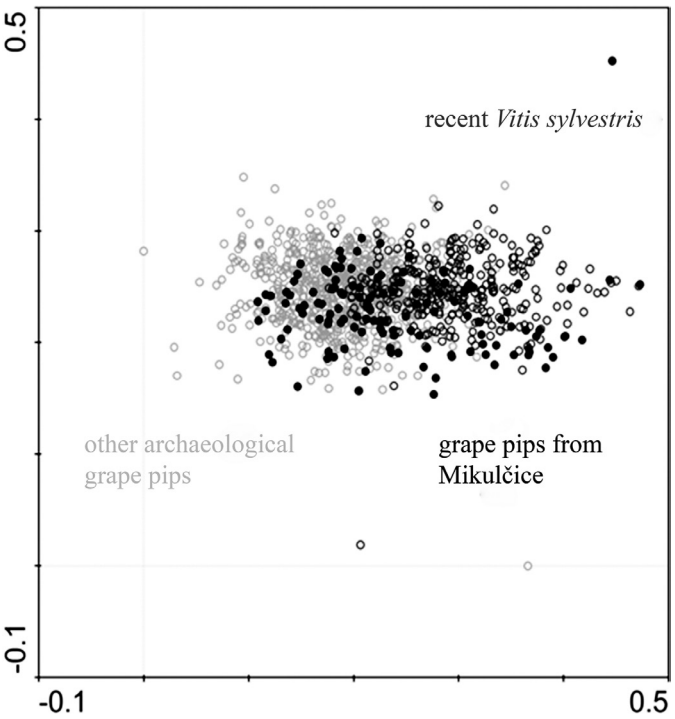


Fig. 7. DAC analysis. Relationship between archaeobotanical grape pips and recent wild grape pips and based on dimensions.

grape pips and finds from archaeological sites were kept in the examined matrix. Their basic dimensions (mean length, length, chalaza diameter and width) were determined as variables. The resulting analysis was subsequently classified according to a factor that could have a major influence on the classification of the samples.

The evaluated finds are classified according to their origin. The graphic visualisation shows that the samples are arranged according to dominant morphological characteristics, with each group being dominated by another. This factor is crucial in arranging the samples in the DCA analysis. Despite the fact that all samples represent one cluster, it is possible to observe trends that indicate significant differences between individual sites. It is clear that there are significant differences in the dimensions and morphology between archaeobotanical finds and recent pips (*Fig. 7*). A distinctive group of finds is the Mikulčice grape pips, which are equally represented both in the group of other archaeobotanical finds and among recent wild grape pips. Although the analysed material seems to form a homogeneous group, it is clear that the individual groups differ from each other, and therefore these groups were compared with each other in further analyses.

Measurement dispersion (box plot)

The basic distinguishing criterion of grape pips for cultivars and wild grapevine is that cultivated grape pip finds should be longer, more elongated, and with a long stalk (beak). Box plots were used to compare and assess the obtained measurements of different parts of the pips. The goal was to evaluate the entire dataset, identify outliers, assess the sym-

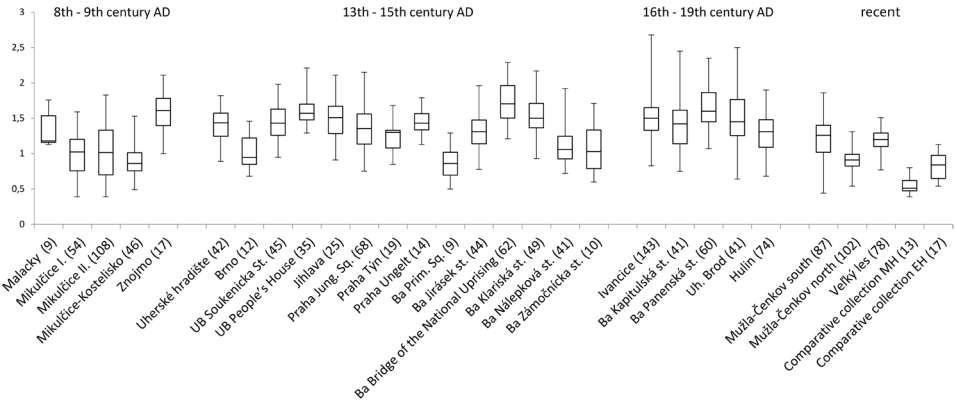


Fig. 8. Histogram of the dispersion of stalk length (LS) of grape pips. The number in parentheses represents the absolute number of finds from the analysed site. Key: VV – *Vitis vinifera*; cf. VV – probably *Vitis vinifera*; VS – *Vitis sylvestris*; cf. VS – probably *Vitis sylvestris*.

metry of the data distribution, and compare the variances of the values at the sites. The basic dimensions were obtained according to the basic method of measuring grape pips (*Bouby et al. 2013*, 6, fig. 2).

During the evaluation, the data were arranged chronologically and divided into four groups. The group of 'oldest' finds is represented by sites dated from the 8th to the mid-10th century AD, while the second group consists of sites dated from the 13th to the 15th century AD. The following group is composed of finds that are dated from the 16th century to the middle of the 19th century AD. The last group is composed of recent grape pips identified as *Vitis sylvestris s.s.*[3]

By comparing the dispersion of stalk length from a chronological point of view, it is possible to observe striking differences across the investigated periods (*Fig. 8*).[4] Stalks gradually lengthen over time, which is one of the basic signs of cultivation (*Bouby et al. 2013*, 2). The largest variances are observed at the youngest sites (16th–19th centuries AD), which could indicate the cultivation of a broad spectrum of grape varieties in this period. In this chronological group, the pips also have the longest stalks, which are the closest in size to grapevine varieties cultivated today.

Noteworthy in this context are finds from Znojmo – St Hypolite hillfort, which the archaeological context dates to the period between the 9th century to the first half of the 10th century AD (*Klíma 2011*, 213). However, compared to other contemporary finds, they differ in the length of the stalk. From a morphological point of view, but also on the basis of their state of preservation (the pips were neither carbonised nor mineralised), it is not possible to assume that they were conserved as a result of a high water table. In addition, all the pips had an almost perfectly conserved shell, which is not common in 'dry' types of

[3] The average length of the recent pips of *Vitis vinifera s.s.* is 6.4 to 7 mm and *Vitis sylvestris* s.s. 4 to 6 mm (*Bojňanský – Fargašová 2007*, 429).

[4] The average length of the stalk of pips of *Vitis vinifera s.s.* is 2 mm, of *Vitis sylvestris s.s.* 0.4 mm (*Köhler-Schneider 2001*, 147).

archaeological contexts dated this early. As such, it can be assumed that they are probably not early medieval finds.

The length of the stalk of the recent wild grapevine (*Vitis sylvestris s.s.*) is significantly smaller in the context of the evaluated archaeobotanical finds. However, just like the total length of the pips, it is similar to the finds from Mikulčice (all three studied agglomeration parts). Some sites with a recent occurrence of wild grapevine (Mužla-Čenkov, South and Veľký les location) even have higher values of median stalk length than finds from the early medieval period, a result that can be interpreted as evidence of the more primitive nature of the Mikulčice finds. The Mužla-Čenkov site was situated in a habitat suitable for the occurrence and optimal growth of *Vitis sylvestris s.s.*

Given that it is not clear if the examined archaeobotanical material is a cultivated or wild grapevine, it can be assumed based on the morphological criteria (*Bouby et al. 2013*, 2) that the archaeobotanical material is from different cultivars. A general view of the dispersion of the index sizes makes it clear that the recent wild grapevine shows the aforementioned features characteristic of *Vitis sylvestris s.s.*, which differs from the archaeobotanical finds. However, the differences within the individual chronological stages vary significantly, which is probably caused by the cultivation process, the growing of different varieties at the sites, or habitat conditions.

Over time, the process of grapevine cultivation can be observed on the basis of morphological changes that reflect the variance of measurements at individual sites. Smaller and wider shapes with a short stalk are more characteristic of the earlier period (8th–9th century AD). However, in the following period (13th–15th century AD) there is a noticeable increase in more elongated and slender shapes with a longer stalk. The most recently examined period (16th–19th century AD) is characterised by the high variability of dimensions, where even the largest specimens are found. In terms of size, the finds from this period are most similar to the pips of currently cultivated grapes.

Vitis vinifera and *Vitis sylvestris*

Unfortunately, the traditional approach, i.e. determination based on the morphology, cannot objectively distinguish cultivated forms of grapevine (*Vitis vinifera s.s.*) from wild grapevine (*Vitis sylvestris s.s.*) in the archaeobotanical material. For this reason, morphometric methods were applied to the examined material in an attempt to distinguish cultivars from wild species by calculating indices. It is also important to bear in mind that in the following analyses, it is not possible to understand the determination of grape pips in the *sensu stricto* sense, but rather in the broader sense of the word, as *sensu lato* (*s.l.*).

Stummer method

The first method that distinguishes between cultivated and wild forms of grapevine is based on the ratio of width to length (B:L*100) of the pip (*Stummer 1911*). Calculation of this Stummer index was performed only for waterlogged and undamaged material. The result is surprising (*Fig. 9*). Most of the evaluated finds have an index value that cannot be clearly assigned to either the cultivated or wild form (indifferent). Between 70 and 90% of the pips were labelled using this method. *Vitis sylvestris s.l.* is documented at sites where its occurrence was proven (e.g. Mikulčice-Valy), but also in places where, in terms of its

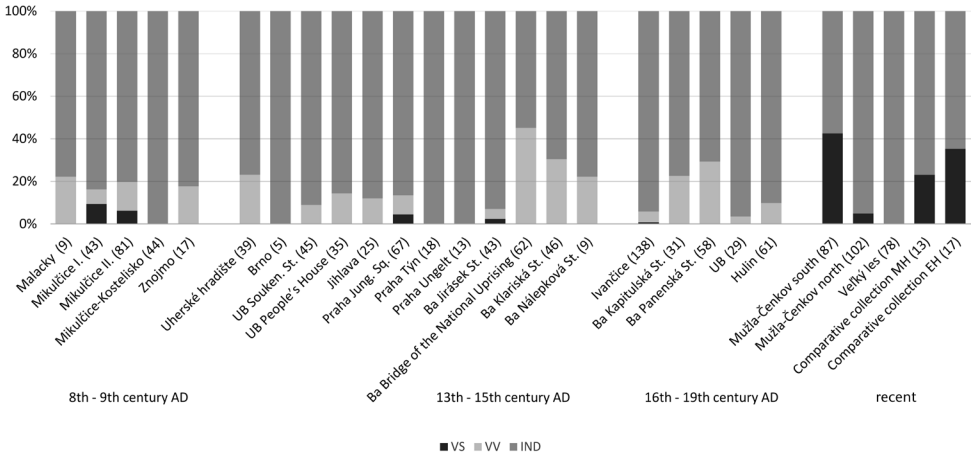


Fig. 9. Interpretation of the character of grape pips according to Stummer's index. The number in parentheses expresses the absolute number of finds from the analysed site. Key: same as *Fig. 8*.

habitat requirements, it probably could not grow (e.g. Prague – Jungmann Square, Bratislava – Jirásek Street). According to this method, wild grapevine (*Vitis sylvestris s.l.*) occurs at archaeological sites only to a limited extent (3–10%), with these pips coming primarily from the oldest studied phases of the Early Middle Ages: Břeclav-Pohansko and Mikulčice-Valy.[5] At the other sites, 5–50% of the pips were identified by this method as cultivated grapevine (*Vitis vinifera s.l.*). At the evaluated sites with a recent occurrence of wild grapevine (*Vitis sylvestris s.s.*), this method also classifies wild grapevine pips (60–90%) as a clear result. Pips that can be characterised as wild grapevine are documented here in a smaller share (4–40%). It is noteworthy that at the sites from which the pips of wild grapevine came, individuals that could be interpreted as cultivated grapevine (*Vitis vinifera s.l.*) were not identified by the Stummer method.

Mangafa–Kotsakis method

The second method of Mangafa–Kotsakis takes into account other measured dimensions (stalk length and distance from stalk to chalaza) and their ratios (*Mangafa – Kotsakis 1996*). The calculation of all indices based on the equations developed by the mentioned authors was calculated only for carbonised, waterlogged, and undamaged material.

The method of *Mangafa* and *Kotsakis* (*1996*) is based on calculating index values by four different formulae, using three basic parameters (L, LS, and PCH) and/or their indexes, and incorporates several constants. Calculated index values of each formula are compared with given thresholds and the pip is classified as wild, probably wild, probably cultivated, or cultivated. Unlike Stummer's method, neither formula uses width (B), as this measurement was thought by the authors to be the most affected by charring.

[5] Unfortunately, not all sites included in the database are presented in graphic form. These sites did not produce enough finds for this form of visualisation as they mostly had just one find (e.g., Bojná-Valy I, Rusovce – Tehelný Hon, Břeclav-Pohansko, Iža-Leányvár, and Nitra-Castle).

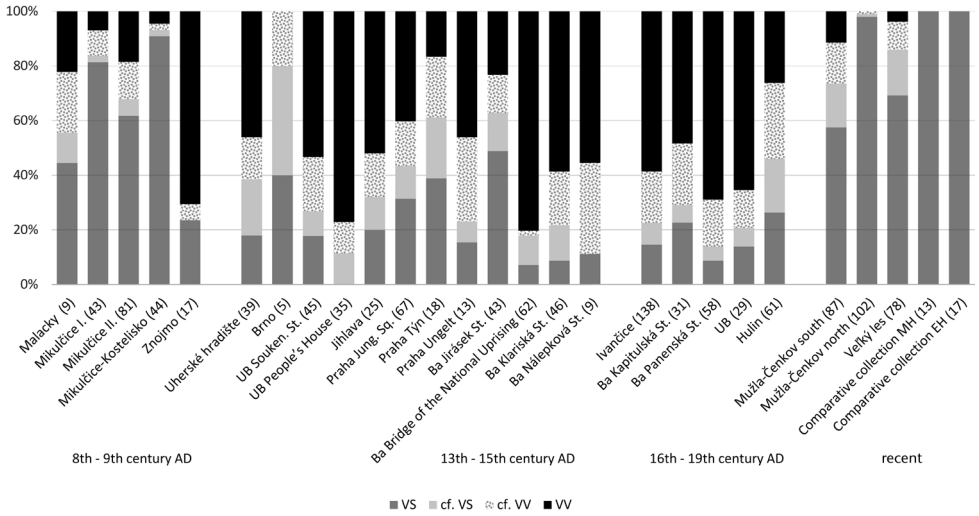


Fig. 10. Interpretation of the character of grape pips according to the Mangafa–Kotsakis method, formula 1. The number in parentheses expresses the absolute number of finds from the analysed site. Key: same as *Fig. 8*.

The authors of the second method (*Mangafa – Kotsakis 1996*) developed four equations:

Formula 1

$-0.3801 + (-30.2 \times LS/L + 0.4564 \times PCH - 1.386 \times L + 2.88 \times PCH/L + 9.4239 \times LS)$

Formula 2

$0.2951 + (-12.64 \times PCH/L - 1.6416 \times L + 4.5131 \times PCH + 9.63 \times LS/L)$

Formula 3

$-7.491 + (1.7715 \times PCH + 0.49 \times PCH/L + 9.56 \times LS/L)$

Formula 4

$0.7509 + (-1.5748 \times L + 5.297 \times PCH - 14.47 \times PCH/L)$

Formula 1: The results of using the first formula demonstrate a different picture of the classification of grape pips than with the Strummer method (*Fig. 10*). The highest occurrence of pips marked as wild grapevine (*Vitis sylvestris s.l.*) is in the earliest observed period of the Early Middle Ages (sites Bojná-Valy I, Malacky-Vinohrádok, and Mikulčice-Valy). Among the sites dated to the Early Middle Ages, similar to the evaluation of the dispersion of measurements (box plots) of pip parts, the finds from Znojmo – St Hypolite hillfort deviate from the period trend. Nearly 80% of the finds from Znojmo were determined to be pips of cultivated grapes (*Vitis vinifera s.l.*); the dominance of cultivated grapes is not documented at any other contemporaneous site. The image provided by the finds from Znojmo is again more characteristic of the later period. According to this method, the occurrence of wild grapevine (*Vitis sylvestris s.l.*) also ranges from 5 to 50% at other later sites. At most of these sites, wild grapevine (*Vitis sylvestris s.s.*) does not occur naturally (e.g., Prague, Jihlava). According to this method, the highest occurrence of wild grapevine (*Vitis sylvestris s.l.*) during the High Middle Ages is recorded at the sites from which material from waste pits comes (Brno, Prague – Jungmann Square, Týn Courtyard, Bratislava –

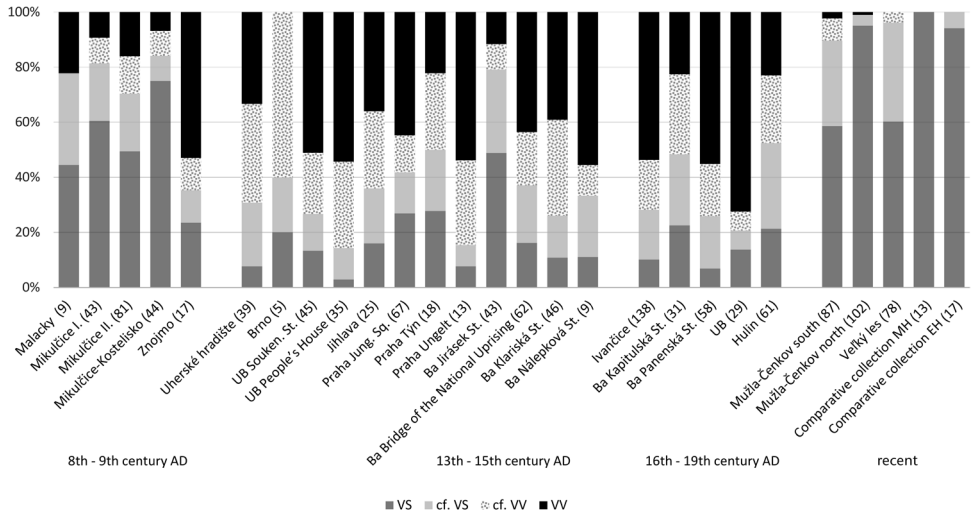


Fig. 11. Interpretation of the character of grape pips according to the Mangafa–Kotsakis method, formula 2. The number in parentheses expresses the absolute number of finds from the analysed site. Key: same as *Fig. 8*.

Jirásek and Kapitulská Street). The change in the size of the plant material can also be related to the physical-chemical environmental conditions in the waste pits.

By comparing pips in terms of chronological development, it is possible to observe an interesting trend, namely an increase in the percentage of pips determined as cultivars (*Vitis vinifera s.l.*) and simultaneously a decrease in pips determined as wild grapevine (*Vitis sylvestris s.l.*). In the earliest studied period (8th–9th century AD), up to 68.6% of the pips were determined by this method to be wild grapevine (*Vitis sylvestris s.l.*), while at sites dated from the 16th to the 19th century AD, only 16.4% of finds are determined in this way. Cultivated grapevine (*Vitis vinifera s.l.*) is most often found in the latest investigated period (16th to 19th centuries AD). Cultivars account for up to 54% in this period, while in the Early Middle Ages, the share of cultivars is only 17.5%.

The pips of recent wild grapes (*Vitis sylvestris s.s.*) evaluated by this method were in nearly the majority of cases correctly classified as wild grapevine. However, there were individuals found at the Mužla-Čenkov, South and Veľký les subsites that were evaluated by this method as cultivated grapevine (*Vitis vinifera s.l.*). Based on this, it can be assumed that even among wild grapes (*Vitis sylvestris s.s.*) there may be pips whose dimensions are similar to those of cultivars (*Vitis vinifera s.s.*).

Formula 2: Using the second formula, which takes into account other variables, the result is similar to the first (*Fig. 11*). Similarly, finds that were identified as wild grapevine (*Vitis sylvestris s.l.*) have a dominant position in the earliest investigated period, while the difference of the pips from Znojmo is also evident. The outlined trend of the increasing share of pips that these methods characterise as evidence of cultivars (*Vitis vinifera s.l.*), is also apparent with this formula. The highest share is reached by pips in the latest observed period (16th to 19th century AD) up to almost half (46.68%), while in the Early Middle Ages it is 16%. Pips identified as wild grapes (*Vitis sylvestris s.l.*) make up the

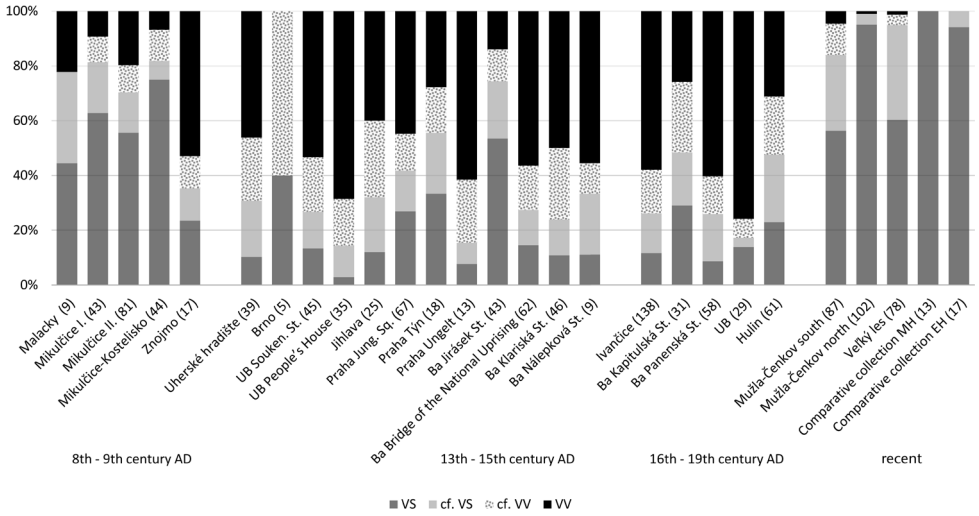


Fig. 12. Interpretation of the character of grape pips according to the Mangafa–Kotsakis method, formula 3. The number in parentheses expresses the absolute number of finds from the analysed site. Key: same as *Fig. 8*.

majority (55.15%) in the Great Moravian period, while in the 16th to 19th century AD, finds identified in this way make up 13.2%. From the perspective of the occurrence of wild or cultivated grapevines, the period of the High Middle Ages (13th to 15th century AD) is more similar to the period of the Late Middle Ages to the modern era. When using this equation, the share of finds that could not be clearly attributed to cultivated or wild grapevine also increases.[6]

In the case of recent pips of wild grapevine (*Vitis sylvestris s.s.*), the result is also similar to the first equation. A significant difference when using this approach is that some pips labelled in the previous analysis as cultivated grapes (*Vitis vinifera s.l.*) were reclassified and identified as probably wild grapevine (cf. *Vitis sylvestris s.l.*).

Formula 3: The use of the third formula yields an image almost identical to the previous analysis performed by formula 2. Relatively few finds were reclassified by this method, having no significant effect on the results (*Fig. 12*).

Formula 4: The results of the fourth formula are significantly different (*Fig. 13*), presumably due to the fact that, unlike the previous equations, measurements of stalk length (LS) are not included in this equation. For this reason, it is clear that the material has the highest incidence of finds that were determined only with a degree of probability (*cf.*). Pips that were determined by this method as *cf. Vitis sylvestris s.l.* have up to 91% probability that they are *Vitis sylvestris s.l.* (*Mangafa – Kotsakis 1996*, 415). With such a high probability, it is clear that even when using this formula, the analysed pips show the same trend as in the previous cases (see Formula 1–3).

[6] Pips with this determination were labelled with the abbreviation *cf.* (*confer*).

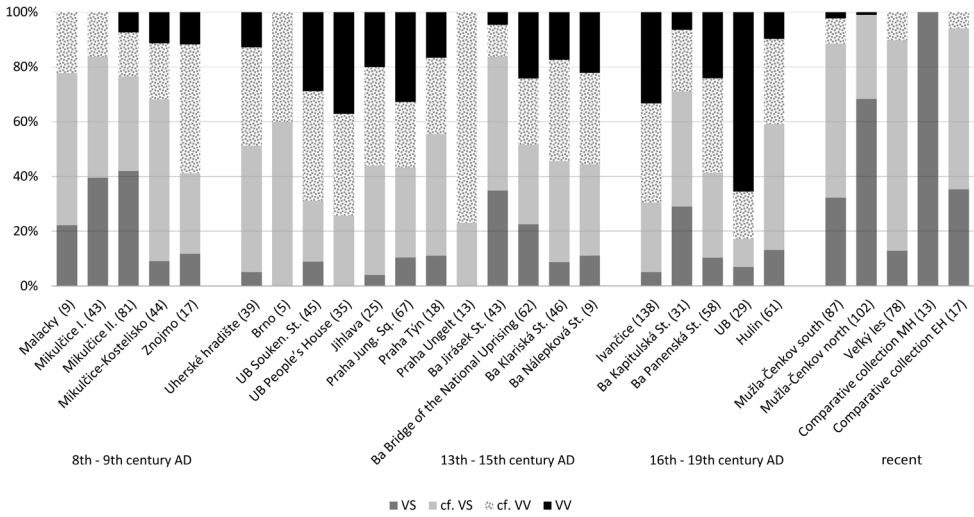


Fig. 13. Interpretation of the character of grape pips according to the Mangafa–Kotsakis method, formula 4. The number in parentheses expresses the absolute number of finds from the analysed site. Key: same as *Fig. 8*.

The obtained results of the morphometric measurement of grape pips indicate that individual specimens were repeatedly reclassified depending on the method or equation used. It is therefore not possible to clearly determine which method most accurately characterises the origin of the pips. This uncertainty was also presented for the wild grapevine finds (*Hajnalová et al. 2023*). Despite the fact that the presented methods have a tendentious character, it is possible to observe certain trends in the archaeological material suggested by morphometric methods.

Discussion

The acquired results can be interpreted mainly from a chronological point of view. The material shows an increasing trend of finds that can be characterised as cultivated (*Vitis vinifera s.l.*) and at the same time a decrease in the share of wild grapevine (*Vitis sylvestris s.l.*). This trend can be observed in each analysis separately and even in the overall interpretation of the pips for each site. The gradual lengthening of the body and stalk of the pip reflects the process of grapevine cultivation and the development of the cultivation of different varieties.

The oldest (and undamaged) find that was evaluated in this study comes from the Iža-Leányvár site (Late Roman Period) and was classified as a cultivated grapevine (*Vitis vinifera s.l.*) by all the applied methods. This lone pip comes from a well (*Hajnalová – Rajtár 2009*, 200) situated in a Roman border military camp. The database also includes another similarly dated pip find classified as wild grapevine and retrieved from the Rusoviec – Tehelný Hon site, which was interpreted as a villa rustica (*Varsík 2020*). It is noteworthy that in the Czech Republic, no finds of grape pips from the Roman Period are available

(*ArboDat database*), which is probably related to the state of research, since grape pip finds from that period also come from a nearby site in Austria–Stillfried (*Köhler-Schneider 2001*, 147–149). The same analyses of finds of grape pips from Roman times were carried out at the mentioned site, and were classified as cultivars (*Vitis vinifera s.l.*). While rare finds from the Roman Period probably do not testify to the local cultivation of wine, as written sources document, they probably indicate trade with this economically important commodity (*Hajnalová 2001*, 66).

In the later part of the Early Middle Ages, grape pips were quite rare at most archaeological sites, as their finds were recorded at only six sites (Nitra-Castle, Břeclav-Pohansko, Mikulčice-Valy, Malacky-Vinohrádok, Bojná-Valy I, and Znojmo – St Hypolite hillfort). However, an analysis was performed on pips from three sites dated to the Early Middle Ages (Mikulčice-Valy, Malacky-Vinohrádok and Znojmo – St Hypolite hillfort). More than half (60%) of the pips from Mikulčice evaluated using morphometric methods were classified as wild grapevine (*Vitis sylvestris s.l.*), while only 11% were determined as cultivars (*Vitis vinifera s.l.*). A similarly high occurrence (44%) of pips characterised as wild grapevine (*Vitis sylvestris s.l.*) was recorded at the Malacky-Vinohrádok site, which was dated to the 8th century AD (*Hajnalová – Elschek 2015*, 155). In the context of evaluating the character of grapevine from early medieval sites, the pip finds from Znojmo are exceptional. The shape, size, and state of conservation of these finds resemble those from later periods (see above).

In the Early Middle Ages, grape pips began to appear more often at archaeological sites, which is probably related to the beginnings of grapevine cultivation in this area linked with gradual Christianisation (*Hajnalová 2001*, 44). As one of the main Eucharistic symbols, wine demonstrates, among other things, the major influence of the church on the beginnings of winemaking. In this period, the cultivation of grapevine was probably not pursued for economic reasons, but wine served primarily for liturgical purposes–for communion under both kinds.

The High Middle Ages and the modern age are characterised by a great increase in the number of grape pips (*Vitis vinifera s.l.*) classified as cultivated. Morphometric methods showed that almost all sites had a high share of these pips (50–75%), for example in Ivančice and Uherský Brod – House of Culture, many of these finds being classified as grapevine cultivars. Nevertheless, some sites had a high share of pips classified as wild grapevine (*Vitis sylvestris s.l.*), which seems to contradict the written sources and laws addressing viticulture in this period (*Frolec 1973*). Viticulture became an important economic factor in the 12th and 13th centuries AD, but until the 17th and 18th centuries the area was dominated by monasteries and wealthy burghers from the royal cities. The peak of viticulture was reached in the 17th century AD during the Thirty Years' War (1618–1648), after which vineyards fell into disrepair and disappeared due to climate change and labour shortages. The renewal of vineyards came only in the 19th century (*Frolec 1973*).

The development outlined by historical sources is reflected to a certain extent, or even illustrated by, archaeobotanical finds of grapevine. On the basis of a detailed assessment of the accuracy of morphometric methods on recent wild grape pips (*Hajnalová et al. 2023*), it is clear that the results of these methods cannot be accepted unequivocally and uncritically. Although the majority of grape pips were correctly classified by all methods, morphometric methods also classified a high share of pips (15–25%) as domesticated forms of grapevine. The analysis shows that wild grapevine in Slovakia produced a higher number

Stummer	Formula 2	Formula 3	Number	% Ratio
VV	VV	VV	6	2.75
IND	VV	VV	17	7.8
VV	IND	IND	5	2.3
VV	IND	VS	2	0.9
VV	VS	VS	5	2.3
IND	IND	VV	2	0.9
IND	IND	VS	4	0.18
IND	VS	VS	116	53.2
VS	VS	VS	21	9.6
IND	IND	IND	40	18.3

Tab. 2. Resulting interpretation of character of archaeobotanical grape pips using the Stummer and Mangafa–Kotsakis methods for the 8th–9th century AD group. Key: VV – *Vitis vinifera*; cf. VV – probably *Vitis vinifera*; VS – *Vitis sylvestris*; cf. VS – probably *Vitis sylvestris*; IND – indifferent.

Stummer	Formula 2	Formula 3	Number	% Ratio
VV	VV	VV	40	9
IND	VV	VV	122	27.5
VV	IND	IND	19	4.3
VV	IND	VS	1	0.2
VV	VS	VS	6	1.35
IND	IND	VV	20	4.5
IND	IND	VS	6	1.35
IND	VS	VS	105	23.64
VS	VS	VS	5	1.1
IND	IND	IND	120	27

Tab. 3. Resulting interpretation of character of archaeobotanical grape pips using the Stummer and Mangafa–Kotsakis methods for the 13th–15th century AD group Key: same as *Tab. 2*.

Stummer	Formula 2	Formula 3	Number	% Ratio
VV	VV	VV	27	7.5
IND	VV	VV	121	33.7
VV	IND	IND	7	1.94
VV	IND	VV	3	0.83
VV	VS	VS	3	0.86
IND	IND	VV	13	3.62
IND	IND	VS	7	1.94
IND	VS	VS	71	19.7
IND	VS	IND	1	0.27
VS	VS	VS	1	0.27
IND	IND	IND	105	29.24

Tab. 4. Resulting interpretation of character of archaeobotanical grape pips using the Stummer and Mangafa–Kotsakis methods for the 16th–19th century AD group. Key: same as *Tab. 2*.

Stummer	Formula 2	Formula 3	Number	% Ratio
VV	VV	VV	27	7.5
IND	VV	VV	121	33.7
VV	IND	IND	7	1.94
VV	IND	VV	3	0.83
VV	VS	VS	3	0.86
IND	IND	VV	13	3.62
IND	IND	VS	7	1.94
IND	VS	VS	71	19.7
IND	VS	IND	1	0.27
VS	VS	VS	1	0.27
IND	IND	IND	105	29.24

Tab. 5. Resulting interpretation of character of recent grape pips (*Vitis sylvestris s.s.*) using the Stummer and Mangafa–Kotsakis methods. Key: same as *Tab. 2*.

of pips with characteristics similar to cultivated forms. On the other hand, in the presence of atypical wild grapevine pips, both methods are prone to classification errors. While morphometric methods significantly help in the determination of pips of the genus *Vitis*, it is necessary to remember that the character, shape and condition of archaeobotanical finds are influenced by a range of factors (genetics, environmental, habitat conditions during growth, method of preservation, context, and diagenetic processes).

It is clear from the results of the analysis that the majority of finds were repeatedly incorrectly classified (*Tab. 2–5*). A detailed assessment of the accuracy of morphometric methods (*Hajnalová et al. 2023*) showed that these approaches have a high rate of misclassification of the pips of recent wild grapevine, which was also identified on the basis of vegetative characteristics as *Vitis sylvestris s.s.* Despite the high error rate, these methods

can be effectively used in the identification of archaeobotanical finds in conjunction with the macroscopic evaluation of specific finds. However, the greatest problem is that in some cases the finds are evaluated by one method as wild grapevine and another as cultivated and *vice versa*. Nevertheless, such cases are quite rare. The results of Stummer's method differ the most from the second and third formulas of Mangafa–Kotsakis. In some cases, however, the results also differ between the individual Mangafa–Kotsakis formulas. For this reason, when evaluating larger sets of grape pips from a specific location, it is appropriate to evaluate the sites as a whole by multiple methods and visual evaluation. In conclusion, for a better understanding of the character and development of grape pips at archaeological sites, it would be appropriate to employ a more comprehensive approach. Of all the possible combinations, the combinations IND/VV/VV, IND/VS/VS and IND/IND/IND occurred most often in archaeobotanical and recent material.

Although the results for the Roman Period are not presented in the text due to the small number of finds (see *Online Supplementary Material 1*), the obtained finds demonstrate that in this period the macro-remains from the Iža-Leányvár and Stillfried sites were mainly classified as IND/VV/VV. The only find from the Rusovce – Tehelný Hon site was classified as IND/VS/VS, which may be related to the proximity of riparian forests in Lower Austria.

Finds from the Znojmo – St Hypolite hillfort were also left out the table for the Early Middle Ages due to serious doubts over their accurate dating (see the text above). Finds from this site are most inclined to IND/VV/VV combinations, but in four cases there were also finds marked as IND/VS/VS.

In the evaluated set, the greatest re-classifications and errors occur in the period from the 16th to the 19th century. The highest number of different classifications based on the morphometric approach are recorded in this time horizon. In each of the observed horizons, combinations of classifications referred to as 'similar' dominate. The number of grape pips that would clearly be classified as cultivated (using the three formulas) is relatively low in all horizons. In the horizon between the 13th and 15th centuries, such pips made up 9%, while they were completely absent in the group of recent finds. On the other hand, finds that would be unequivocally marked as wild clearly dominate among recent pips (14.76%) and their lowest occurrence is in the horizon from the 16th to the 19th century, where such finds make up 0.27%.

The occurrence of a combination in which the finds cannot be clearly classified by any of the possible formulas is relatively high (IND). Finds marked in this way usually form the second most frequent possible combination in all analysed horizons (with a variance from 19.46% to 29.24%). A high share of these finds also appears among recent pips, which can be connected with the limited descriptive scope of Stummer's method unable to classify the majority of all examined finds unambiguously.

Apart from Stummer's method, it is clear that the morphometric Mangafa–Kotsakis method (especially the second and third formulas) was able to classify a relatively high share of finds. However, it correctly classified as wild species up to 59.06% of all recent pips which were also botanically identified as wild grapevine (*Vitis sylvestris s.s.*), but mistakenly classified three specimens as a cultivated form of grapevine. From the assemblage of archaeobotanical finds, relatively large groups of finds were identified as cultivated or wild grapevine forms. The highest occurrence of pips that were classified as wild grapevine is up to 53.2% in the high medieval period, which is the second highest occurrence

after the group of recent finds. In this time horizon, finds classified as a cultivated form of grapevine make up 7.8%, which is, on the other hand, the lowest occurrence in the studied time horizons. In contrast, it is clear that in the period from the 16th to the 19th century, the highest occurrence of finds that were classified as a cultivated form of grapevine (33.7%) and the lowest number of finds labelled as wild grapevine (19.7%) are recorded.

The prevailing opinion in earlier archaeobotanical literature was that the wild grapevine (*Vitis sylvestris s.s.*) was more abundant in the evaluated territory (*Opravil 1965*; *1977*; *1980*; *1997*; *Hajnalová 2001*, 66). The argument that earlier botanists from the last century (*Hegi 1925*) found riparian forests in a 'virgin' state and were able to record plant species that no longer exist there (*Opravil 1977*, 361) has several ambiguities. Archaeobotanical sampling of archaeological sites in the Czech Republic and Slovakia has a relatively long tradition (more than 60 years, the first meeting of the IWGP was held at Kačina Château in 1968), which resulted in extensive assemblages of plant macro-remains of a various nature. If wild grapevine (*Vitis sylvestris s.s.*) were to occur in the territory as a wild species of riparian forests, it would probably be identified at more intensively sampled prehistoric or high medieval sites. The fact that grape pips at some sites (Mikulčice-Valy, Hlinsko near Lipník, Plzeň – Solní Street, Prague – Jungmann Square, Prague – Malá Strana, Olomouc – Školní Street and Opava – 1. Máje Square) were designated as wild grapevine probably points to the sound ability of archaeobotanists to observe and recognise the specific character of certain pips in the material. Institutions that have historical herbarium collections of pips and fruits, as well as vascular plants (Herbarium Collection of Seeds and Fruits at Charles University, Herbarium Collection of Seeds and Fruits of the Institute of Botany of the Czech Academy of Sciences, the Herbarium Collection of the PRA) were approached to obtain comparative material for wild grapevine. Unfortunately, wild grapevine diasporas are not among the items available from the addressed institutions – only cultivated forms.

Conclusion

The paper presented an analysis and interpretation of the origin of grapevine pips from the Early Roman Period to the 19th century AD in the territory of Bohemia, Moravia, and Slovakia. The applied analysis was based on the principles of morphometric methods. A total of 1387 grapevine pips were included in the analysis, the parts of which were measured, and of this number, there were 1,090 archaeobotanical finds and 297 recent pips identified as wild grapevine.

The aim of this study was to determine whether the archaeobotanical finds of grape pips represent evidence of cultivated fruit or wild species. Based on the variance of the measurements and the comparison of the archaeobotanical finds and recent pips of wild grapevine, it is clear that the archaeobotanical material represents a variety of grape cultivars. The dispersion of the measurements of parts of the pips at sites points to a higher variability of sizes in archaeobotanical finds compared to recent wild grapevine.

The results of morphometric analyses of pips (*Stummer 1911*; *Mangafa – Kotsakis 1996*) prove that the highest occurrence of pips labelled as wild grapevine (*Vitis sylvestris s.l.*) was recorded in the Early Middle Ages. Finds from sites dated to this period also show a higher dispersion of pip stalk measurements. However, finds from Znojmo – St Hypolite

hillfort deviate from this trend, which suggests that it might involve contamination of Great Moravian graves. These finds from Znojmo are more characteristic of the later period, and therefore it can be assumed that the grape pips stones arrived there later. One of the possible explanations for how the pips reached Great Moravian graves is the fact that the author of the study also identified the remains of a vineyard from the High Middle Ages stratigraphically above the burial site, from where most of the grape pip finds come. This vineyard has been dated to the 14th century AD based on an associated coin (*Klíma 2001*, 45).

By comparing the grape pips from the perspective of chronological development, a trend can be observed of an increase in the percentage of pips determined according to this method as cultivars (*Vitis vinifera s.l.*) and at the same time a decrease in the number of specimens determined as wild grapevine (*Vitis sylvestris s.l.*). In the period (8th to 9th century AD) wild grapevine (*Vitis sylvestris s.l.*) was dominant among all finds according to this comparison, while at sites dated from the 16th to 19th century AD only a third of the finds are determined. The most commonly cultivated grapevine (*Vitis vinifera s.l.*) is found in the latest investigated period (16th to 19th century AD). At this time, cultivars make up more than half, while in the Early Middle Ages, the share of finds identified in this way is one-third.

The pips of the recent wild grapevine (*Vitis sylvestris s.s.*) evaluated by this method were in most cases correctly classified as wild grapevine. However, at the sites of Mužla-Čenkov, South and Veľký les subsites, there are specimens that the mentioned method evaluated as cultivated grapevine (*Vitis vinifera s.l.*). Based on this, it can be assumed that even among wild grapes (*Vitis sylvestris s.s.*) there may be individuals whose dimensions are similar to those of cultivars (*Vitis vinifera s.s.*).

The applied morphometric methods are based on recent observations of local grapevine in areas where these methods originated. Apparently, this factor also contributed to the existence of several inconsistencies in the examined archaeobotanical material, as the size of the pip changes due to environmental conditions, though not its original shape. Using the overall character of the pip (*Terral et al. 2010*; *Bouby et al. 2013*; *Pagnoux et al. 2015*), in the case of some of the investigated finds, it is possible to consider that it is a cultivated grapevine of a more primitive character or local cultivars.

I would like to thank my colleagues Mária Hajnalová, J. Hlavatá, and J. Mihályiová for providing access to material and other information, as these made a major contribution to the results of this study.

References

Arnold, C. – Bachmann, O. – Schnitzler, A. 2017: Insights into the Vitis complex in the Danube floodplain (Austria). Ecology and Evolution 7, 7796–7806. https://doi.org/10.1002/ece3.3187

Barta, P. – Hajnalová, M. – Látková, M. 2014: Radiocarbon dating of plant macro-remains from river channel at PL 93 in Mikulčice and its implication for reconstruction of sediment deposition processes. In: L. Poláček (ed.), Mikulčice River Archaeology. New Interdisciplinary Research into Bridge No. 1. Internationale Tagungen in Mikulčice X. Brno: Institute of Archaeology of the Academy of Sciences of the Czech Republic, Brno, 113–116.

Beranová, M. 2000: Slované. Praha: Libri.

Beranová, M. – Kubačák, A. 2010: Dějiny zemědělství v Čechách a na Moravě. Praha: Libri.

Bernardová, A. – Novák, J. – Houfková, P. – Meduna, P. 2010: The reconstruction of the Early Medieval vegetation in the Mělník vineyard region, Czech Republic. In: Terra Nostra. Schriften der GeoUnion Alfred-Wegener-Stiftung – 2010/2, 15th International Conference of the International Work Group for Palaeoethnobotany. Programme and Abstracts. Berlin: GeoUnion Alfred-Wegener-Stiftung, 110.

Boardman, S. – Jones, G. 1990: Experiments on the effects of charring on cereal plant components. Journal of Archaeological Science 17, 1–11. https://doi.org/10.1016/0305-4403(90)90012-T

Bojňanský, V. – Fargašová, A. 2007: Atlas of Seeds and Fruits of Central and East-European Flora: the Carpathian Mountains Region. Dordrecht: Springer.

Borzová, Z. 2005: Poľnohospodárske náradia a nástroje v období 6.–12. storočia na území dnešného Slovenska. Nitra: Univerzita Konštatína Filozofa v Nitra. Unpublished PhD thesis.

Borzová, Z. – Pažinová, N. 2010: Vybrané problémy súčasného poľnohospodárstva v Sedmohradsku (prípadová štúdia z obce Bezid). Ethnologia Actualis – Revue pre výskum kultúr etnických spoločenstiev 11, 169–187.

Bouby, L. – Figueiral, I. – Bouchette, A. – Rovira, N. – Ivorra, S. – Lacombe, T. – Pastor, T. – Picq, S. – Marinval, P. – Terral, J. F. 2013: Bioarchaeological insights into the process of domestication of grapevine (*Vitis vinifera* L.) during Roman time in Southern France. PLoS One 8, e63195. https://doi.org/10.1371/journal.pone.0063195

ter Braak, C. J. F. 1996: Unimodal models to relate species to environment. Wageningen: DLO-Agricultural Mathematics Group.

Čech, P. – Kočár, P. – Kozáková, R. – Kočárová, R. 2013: Ekonomika a životní prostředí raně středověké aglomerace v Žatci. Praha: Archeologický ústav AV ČR, Praha.

Čulíková, V. 2008: Rostlinné makrozbytky z pravěkých a raně středověkých antropogenních sedimentů v Lovosicích. Archeologické rozhledy 60, 61–74.

Dřímal, J. 1965: Vinice brněnských měšťanů v Brně a na jižní Moravě do roku 1526. In: Ročenka okresního archivu pro okres Břeclav v Mikulově. Mikulov: Okresní archiv, 17–44.

Facsar, G. – Jerem, E. 1985: Zum urgeschichtlichen Weinbau in Mitteleuropa, Rebkernfunde von Vitis vinifera L. aus der urnenfelder-, hallstatt- und latènezeitlichen Siedlung Sopron-Krautacker. Wissenschaftliche Arbeiten aus dem Burgenland 71, 121–144.

Fietz, A. 1941: Mikroskopische Untersuchung von drei mittelalterlichen Bauopfern aus Brünn. Mitteilungen und Verhandlungen der naturforschenden Vereinigung Brünn 72, 62–70.

Frolec, V. 1973: Vinohradnictví. Kapitoly z dějinného vývoje od minulosti do současnosti na Moravě a v Čechách. Brno: Blok.

Hajnalová, E. 1989: Archeobotanické pramene vinohradníctva na Slovensku. Zborník Filozofickej fakulty Univerzity Komenského – Historica 39–40, 171–176.

Hajnalová, E. 2001: Ovocie a ovocinárstvo v archeobotanických nálezoch na Slovensku. Acta Interdisciplinaria Archaeologica 10. Nitra: Archeologický ústav SAV.

Hajnalová, M. 2012: Archeobotanika doby bronzovej na Slovensku. Štúdie ku klime, prírodnému prostrediu, pol'nohospodárstvu a paleoekonómii. Nitra: Univerzita Konštantína Filozofa.

Hajnalová, M. – Elschek, K. 2015: Ein dendrodatierter Brunnenfud des 8. Jhs. aus Malacky (Westslowakei): Archäobotanische und Archäologische Untersuchungen. In: H. Friesinger – A. Stuppner (eds.), Mensch und Umwelt – Ökoarchäologische probleme in der Frühgeschichte. Wien: Österreichische Akademie der Wissenschaften, 153–172.

Hajnalová, M. – Látková, M. – Kajanová, M. – Eliaš, P. – Ďurišová, L. 2023: Wild or cultivated? a study of *Vitis sylvestris* in natura in Slovakia and implications for archaeology and archaeobotany (morphometric approach). Vegetation History and Archaeobotany 32, 321–337. https://doi.org/10.1007/s00334-023-00909-1

Hajnalová, M. – Rajtár, J. 2009: Supply and subsistence: the Roman fort at Iža. In: W. S. Hanson (ed.), The Army and Frontiers of Rome. Papers offered to David Breeze on the occasion of his sixty-fifth birthday and his retirement from Historic Scotland. Journal of Roman Archaeology Supplementary Series 74. Portsmouth: Journal of Roman Archaeology, 192–207.

Hegi, G. 1925: Illustrierte Flora von Mittel-Europa. München: J. F. Lehmanns Verlag, 359–456.

Hlavatá, J. 2015: Archeobotanické nálezy rastlín a ich vypovedacia schopnosť vo vzťahu k poľnohospodárstvu včasného stredoveku. In: Z. Borzová (ed.), Interdisciplinárne o poľnohospodárstve včasného stredoveku. Nitra: Univerzita Konštantína Filozofa, 9–44.

Klíma, B. 2011: Znojmo (okr. Znojmo). Hradiště sv. Hypolita. Středohradištní, mladohradištní období. Pohřebiště. Záchranný a předstihový výzkum. Přehled výzkumů 52, 212–213.

Kočár, P. – Kočárová, R. – Opravil, E. – Procházka, R. 2014: Archeobotanická výpověď brněnských parcel. Přehledy výzkumů 55, 125–166.

Köhler-Schneider, M. 2001: Verkohlte Kultur – und Wildpflanzenreste aus Stillfried an der March als Spiegel spätbronze Landwirtschaft im Weinviertel. Niederösterreich. Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Köhler-Schneider, M. 2003: Contents of a storage pit from late Bronze Age Stillfried, Austria: another record of the „new" glume wheat. Vegetation History and Archaeobotany 12, 105–111.

Kolník, T. 1971: Prehľad a stav bádania o dobe rímskej a sťahovaní národov. Slovenská archeológia 19, 499–540.

Komárková, V. 2005: Analýza rostlinných makrozbytků ze slovanských zásobních jam ve Statenicích. Archeologie ve středních Čechách 9, 549–555.

Kraus, V. 2009: Vinitorium historicum. Praha: Radix.

Krčová, D. 2016: Zdroje obživy, príprava jedál a stravovacie zvyklosti Germánov v strednom Podunajsku vo svetle historických a hmotných prameňov. Nitra: Univerzita Konštantína Filozofa v Nitra. Unpublished PhD thesis.

Krekovič, E. 2000: Kniežacie hroby. Pamiatky a múzeá 3, 48–51.

Látková, M. 2017: The Archaeobotany of Mikulčice. Food Supply to the Early Medieval Stronghold. Studien zum Burgwall von Mikulčice XI. Spisy archeologického ústavu AV ČR Brno 55. Brno: Archeologický ústav AV ČR, Brno.

Látková, M. – Hajnalová, M. 2014: Plant macro-remains from the palaeochannel sediments in Mikulčice, trench B 2012. In: L. Poláček (ed.), Mikulčice River Archaeology. New Interdisciplinary Research into Bridge No. 1. Internationale Tagungen in Mikulčice X. Brno: The Institute of Archaeology of the Czech Academy of Sciences, Brno, 93–112.

Látková, M. – Hajnalová, M. – Havlík, M. 2019: Grape vine and viticulture tradition in Mikulčice. Přehled výzkumů 60, 79–91.

Logothetis, B. 1970: The development of the vine and of viticulture in Greece based on archaeological findings in the area. Epistimoniki Epetiris tis Geoponikis kai Dasologikis Sholis, University of Thessaloniky 13, 167–249.

Logothetis, B. 1974: The contribution of the vine and the wine to the civilization of Greece and Eastern Mediterranean. Epistimoniki Epetiris tis Geoponikis kai Dasologikis Sholis, University of Thessaloniky 17, 5–286.

Maděra, P. – Martinková, M. 2002: Assessing the occurrence of Vitis vinifera subsp. sylvestris (C. C. Gmelin) Hegi in the Czech Republic. Journal of Forest Science 48(11), 482–485.

Mangafa, M. – Kotsakis, K. 1996: A new metod for the identification of wild and cultivated charred grape seeds. Journal of Archaeological Science 23, 409–418. https://doi.org/10.1006/jasc.1996.0036

Meduna, P. 2017: Vinařství v Čechách v době předkarlovské. In: V. Žůrek (ed.), Karel IV. a burgundské. Tradice pěstování a pití burgundského vína v českých zemích od středověku dodnes. Praha: Univerzita Karlova, 13–18.

Měřínský, Z. 1972: Vinařský nůž z římské stanice u Mušova. Národopisný věstník československý 7, 103–112.

Miller, N. F. 2008: Sweeter than wine? The use of the grape in early Western Asia. Antiquity 82, 937–946. https://doi.org/10.1017/S0003598X00097696

Opravil, E. 1963: Z minulosti vinohradů ve Slezsku a na severní Moravě. Zprávy Slezského ústavu ČSAV v Opavě, řada B 124, 9.

Opravil, E. 1965: Rostliny ze středověkých nálezů v Olomouci. Archeologické rozhledy 17, 193–197.

Opravil, E. 1972: Rostliny z velkomoravského hradiště v Mikulčicích (Výzkum z let 1954–1965). Studie Archeologického ústavu ČSAV v Brně 2. Praha: Academia.

Opravil, E. 1977: Vinná réva na území Československa v pravěku. Archeologické rozhledy 29, 361–365.

Opravil, E. 1980: K původnímu rozšíření lesní révy a její domestikaci. Moravín – Sborník vinohradnicko-vinařských aktualit, 81–83.

Opravil, E. 1985: Vinná réva a ovocné plodiny v Mikulčicích a na Pohansku v době hradištní. Moravín – Sborník vinohradnicko-vinařských aktualit, 95–97.

Opravil, E. 1997: Wilder Weinstock (Vitis vinifera subsp. sylvestris) in Äneolithikum Mährischen Pforte (Mähren, Tschechische Republic). Časopis Slezského zemského muzea A46, 169–172.

Opravil, E. 2000: Zur Umwelt des Burgwalls von Mikulčice und zur pflanzlichen Ernährung seiner Bewohner. In: L. Poláček (ed.), Studien zum Burgwall von Mikulčice IV. Brno: Archäologisches Institut der Akademie der Wissenschaften der Tschechischen Republik, Brno, 9–169.

Opravil, E. 2003: Vegetation des Burgwalls von Mikulčice und ihre wirtschaftliche Bedeutung. In: L. Poláček (ed.), Studien zum Burgwall von Mikulčice V. Brno: Archäologisches Institut der Akademie der Wissenschaften der Tschechischen Republik Brno, 75–81.

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. https://doi.org/10.1007/s00334-014-0482-y

Pagnoux, C. – Bouby, L. – Valamoti, S. M. – Bonhomme, V. – Ivorra, S. – Gkatzogia, E. – Karathanou, A. – Kotsachristou, D. – Kroll, H. – Terral, J. F. 2021: Local domestication or diffusion? Insights into viticulture in Greece from Neolithic to Archaic times, using geometric morphometric analyses of archaeological grape seeds. Journal of Archaeological Science 125, 105263. https://doi.org/10.1016/j.jas.2020.105263

Pokorná, A. – Dreslerová, D. – Křivánková, D. 2011: Archaeobotanical Database of the Czech Republic, an Interim Report. Interdisciplinaria archaeologica – Natural Sciences in Archaeology II/1, 49–53.

Pospíšilová, D. – Šimora, R. 2019: Lesný vinič Vitis vinifera ssp. silvestris Gmel. a jeho výskyt na Slovensku. Bratislava: VEDA, vydavateľstvo Slovenskej akadémie vied.

Rebay-Salisbury, K. 2002: Die hallstattzeitliche Grabhügelgruppe von Zagersdorf im Burgenland. Wissenschaftliche Arbeiten aus dem Burgenland 107. Eisenstadt: Amt der Burgenländischen Landesregierung.

Rebay-Salisbury, K. 2003: Wein in der Eisenzeit. In: J. Leskovar – G. Schwanzar – G. Winkler (eds.), Worauf wir stehen: Archäologie in Oberösterreich. Linz: Oberösterreichische Landesmuseen, 289–297.

Renfrew, J. M. 1973: Palaeoethnobotany. The prehistoric food plants of the Near East and Europe. London: Methuen.

Rösch, M. 2002: Der Inhalt der beiden Bronzekannen. In: H. Baitinger – B. Pinsker (eds.), Glaube – Mythos – Wirklichkeit. Das Rätsel der Kelten vom Glauberg. Stuttgart: Theiss, 119–120.

Rzehak, A. 1909: Die Gefässfunde im Baugrund der Brünner Häuser. Zeitschrift des mährischen Landesmuseums 9, 92–135.

Smith, H. – Jones, G. 1990: Experiments on the effects of charring on cultivated grape seeds. Journal of Archaeological Science 17, 317–327.

Stika, H. P. 1999: Keltisches Bier aus Hochdorf. Schriften des Keltenmuseums Hochdorf/Enz 1, 64–75.

Stöllner, T. 1993: Weissgrundige Keramik der Frühlatènezeit in Böhmen: Ein Beitrag zur Frage des Keramikhandels bei den Kelten. In: J. Waldhauser (u. a.), Die hallstatt- und latènezeitliche Siedlung mit Gräberfeld bei Radovesice in Böhmen. Archeologický výzkum v severních Čechách 21 (1993). Praha, 250–256.

Stöllner, T. 2002: Die Hallstattzeit und der Beginn der Latènezeit im Inn-Salzach-Raum. Archäologie in Salzburg 3/I. Salzburg: Amt der Salzburger Landesregierung (Landesarchäologie).

Stummer, A. 1911: Zur Urgeschichte der Rebe und des Weinbaues. Mitteilungen der Anthropologischen Gesellschaft in Wien 41, 283–296.

Šálková, T. – Bezděk, A. – Březinová, H. – Farkašová, K. – Houfková, P. et al. 2015: Bioarchaeologická rekonstrukce pohřebního ritu – případová studie na základě organického materiálu z halštatské mohyly na lokalitě Zahrádka (jižní Čechy, Česká republika). Památky archeologické 106, 95–135.

Tejral, J. 2002: Doba římská v oblasti vodního díla. In: S. Stuchlík (ed.), Oblast vodního díla Nové mlýny od pravěku do středověku. Brno: Archeologický ústav AV ČR, Brno, 291–328.

Terral, J. F. – Ta Bard, E. – Bouby, L. – Ivorra, S. – Pastor, T. et al. 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. Annals of Botany 105, 443–445.

Tomková, K. 2021: K archeologickým nálezům peciček vinné révy a topografii vinic v raně středověkých Čechách. Archeologicke výzkumy v jižních Čechách 34, 319–323.

Turčan, V. 2012: Depoty z Bojnej a včasnostredoveké hromadné nálezy železných predmetov uložené v zbierkach Slovenského národného múzea – Archeologického múzea. Bratislava: Slovenské národné múzeum.

Valamoti, S. M. 2015: Harvesting the "wild"? Exploring the context of fruit and nut exploitation at Neolithic Dikili Tash, with special reference to wine. Vegetation History and Archaeobotany 24, 35–46. https://doi.org/10.1007/s00334-014-0487-6

Valamoti, S. M. – Darcque, P. – Koukouli-Chrysanthaki, C. – Malamidou, D. – Tsirtsoni, Z. 2015: An Archaeobotanical investigation of Prehistoric grape vine exploitation and wine making in Northern Greece: recent finds from Dikili Tash. In: A. Diler – K. Senol – Ü. Aydinoglu (eds.), Olive Oil and Wine Production in Eastern Mediterranean during Antiquity. International Symposium Proceedings 17–19 November 2011, Urla, Turkey. Ege Üniversitesi, Izmir, 125–139.

Valamoti, S. M. – Pagnoux, C. – Ntinou, M. – Bouby, L. – Bonhomme, V. – Terral, J. F. 2020: More than meets the eye: new archaeobotanical evidence on Bronze Age viticulture and wine making in the Peloponnese, Greece. Vegetation History and Archaeobotany 29, 35–50. https://doi.org/10.1007/s00334-019-00733-6

Varsik, V. 2000: Vidiecke sídlisko v zázemí kastela Gerulata. Pamiatky a múzeá 49(3), 15–17.

Webb, D. A. 1968: Vitaceae. In: T. G. Tutin – V. H. Heywood – N. A. Burges – D. M. Moore – D. H. Valentine – S. M. Walters – D. A. Webb, Flora Europaea 2. Rosaceae to Umbeliferae. Cambridge: Cambridge University Press, 246–247.

Zecca, G. – Mattia, F. – Lovicu, G. – Labra, M. – Sala, F. – Grassi, F. 2010: Wild grapevine: silvestris, hybrids or cultivars that escaped from vineyards? Molecular evidence in Sardinia. Plant Biology 12, 558–562. https://doi.org/10.1111/j.1438-8677.2009.00226.x

van Zeist, W. 1991: Economic aspects. In: W. van Zeist – K. Wasylikowa – K. E. Behre (eds.), Progress in Old World palaeoethnobotany. Rotterdam: Balkema, 109–130.

Zohary, D. – Spiegel-Roy, P. 1975: Beginning of fruit growing in the Old World. Science 187, 319–327.

MICHAELA LÁTKOVÁ, Institute of Archaeology in Brno, Czech Academy of Sciences, Čechyňská 363/19, CZ-602 00 Brno, Czech Republic; latkova@arub.cz