Jihočeská univerzita v Českých Budějovicích
Přírodovědecká fakulta

Hunter-gatherer archaeobotany: Central European Mesolithic

Master thesis

Bc. Michaela Divišová

Školitel: Doc. PhDr. Jaromír Beneš, Ph.D.

České Budějovice 2014

Divišová, M., 2014: Hunter-gatherer archaeobotany: Central European Mesolithic. Mgr. Thesis, in English. – 97 p., Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic.

Annotation:

The present work attempts to provide understanding of the issue of Mesolithic archaeobotany, especially in terms of plant use, woodland clearance, and discussion concerning Mesolithic agriculture. Special attention is also paid to taxa occurring within archaeological context at European Mesolithic sites and some methodological implications. Also, specific patterns in food preparation and consumption are considered, particularly with emphasis on certain archaeological features. The thesis also brings new original data from the Czech Republic. In this regard, assemblage from Dvojitá Brána u Rohlin has provided hints towards the study of the Neolithisation process in the Czech Republic, whereas case study from the Schwarzenberg Lake has brought considerable focus on the issue of depositional/postdepositional processes, especially when dealing with shallow sandy sediments. The thesis also strongly reflects the growing need for interdisciplinary work to address issues related to Mesolithic hunter-gatherers.

Declaration of author:

I hereby declare that I had a significant contribution to the papers forming part of the thesis.

Prohlašuji, že jsem se významně podílela na vzniku publikací, předkládaných jako součást diplomové práce.

I would like to thank my supervisor Doc. PhDr. Jaromír Beneš, Ph.D. for all his friendly guidance and support. I also wish to thank PhDr. et Mgr. Petr Šída, PhD. for providing me material, for fruitful discussions and countless inspirational remarks.

Mgr. Tereza Šálková, to whom I feel particularly indebted, I thank very much for acquainting me with the analysis of plant macoremains and plant determination in practise, for valuable remarks and her overall help. I also feel indebted to Mgr. Veronika Komárková, Dr. Sabine Karg, Mgr. Pavla Žáčková, Ing. Milan Štech, Ph.D., and Jan Kučera, Ph.D. for their kind help with the identification of plant macroremains. For technical help, I also wish to thank Bc. Jiří Bumerl. Mgr. Martin Pták deserves my heartfelt thank for his patient help with the preparation of the manuscript as well as for numerous suggestive discussions.

Above all, I am extremely grateful to my fellow colleagues and friends for their patience and overall support. The work would not have been possible without the support and energy provided by music artists, namely Šanov 1, Bad Religion, and Ramones.

Dále mé poděkování patří mé rodině a mým nejbližším.

The work was supported by the research project ‘Prior to the Neolithic: Contextual Analysis of Environmental Dynamics during Early Postglacial Transformation of Central Europe’, financed by the Czech Science Foundation (13-08169S).

Contents

1. Introduction

1.1. Background

The study of European Mesolithic hunter-gatherers by means of archaeobotanical analysis (macroremains analysis in particular) represents seriously understudied topic. The thesis forms part of the research project 'Prior to the Neolithic: Contextual Analysis of Environmental Dynamics during Early Postglacial Transformation of Central Europe', financed by the Czech Science Foundation (13-08169S). The main goal of the research project is to fill gaps in our knowledge concerning changes and processes occurring in the Early Postglacial Central Europe. Within this frame, the thesis concerns the study of hunter-gatherer archaeobotany, with the main focus on Central European Mesolithic.

1.2. Aims

The thesis is primarily aimed to be a literature study based on published information. This study thus seeks to provide knowledge about European Mesolithic hunter-gatherers by focusing on plant use and human impact on the vegetation. A further aim is to analyse plant macroremains recovered from two Mesolithic sites from the Czech Republic.

To be able to fulfil above mentioned aims, the following issues need to be considered:

- To evaluate the existing state of research into the Central European Mesolithic, particularly in terms of plant use and human impact upon the vegetation;
- To bring new data on Mesolithic archaeobotany in the Czech Republic by means of plant macroremains analysis;
- To incorporate various lines of evidence and deliver a holistic understanding of the issue. The desired outcome is a review supplemented by new results.

1.3. A methodological issue

The thesis is based on integration of various disciplines in order to collect all available data and obtain the clearest picture possible of the topic. The study of plant use by the hunter-gatherers is thus based on data extracted from the literature particularly of the disciplines of archaeology, archaeobotany, experimental archaeology, and ethnobotany.

A literature search for references to the specific plant use offered by the ethnobotanical record was carried out. Naturally, one cannot assume that recorded traits are inevitably identical with the ancient ones. On the other hand, patterns of behaviour documented ethnographically are useful to be compared with patterns observed in the archaeological record (Schiffer 1978). Moreover, ethnobotany, the study of people and plants and their interactions providing evidence on a variety of edible plants as well as information how the plants are used, manipulated and cultivated, can be very useful for archaeologists and archaeobotanists studying plant remains recovered from the archaeological sites (Messer 1979). Not only plant remains themselves, but also archaeological structures and overall archaeological context is studied and presented. Moreover, application of experimental archaeology sheds more light on the studied issues. Then, it is possible to interpret archaeobotanical findings and generate and test hypotheses.

The other part of this work focuses primarily on two Mesolithic sites in the territory of the Czech Republic, studied by means of plant macroremain analysis. For further details of material and methods see chapters 4 and 5.

1.4. The analysis of plant remains in the archaeological context

Archaeobotany, the discipline of environmental archaeology, examines botanical finds in the context of archaeology. Analytically it consists of different methods, which can be divided into two main groups. First one deals with microscopic objects such as pollen, diatoms, and phytolites. The other group examines macroremains such as fruits, seeds, wood/charcoal, leaves, tubers, etc. (Miller 1997; Beneš 2008). The main focus of this work is on the analysis of plant macroremains.

Archaeobotanical analysis in terms of plant macroremains aims to study past plant-human relationship in terms of diet, subsistence, agricultural strategies, social and cultural role of plants, production of fodder as well as the exploitation wild foods (Jacomet – Kreuz 1999; van der Veen 2007). The last mentioned is of special importance with regard to hunter-gatherer archaeobotany, which is the main focus of this study. However, the reconstructions are strongly dependent on the quality of data recovered from excavation, sampling and sieving techniques, and also specific preservation conditions. The most common encountered modes of preservation are carbonization, waterlogging, mineralization, and desiccation (Jacomet – Kreuz 1999; Fuller 2007; van der Veen 2007; Beneš 2008).

In addition, a range of different factors including formation and taphonomic processes influence the assemblages. Therefore, understanding of these processes is of crucial importance when trying to interpret archaeobotanical data. It is also important to bear in mind that various processes could have been involved in assemblage formation and material of mixed origin can occur within one sample (van der Veen 2007).

To summarize, the analysis of plant macroremains can help to answer questions outlined above, when properly applied. This is especially true in combination with other methods, particularly pollen analysis bringing information on vegetation as well as human impact on the landscape on a broader scale (Behre 1981). The plant macroremains analysis, on the other hand, provides more precise information on species level and related to the local vegetation. Currently, only the interdisciplinary research can be considered as suitable tool for answering questions concerning human past (Beneš 2008).

In this work, main attention is paid to plant remains retrieved from archaeological features and layers. It should be stressed that this thesis does not attempt to reconstruct specific vegetation types or to address ecological issues. Rather, it aims to shed more light on plant-human interactions as well as reconstruction of formation of archaeological features infills.

1.5. Chronological and spatial framework of the work

This study focuses primarily on the territory of **the Czech Republic**. However, a literature study concerning archaeobotanical evidence covers the whole European region, due to little attention paid to the archaeobotany of hunter-gatherers in particular and consequently poor data within the region. Ethnobotanical references used within this work are not geographically defined, since their role is to broadly examine human behaviour and its material context instead of drawing persuasive analogies and interpretations (Binford 1967).

Chronologically, this work concerns the period during which particularly **the Mesolithic**, and peripherally also **the Early Neolithic**, which was dominated in earlier phase by the Linear Pottery Culture (LBK, derived from the German term Linearbandkeramik) occurred. Chronological questions may be addressed by various types of records such as biostratigraphic evidence, archaeological typology, and radiocarbon dating (Kuna et al. 2007, 101-105). According to the archaeological chronology, the Early Mesolithic, predominantly characterised by presence of microlithic triangles, segments and Tardenoisian points as a diagnostic tool types, lasted between 10,000 – 7000 BP. The Late Mesolithic, a period of dominance of geometric trapezes and blades longer than before, concerns the period between 7000 – 6500 BP (Vencl 2007; Svoboda 2008, 227). The existence of the LBK can be roughly linked to the period from the beginning of the 6th millennium BC to the beginning of the 5th millennium BC (5600 – 4900 BC) (Pavlů 2004; Pavlů – Zápotocká 2007).

Environmentally, this period covers the time span from the Preboreal to the Atlantic stage of Holocene. **The Preboreal** was marked by dramatic climatic change with annual temperatures about 3 degrees lower than today and an observable growing density the birch-pine stands and a simultaneous retreat of steppe vegetation**. The Boreal** can be characterised by a further temperature increase. The birch-pine forests were invaded by *Quercus*, *Ulmus*, and *Corylus*, whereas heliophilous and montane plants disappeared. **The Atlantic** was marked by continuity of warm and human condition, characterised by thermophilous oak forest and mesophilous mixed lime-oak forest spreading in the lowlands and new trees such as *Tilia, Acer, Fraxinus, Ulmus*, and *Taxus* spreading over the whole area (Roberts 1989; Dreslerová et al. 2007; Ložek 2007).

1.6. A short introduction to the Mesolithic in the Czech Republic

The term "Mesolithic" was coined by M. H. Westropp to distinguish lithic artefacts belonging to the Palaeolithic and polished stone tools of the Neolithic (1866, 291). Although Mesolithic artefacts were collected by amateurs in the Czech Republic from the very beginning of the 20th century, the existence of the Mesolithic was disregarded by Czech archaeology (Vencl 2007, 124). A general scepticism was even shared by some leading authorities about the very existence of the Mesolithic in the region of Central Europe (see e.g. Vencl 2007; Svoboda 2008, 224). In the Czech Republic, the Mesolithic was almost unknown period for years (Vencl 2007, 124-125). Moreover, study of the Mesolithic period was neglected in the second half of the 20th century by Czech archaeologists, who instead paid attention to the study of the following Neolithic age. Therefore, the study of the Mesolithic-Neolithic transition in the Czech Republic is distorted by large systematic error (Beneš 2004, 147). For detailed study concerning Neolithisation process in Central Europe see appendix.

On the other hand, currently, there is clear evidence for Mesolithic settlement of the Czech Republic (see for instance Prošek 1951; Vencl 1990; 1992; 2007; Svoboda et al. 1999; 2007; 2013; Svoboda ed. 2003; Vencl ed. 2006; Šída – Prostředník 2007; 2010; 2011; Vencl 2007; Svoboda 2008; Pokorný et al. 2010; Čuláková et al. 2012). Mesolithic occupation, as documented in the present-day archaeological record, demonstrates a change of settlement strategies compared to the Neolithic, which is reflected in all three types of sites encountered in the region: open-air sites, karstic caves, and pseudokarstic rockshelters (Svoboda 2008, 221-224). Mesolithic populations thus preferred rocky areas with lakes, wetlands, and forested areas.

1.7. An outline

Chapter 1 '*Introduction*' brings the general information and introduction to the topic, which sets out the overall framework of the work.

Chapter 2 '*Hunter-gatherer archaeobotany from a European perspective*' provides a look at selected issues in hunter-gatherer archaeobotany. This chapter is not meant to be a complete literature review of the subject. Rather, some particular aspects such as plant use in the Mesolithic, woodland clearance and discussion concerning Mesolithic agriculture are presented. Special attention is paid to particular plant taxa occurring at Mesolithic sites in Europe.

Chapter 3 '*Food preparation and consumption*' represents an attempt to briefly summarize evidence and methods of dietary reconstruction and food preparation. The chapter includes two papers. The first one discusses acorns as a food resource, with emphasis on taste of acorn products and their preparation methods. The second paper focuses on specific cooking techniques associated with particular archaeological features. Particular attention is also paid to experimental work dealing with hearth-pits.

Chapters 4 and 5 bring new data obtained by means of analyses of plant macroremains from two Mesolithic sites in the Czech Republic. '*Archaeobotany of Schwarzenberg Lake, South Bohemia*' is dealing with material recovered from archaeological features lying on the sandy peninsula adjacent to the original shore of the lake. Special attention is paid to factors affecting composition of archaeobotanical remains such as taphonomy and depositional dynamics. '*Archaeobotany of Dvojitá Brána u Rohlin, North Bohemia*' then focuses on the Mesolithic in Bohemian Paradise bringing interesting, although tentative, indications connected with the study of Mesolithic-Neolithic transition .

Chapter 6 '*Conclusion*' summarizes the key points made in the work. This closing section of the work also reflects the significance of a holistic comprehensive research and a growing need for interdisciplinary activities between specialists in both natural sciences and humanities.

Finally, the appendix presents the author's paper '*Current knowledge of the Neolithisation process: a Central European perspective*' summarizing current state of research into the transition to farming in Central Europe, which is in many points connected to the hunter-gatherer archaeobotany, the subject matter of the work.

2. Hunter-gatherer archaeobotany from a European perspective

2.1. An outline of the history of research into the hunter-gatherer archaeobotany with an emphasis on the European Mesolithic

The importance of plants in diet of modern hunter-gatherer has already been stressed by Lee (1968) on the basis of data from the *Ethnographic atlas* (Murdock 1967). However, archaeologically, most studies dealing with foods, has long put emphasis on animal remains, bones, likely with respect to their visibility in the archaeological record and also due to applied research methods. Moreover, when dealing with plants, investigations of domesticated and cultivated plants or their immediate wild relatives has long dominated in archaeobotanical studies (Hather – Mason eds. 2002). As a result, the role of plants has been long systematically underestimated (Zvelebil 1994; Hather – Mason eds. 2002).

In European perspective, a crucial turning point occurred in 1994, when M. Zvelebil published a key study concerning plant use in the Mesolithic. In this study, he builds on Clarke's model (1976), in which Clarke emphasizes the wide availability of potential plant food in temperate and Mediterranean Europe. Zvelebil (1994), however, has reviewed that time evidence and has brought information on finds of edible plant remains from 74 northern European sites. He revealed that at 40 sites only remains of *Corylus* sp. were reported. Further, 24 sites had only two species, commonly *Corylus* sp. and *Quercus* sp. or *Trapa natans*. Taxa such as *Prunus* sp., *Chenopodium* sp., *Nuphar lueta*, *Nymphaea alba*, *Rubus idaeus*, *Polygonum* sp., *Crataegus* sp., *Rumex* sp., *Filipendula* sp. *Malus* sp., or *Pyrus* sp. have also been occasionally reported. Apart from plant macroremains, Zvelebil has also discussed other lines of evidence of plant use such as pollen data, artefactual, and palaeopathological evidence concluding that the patterns of plant use in the Mesolithic should be considered in terms of wild plant food husbandry instead of the incidental and opportunistic use of plants for food, based on these four lines of evidence.

Since then, rather individual reports by few authors instead of systematic study of the issue can be observed (e.g. Holden et al. 1995; Regnell et al. 1995; Kubiak-Martens 1996; 1999; Knörzer et al. 1999; Perry 1999; Mason – Hather 2000; Robinson 2000; Rösch 2000). The exception is the edited volume *Hunter-gatherer* *archaeobotany. Perspectives from the northern temperate zone* (Hather – Mason eds. 2002), which represents a significant milestone in hunter-gatherer archaeobotany. Within this volume, a number of investigations of European sites have been undertaken (e.g. Mason et al. 2002; Perry 2002; Robinson – Harild 2002; Zapata et al. 2002). Several tentative conclusions have been drawn from this project. Firstly, the number of small seeds and fruits recovered is extremely low, which can be assigned to poor preservation, implying that focusing only on fruits and seeds may not be sufficient when dealing with pre-agricultural societies. Secondly, most importantly, identification of parenchyma turned out to be of crucial importance when studying past hunter-gatherers, since underground storage organs such as rhizomes, roots, and tubers are expected to play an important role in relation to seeds and fruits and, also, are frequently present at investigated sites. However, identification of parenchymatous tissues is associated with many practical problems, particularly a need of examining the remains by scanning electron microscopy (SEM). Further, larger seeds and fruits such as *Corylus* sp., *Trapa natans*, *Quercus* sp., *Prunus* sp. or *Crataegus* sp. are often present and identified. With respect to methodology, a need of holistic approach incorporating various disciplines such as experimental archaeology, ethnobotany, and also broader archaeobotanical analyses including anthracology and palynology are stressed (Mason et al. 2002). Also, proper sampling and recovery techniques should be applied to obtain satisfactory reflection on the issue. Authors further note that adapting of such a holistic approach is relatively time-consuming and its time-effectiveness often questionable, which may also be reflected on the state of research.

Since then, several works presenting new data deserve to be mentioned here (Kubiak-Martens 2002; Aura et al. 2005; Out 2008a). However, another important point in the history of research into hunter-gatherer archaeobotany worth considering is the dissertation of W. Out, *Sowing the seed? Human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500-3400 cal BC)*, bringing substantial evidence on natural vegetation, human impact, plant use and cultivation processes in the Dutch wetlands during the Mesolithic and Neolithic, hence, contributing to an understanding of the transition from hunting and gathering to agriculture on the basis of archaeobotanical research (Out 2009). In terms of further development of research, some studies concerning archaeobotany at European Mesolithic sites should be mentioned (Filipović et al. 2010; Holst 2010; Regnell 2011; Out 2012; Deforce et al. 2013; Marinova et al. 2013; Out – Verhoeven 2014).

Another point to be made is that, apart from foods, evidence of broader human use of plants, such as structures and artefacts, should be focused. These are for instance housing, thatching, vessels, objects of art, sources of fibres for cordage and textiles, dyeing tanning, medicinal and psychoactive agents etc. (Hather – Mason 2002). This issue have been tackled by a number of authors such as Burov (1998), Hurcombe (2000; 2007), Mason et al. (2002), Zapata et al. (2002), Hardy (2007; 2008), Wood (2011) from the perspective of ethnographic, archaeobotanical, and experimental evidence.

When focusing on the territory of the Czech Republic, few studies bringing extremely scarce data in terms of plant remains found in the Mesolithic context can be mentioned (Opravil 2003; Pokorný 2003; Hajnalová in Svoboda et al. 2007 Pokorný et al. 2010). The presence of *Corylus avellana*, *Trapa natans*, *Rubus idaeus*, *R. saxatilis*, *Sambucus nigra*, *Chenopodium album*, and *Galium* sp. is reported.

To summarize, according to above mentioned studies, several patterns can be observed. Firstly, plant macroremains bring substantial evidence about only few intentionally used species. Secondly, a clear pattern concerning hazelnuts as the most important plant food resource arises (e.g. Holst 2010; Regnell 2011). However, their role may be overestimated, particularly in relation to other resources such as roots and tubers (Mason et al. 2002). This is connected with another important issue concerning foods such as roots, inner bark, stems, leaves, or other vegetative parts of plants. Their presence in the assemblage suggests they were available. However, there is a need to identify them and integrate the results from all categories of evidence, since number of studies has proved that these remains may be identified by scanning electron microscopy (e.g. Hather 1991; 1993; 2000; Holden et al. 1995; Kubiak-Martens 1996; 1999; 2002; 2008; Perry 1999). Therefore, modification of methodological practices common on agrarian sites is needed. Lastly, one should note that most of published information on plant use in the Mesolithic lack a critical evaluation, since the presence of taxa cannot be uncritically associated with their utilisation.

2.2. Plant use patterns in hunter-gatherers

Another issue deserving attention is the intensity of plant use in the Mesolithic. As already mentioned, archaeobotanical data are very scarce to estimate the contribution of plants to the Mesolithic diet. The extent and significance of Mesolithic plant use have been suggested to vary from 5% to 80%, with 15 – 20% being the most commonly proposed estimate by several scholars (e.g. Clarke 1976; Jochim 1976; Price 1978; see Zvelebil 1994 for further details). These represent very approximate estimations and one should take into account considerable variation, which is likely occurring among individual European regions, also depending on the availability of fatty aquatic resources, fat content of terrestrial mammals, birds, fish, and the overall seasonality. With respect to previously mentioned, it is important to bear in mind that human intolerance of lean meat-based diet indicates that at least 50% of human energy needs have to come from fat or plant foods (Speth et al. 1991), since lean meat can compose no more than 35 % of dietary energy (Hardy 2010). When focusing on Central European inland Mesolithic communities with rare or no fatty aquatic resources, contribution of plants varying between 30% and 40% in order to satisfy human energy needs and protein requirements has been proposed, depending on fat content of available terrestrial mammals, game birds, and fish (Zvelebil 1994, 58).

Moreover, these data are possible to be compared with ethnographic accounts, since diets of modern-day hunter-gatherers may represent a reference to past pre-agricultural dietary practices. Subsistence data in worldwide hunter-gatherer diet based on ethnographic atlas (Gray 1999) have been analysed and following trends have been recognised (Cordain et al. 2000). Authors report that, when it was ecologically possible, hunter-gatherers gained between 45 – 65% of energy from animal foods. Most (73%) hunter-gatherer societies derived between 56% and 65% of their subsistence from animal foods, whereas 14% of these communities consumed more than 50% of wild plant foods (Cordain et al. 2000). Another noticeable fact, considering ethnographic evidence, is represented by the diversity within known hunter-gatherer diet. According to Kelly's ethnographic atlas (1995), diets whose gathered component (including small mammals and fish) varies from 0% to 85%, hunted portion from 10% to 90% and fish element from 0% to 80%.

Taken together, these observation suggest that plant component in hunter-gatherer diet is not negligible. On the other hand, one should be cautious, since food resources vary by latitude, environment, and season, as already mentioned above. Thus, overgeneralization and drawing precise analogies between modern-day and Mesolithic hunter-gatherer may be problematic, particularly due to the fact that diets of many modern hunter-gatherer communities contain substantial portions of domesticated resources having different concentrations of fats, carbohydrates, vitamins, fibre, minerals etc. (Jenike 2001, 208).

Furthermore, ethnographic record also indicates that not all available resources were utilised. This fact is clearly apparent on the example of the Kalahari !Kung, who consider 85 plant species edible, however, more than half of the entire plant diet is formed by a single plant species the mongongo (*Schinziophyton rautanenii*) (Lee 1968; 1973). Also, other factors affecting food choice should be taken into consideration. Apart from above mentioned availability, one should bear in mind that social factors, fashion, affluence, price, religion, tradition, cultural patterns, etc. could have played an important role in food choice (Fisher – Bender 1970, 6-7).

Furthermore, ethnographic accounts have repeatedly shown the wide range of behaviours and the flexibility of hunter-gatherers. Hunter-gatherer diversity in habitat, technology, diet, physical attributes, reproductive histories, technology, languages, social organisation, issue of local response to environmental constraints etc. is well reported among present and past hunter-gatherers (Panter-Brick et al. 2001). Therefore, the danger of misinterpretation and overgeneralization must be emphasised.

To summarize, current finds need to be critically re-evaluated since many of them lack information concerning particular archaeological context and the presence of potential useful plants at the site itself cannot be considered as convincing evidence for their utilisation. Unfortunately, this is often disregarded in publications dealing with hunter-gatherer archaeobotany. Evidence of food plants can be then provided by plant remains found in human intestines or human coprolites. Strong indication for plant foods may be represented for instance by plant residues in storage pits or vessels, which are regrettably exceptional in the Mesolithic context. On the other hand, criteria to prove human transport and manipulation of plants suggested by Dietsch (1996) should be taken into consideration. According to Dietsch (1996), following five main criteria may be observed to enable detection of wild plants manipulated by humans:

1) Ecology, which can be used to identify presence of taxa outside their natural environment;

2) Number of plant remains, since overrepresentation of some taxa may reflect gathering;
3) Carbonization, which may indicate human processing activities;
4) Fragmentation, also suggesting possible plant processing practices;
5) Spatial distribution, as location in archaeological structures may reflect anthropogenic manipulation.

2.2.1. Human impact on the vegetation: woodland clearance

Apart from the evidence available from plant macroremains, pollen studies play important role in understanding human impact on the vegetation in the Mesolithic. During this period, hunter-gatherers started to be less mobile due to environmental changes and consequently affected local environments around camp sites more intensively (Kuneš et al. 2008). Particularly, the phenomenon of woodland clearance belongs to the most discussed issues concerning Mesolithic societies.

Although traditionally, Mesolithic communities were not expected to clear forests (see Vera 2000), these disturbance phases visible in pollen diagrams, for example in Britain (e.g. Simmons 1996; Innes et al. 2003), Germany (Bos – Urz 2003), and recently also the Czech Republic (Nováková et al. 2008; Pokorný et al. 2008; 2010), are associated with evidence of regular and recurrent burning and clearance activity delaying forest regeneration (Jacobi et al. 1976; Mellars 1976). Such burning of the vegetation is documented not only by the permanent presence of microcharcoal in pollen records, but also increased incidence of certain anthropogenic pollen indicators. These are plants that prefer open habitats such as *Thalictrum*, *Rumex*, *Melampyrum*, *Plantago lanceolata*, Poaceae, and that expand to fire-affected areas including *Pteridium aquilinum*, or *Calluna vulgaris* (Simmons 1996; Pokorný 1999; Kuneš et al. 2008; Pokorný et al. 2008).

Such evidence also supports the suggestion that Mesolithic people deliberately manipulated their environment as a part of organized land use strategy (Zvelebil 1994). However, these disturbances can be interpreted also in terms of natural processes such as lightning strike, storms, windthrows etc. that would leave an identical signal in the palaeoecological record as anthropogenic clearance (Simmons 1996; Brown 1997). In addition to mentioned above, it has been proposed that only the presence of cereal pollen can indicate without doubt the anthropogenic origins of disturbances (Simmons – Innes 1987), but this would consider only forest clearances associated with cereal cultivation (Zvelebil 1994). Despite all of this, Mesolithic sites are almost everywhere in the world accompanied by large amounts of microcharcoal, which is found in sedimentary records. This plays into the idea of burning forests as a usual way of dealing with nature (Sádlo et al. 2008) and continuous presence of microscopic charcoal in the sediments is now also considered as reliable indicator of human activity during the pre-agricultural Holocene (Pokorný 1999).

Moreover, it is generally accepted that woodland clearances, irrespectively of their causation, were utilized by Mesolithic populations for food procurement. However clearances were created, they had an economic use. Plant and animal productivity could be almost doubled by a strategy of controlled burning (Mellars 1976). Forest clearance would have led to particular advantages for the propagation of edible plants and clearings serve also in order to facilitate hunting as well as mobility of human populations (Jacobi et al. 1976; Mellars 1976; Zvelebil 1994; Mason 2000).

One should also take in account the fact that discussion concerning Mesolithic socialities is seriously lacking (Davies et al. 2005). However, ecological relationships may have been a key factor in the development of social relationships in the Mesolithic and it is important not to separate the economic from the cultural, particularly in terms of understanding human interaction with woodlands in the Mesolithic (Moore 2003). Nonetheless, environment and trees within it could be considered as more than a background to human activity. In this regard, it is important to distinguish between two possible modes of human-environment relationships. The first one can be described as beneficent human-environment relationship, where human and non-humans influence one another in a mutually beneficial way. This contrasts, however, with another mode of human-environment relationship, concept of wilderness, where fear is a primary motivator determining behaviour and surroundings is more often seen as malevolent rather than benevolent (Evans et al. 1999; Warren 2003; Davies et al. 2005).

With respect to anthropological and ethnographic evidence, Davies et al. (2005) suggest that Mesolithic populations may have been driven more likely by anxiety and fear of their surroundings, rather than be familiar with it. Therefore, thinking of the woodlands as being marked by paths (Warren 2003; Tilley 1994, 202), one of the primary motivators in establishing paths may have been fear of actual harm of wildlife, spirits, or getting lost in surroundings where the horizon is seldom visible. Consequently, woodland clearings may result from such fears and could be explained as a purely social phenomenon.

2.2.2. Mesolithic agriculture?

Moreover, recently there has been also discussion of accumulating palaeobotanical evidence that points out to agricultural activity in Central and Northern Europe well before the onset of the Neolithic (Innes et al. 2003; Klassen 2004; Poska and Saarse 2006; Behre 2007; Tinner et al. 2007). The palynological evidence is based on the consistent presence of the Cerealia pollen within the sediments that provide high temporal resolution and precision for the period of interest. The presence of pollen of Cerealia during the Mesolithic period also correlates with the pollen of semi-cultural plants or weeds, such as *Plantago lanceolata* that is considered to be one of the most reliable indicators of agriculture (Tinner et al. 2007; see Behre 2007 for further discussion). Given that the evidence for cereal cultivation during the Mesolithic is provided for instance from Switzerland, Austria, France, Estonia, British Isles (Innes et al. 2003; Poska and Saarse 2006; Tinner et al. 2007) etc., some scholars (e.g. Tinner et al. 2007) thus consider the occurrence of pollen indicative of agriculture activities during the Late Mesolithic as a widespread phenomenon in Europe.

However, the topic is in the centre of controversial debates mainly because there are no well-dated macroremains of crop plants of pre-Neolithic age (Behre 2007) that may be caused by the fact that no Late Mesolithic sites in and around central Europe are known with good conditions for preservation of botanical remains (Jacomet – Kreuz 1999). The Mesolithic agriculture, as assumed, is based solely on the occurrence of single Cerealia or Cereal-type pollen in the respective levels of pollen diagrams (Behre 2007; Tinner et al. 2007). Firstly, single pollen grains of Cerealia-type which have been interpreted as indicators of earliest agriculture, however, may not really derive from cereals, because cereal pollen can be morphologically similar to that of wild grasses and is not always distinguishable (Dumayne-Peaty 2001, 381). Another problem is the spontaneous polyploidization of wild grasses, which leads to the development of large pollen grains, contributing to the difficulties of identification cereals (Behre 2007; Pokorný et al. 2008). In addition to misidentification, there are also problems of contamination or possible long-distance transport of the Cereal-type wild grass pollen grains from the Near East and the eastern Mediterranean that cannot be distinguished from cereals (Behre 2007). Another explanation of the appearance of pre-Neolithic cereal-type pollen would be the cultivation of indigenous wild grasses (Zvelebil 1994).

One of the most common arguments for ruling out Mesolithic agriculture is that crops cannot be produced without permanent settlement activity protecting the fields against herbivores (Behre 2007). However, protection can be provided by simple fence construction made from prickly shrubs (Pokorný – Sádlo 2008). Moreover, evidence suggests that possible cereal production during the Mesolithic was low-intensity and the purpose of this could have been planting cereals for prestige reasons (Mithen 1996; Tinner et al. 2007). Although this may represent economically useful activity, one should take into account that growing sedentarism, associated with adoption of agriculture, gave rise to epidemics and health problems and should not be perceived unambiguously (Tringham 2000; Bánffy 2005; Beneš 2013). On the other hand, very little is known about the social organisation and beliefs of Mesolithic communities in Central Europe, particularly in contrast to the South-East European Neolithic and the issue concerning the origins of agriculture, where cult and ritual life has been well documented in the archaeological record (Hodder 1990; Bánffy 2005).

2.2.3. Selected plants occurring in the Mesolithic context: perspectives from archaeobotany and ethnobotany

The plant macroremains of following taxa are recorded to occur at European Mesolithic sites based on above mentioned studies (see chapter 2.1). Special attention is also paid to taxa recovered from the sites in the Czech Republic. Here, also ethnobotanical information on these plants is provided. One should keep in mind that these are not all taxa identified within Mesolithic context. Rather, those occurring at more sites or within context suggesting their manipulation by humans are presented and discussed.

Seeds, fruits and nuts

Corylus avellana

Hazelnut shells represent very abundant macroremains at most sites. Very likely, hazelnuts functioned as staple food, since their energetic value is very high, containing more than 60% fat, 15% proteins and nearly 17% carbohydrate, in addition to a large amount of unsaturated fatty acids, mineral and vitamins (Holst 2010). However, they are easily recognisable in contrast to other sources, particularly underground storage organs in the archaeological record. Therefore, their role may be overestimated (Mason et al. 2002). Their frequent occurrence may also be connected with their roasting, which enables good storability etc. (see chapter 3.2 for further details). Large amounts of hazelnut shells are known for instance from the sites of Duvensee, Germany (Holst 2010) or Staosnaig, Scotland (Mithen et al. 2001). In the Czech Republic, finds of hazelnut shells are reported from Okrouhlík, Dolský Mlýn, Máselník, Pod Zubem, Pod Křídlem, Arba, Sojčí Převis, Jezevčí Převis, Kristova Jeskyně, Schwarzenberg Lake, Údolí Samoty, Dvojitá Brána u Rohlin, (Opravil 2003; Pokorný 2003; Komárková 2005; Pokorný et al. 2008; Žáčková 2008; Svoboda et al. 2013; Divišová in this thesis).

Quercus sp.

Acorns are known to be used extensively for a variety of purposes such as foods, animal fodder, dyeing and tanning agent. For detail information concerning use of acorns see chapter 3.1. Finds of acorns are reported from a number of sites such as Tybind Vig and Halsskov, Denmark (Kubiak-Martens 1999; Robinson – Harild 2002) or Roc del Migdia, Catalonia (Holden et al. 1995).

Trapa natans

Fruits of *Trapa natans* are rich in starch (50%), protein (10%) and fat. They can be eaten raw, as well as boiled or roasted. They can also be preserved for several weeks, when roasted. As in the case of hazelnuts, roasting makes them easier to open, ground to flour and better flavour is also induced (Renfrew 1973; Karg 2006). Remains of *T. natans* have been found for instance at sites in the Dutch central river area (Out 2009). In the Czech Republic, fruits of *T. natans* have been found at the site of Schwarzenberg Lake (Pokorný et al. 2008; 2010).

Cornus mas

Bushes of *Cornus mas* bear edible fruits, which are widely used as food and medicine, since they contain a large amount of vitamin C (Klimenko 2004; Łuczaj 2012). Interestingly, finds of *C. mas* stones in deposit related to burial infill are reported from the site of Vlasac, Serbia (Filipović et al. 2010).

Cornus sanguinea

Although the edibility of fruits of *C. sanguinea* is discussed (Dietsch 1996; Out 2009), they are known to be eaten from ethnobotanical record (e.g. Dénes et al. 2012). The fruits are slightly toxic, but their palatability and edibility increase after preparation. Moreover, selective use of *C. sanguinea* for Mesolithic and Neolithic fish traps has been observed in Netherlands (Out 2008b). There are finds of stones of *C. sanbuinea* at several sites in Netherlands (Out 2009) as well as in Denmark (Kubiak-Martens 1999).

Rubus sp.

Fruits of *Rubus* taxa represent food resource often referred to as unsuitable for storage (Out 2009). On the other hand, recent hunter-gatherers are reported to store them over the winter (Mears – Hillman 2007). Also, these taxa may be consumed directly without any preparation and evidence of their consumption may thus be underrepresented (Out 2009). Ethnobotanically, the utilization of *Rubus* fruits, leaves, roots as well as whole plants mostly for food and medicine may be traced (Moerman 1998, 492-494; Mears – Hillman 2007). Fruits or *Rubus* taxa have been found at several sites, for example *R. idaeus* from the site of Halsskov, Denmark can be mentioned (Robinson – Harild 2002). In the Czech Republic, *R. idaeus* and *R. saxatilis* have been retrieved from Jezevčí Převis and Schwarzenberg Lake (Pokorný 2003; Žáčková 2008; Pokorný et al. 2010).

Sambucus sp.

Sambucus nigra represents one of the most versatile plants used for food, medicine, crafts and games, as well as for ornamental purposes. In addition, almost every part of the plant, including the bark, roots, leaves, flowers, and fruit, has some uses. Finds of *Sambucus ebulus/nigra* are known for instance from Vlasac, Serbia (Filipović et al. 2010). In the Czech Republic, seeds of *Sambucus nigra* were recovered from Jezevčí Převis (Pokorný 2003).

In contrast to *Sambucus nigra, S. racemosa* requires processing to render it edible, since the fruit and its seeds are somewhat toxic. However, *S. racemosa* represents widely used food, as well documented through the ethnobotanical record, representing a particularly good source of vitamin C, copper and fibre. Due to the toxicity, the berries are nearly always described as being cooked prior to consumption.

Native American groups on the southern Northwest Coast cooked red elderberry fruit through steaming on rocks, pit-baking, and boiling. Interestingly, there are no clear reports that seeds were removed during the cooking or drying phases of processing. Seeds were generally removed while the fruit was being consumed. Red elderberry appears to have been a readily and commonly stored fruit on the Northwest Coast, also being described as an important winter food (Moerman 1998, 513-514; Losey et al. 2003). In the Czech Republic, *Sambucus racemosa* was recorded at the site of Dvojitá Brána u Rohlin (Divišová in this thesis).

Chenopodium album

Chenopodium album has edible foliage as well as easily gatherable seeds, which can be harvested in great quantity. Its extensive use for food as well as medicine is widely known. Green leaves and stems are eaten raw, boiled or dried for future use. Seeds are most commonly used for porridge or ground into flour subsequently used for making bread (e.g. Moerman 1998, 154-155; Mears – Hillman 2007). Seeds of *C. album* are commonly found at Mesolithic sites. For example, Halsskov and Tybrind Vig, Denmark (Kubiak-Martens 1999; Robinson – Harild 2002) or German Rhineland (Knörzer et al. 1999) can be mentioned. In the Czech Republic, the presence *C. album* has been recorded at Jezevčí Převis (Pokorný 2003).

Rosa sp.

The fruits of *Rosa* sp. are edible, characterized by uniquely high concentration of vitamin C. On the other hand, it is interesting to note that although the flesh is of good taste, the seeds and hairs need to be rinsed away as they cause choking and irritation of the throat (Mears – Hillman 20007). Fruits of *Rosa* sp. have been found for instance at Danish site of Tybrind Vig (Kubiak-Martens 1999) or at Dutch wetland sites (Out 2009).

Malus sylvestris

Malus sylvetris bears good tasting fruits, although their vitamin content is relatively poor. However, energetic value of dried apples is considerable, since they contain 62% of carbohydrates (Renfrew 1973; Out 2009). Fruit fragments and seeds of *M. sylvestris* have been recovered from many sites in Dutch wetland sites; in some cases even evidence of fruit drying and storage is recorded (Out 2009).

Green vegetables

Many taxa found at the Mesolithic sites represent plants which could have been used as green vegetables, although one should keep in mind that this is extremely difficult to prove. Among these potentially edible taxa, namely *Chenopodium album* (see above), *Urtica dioica*, *Phragmites australis*, *Rumex crispus*, *Rumex* sp., *Atriplex* sp., *Stellaria media*, *Polygonum* sp., *Potentilla anserina* etc. could be considered.

Roots/tubers/rhizomes

As already mentioned, underground storage organs are argued to represent an important food resource in European Mesolithic. Furthermore, many of the following plants are known for their extremely versatile use. A case study concerning the use of *Pteridium aquilinum* is presented below to illustrate this phenomenon. Not only *Pteridium aquilinum*, but also taxa such as *Ficaria verna*, *Bolboschoenus maritimus*, *Beta vulgaris* ssp. *maritimus*, *Typha latifolia/angustifolia*, *Allium* sp., *Sagittaria sagittifolia*, *Polygonum* sp., *Phragmites australis*, *Schoenoplectus lacutris*, *Nymphaea alba*, *Nuphar lutea* etc. should be perceived in this manner.

Pteridium aquilinum

The bracken has been widely utilized in a variety of ways by humans in all parts of the world (Rymer 1976). Bracken has been mainly used as a food. Either the young fronds or the rhizomes have been widely used as food in many areas such as aboriginal Australia, New Zealand, North America, Britain or Japan. Particularly the rhizomes have considerable stores of starch and have been the source for a sort of flour, which was used as a caloric staple by hunter-gatherers such as the Maori of New Zealand (McGlone et al. 2005) and the indigenous people of Western Washington (Norton 1979). The ethnographic record even shows how this fern was collected and prepared as a form of flour and baked or dried into cakes and bread.

The ethnographic record also shows that plant management by burning was occurring in Western Washington in association with bracken, which survives periodic burning well since its top growth dies down in the autumn ant the root system is not harmed by fires. Moreover, not only land management by burning encourage bracken growth, but heating bracken can also reduce its toxicity (Pohl 1955, Norton 1979).

Apart of already mentioned use of bracken as a food resource, bracken fern has been widely used for other purposes such as bedding for animals and man, floor cover, fuel, as ornamental and ritual plant, as dying agent, roofing, baskets, mulch, or as source of potash for the glass and soap industry in various parts of the world in various eras (for further details and literature see Rasmussen 2003). Moreover, in many parts of the world such as Japan, Korea, China or Brazil bracken is still used for food, since the content of ptaquiloside, which causes bracken toxicity, can be significantly reduced by steeping, boiling etc. (e.g. Rasmussen 2003).

Furthermore, to find out if bracken could have been a staple food, Ray Mears and Gordon Hillman conducted an experiment concerning digging up the rhizomes of many populations of bracken in several parts of the British Isles. Surprisingly, they failed to find any with sufficient stores of starch to justify the effort expended, which highlights the importance of detailed local knowledge when foraging for wild foods (Mears – Hillman 2007).

Turning now to the archaeological record, one should bear in mind that spores of bracken fern, *Pteridium aquilinum*, appear in pollen record in Central European Mesolithic (e.g. Pokorný et al. 2008). Another striking fact about that pollen record is that bracken spores seem to be significantly correlated with the human activity and disturbances visible in pollen record (Pokorný 1999; Kuneš et al. 2008).

The important question that remains to be answered is whether bracken fern was utilized by Mesolithic hunter-gatherers, as implied by Western Washington analogy. In this manner, particularly interesting is the case of the Late Mesolithic Netherlands. L. Kubiak Martens (2008) conducted analysis of charred parenchymal tissue from vegetative parts of plants originating from a large number of samples which are associated with the Late Mesolithic site of Hattemerbroek using scanning electron microscope (SEM). She succeeded in identifying parenchymal tissue of at least two types of fern – bracken (*Pteridium aquilinum*) and most likely male fern (*Dryopteris filix-mas*). Those were found along with some other plants such as horsetail (*Equisetum*) or a rhizome belonging to Cyperaceae. According to the author, the context they come from suggests that they represent a food waste, but they must have first become charred, likely during cooking elsewhere.

It is clear at this point that the identification of charred fragments of pyrenchymatical tissue from tubers and rhizomes using SEM is of crucial importance and that evidence gained by this technique is easily overlooked when standard methods of plant identification are used (Perry 1999; Kubiak-Martens 1999; 2008; Mason et al. 2002). However, an identification of root food is not a common part of archaeobotanical research. It is obvious, as already stated, that the analysis of roots and tubers is essential in the study of plant use in the Mesolithic as well as the hunter-gatherer economy. This contribution aims to show that the evidence for the use of root food and other vegetative plant parts can be recovered from many other hunter-gatherer sites and, therefore, the identification of charred fragments of parenchymatous tissue is of special importance in studying Mesolithic hunter-gatherers. Last but not least, it is important to note that the case of bracken fern is only one of many possible plant resources.

Other uses

Apart from plant use for food and medicine, also other uses such as use for dyeing, tanning, constructions, vessels or cordage should be taken into account. Taxa such as *Phragmites australis*, *Pteridium aquilinum*, *Typha angustifolia/latifolia*, *Quercus* sp., *Cornus sanguinea*, *Urtica dioica* etc. can be mentioned here.

3. Food preparation and consumption

Primarily it is important to note that data concerning food preparation and consumption are very scarce and methodology often coarse. Human subsistence practices are therefore difficult to reconstruct, particularly in case of plant foods. Hence, several lines of evidence are under consideration. Diet measurement from bone chemistry brings direct dietary reconstruction (e.g. Sealy 2001). Animal and plant remains as well as study of artefacts and archaeological structures, on the other hand, represent indirect evidence of past diet and food preparation (Fischer et al. 2007).

Direct method of dietary reconstruction is represented particularly by stable isotope analysis. With respect to the Mesolithic, recent research has mainly focused on a sharp shift in subsistence practice during the transition to farming. For further information see appendix. An alternative approach regarding the direct evidence on specific food consumption may be derived from studying human coprolites. Such evidence is recorded in Central Russia, where water lilies seed were found in coprolites from the early Mesolithic cultural layer at the site Ivanovskoye VII (Zhilin – Karhu 2002, 115). Also, analysis of pollen from coprolites at Vlasac may be mentioned (Cârciumaru 1978), since they may provide insight into Mesolithic subsistence by detecting potentially edible plant such as pine, oak, walnut or hazel. However, association of these coprolites with Mesolithic layers is arguable (see Kozlowski – Kozlowski 1986, 97). Similarly, pollen of *Hippophae*, *Solanum dulcamara* and *Sambucus nigra* was contained in coprolite from Schipluiden. This coprolite may, however, belong to human or large dog (Bakels 2006).

Reconstructing food procurement in the Mesolithic has mostly been dealing with animal remains clearly visible in the archaeological record, whereas plants have been long neglected and tend to be underestimated due to various factors such as poor preservation or insufficient research methods (Zvelebil 1994; López-Dóriga 2012). With respect to preparation practices and cooking techniques, one should bear in mind that many practices such as grinding, pounding, sun-drying, eating raw foods are extremely difficult to trace archaeologically. However, present-day research is able to detect even some of these techniques through the study of phytoliths, starch residues or by means of use-wear analysis of tools. As an example, detection of *Corylus* sp. and *Quercus* sp. starch granules on artefacts associated with nut remains from the site of Font del Ros, Spain can be mentioned (Martinez-Moreno – Mora Torcal 2011 after Juan

1997). Another example comes from the territory of the Czech Republic, where analyses of stone tools including microscopic use-wear and residues analyses were performed and plant processing as the primary activity at the short-time site Pod Křídlem was suggested. Alternatively, stone tools recovered from long-term site Pod Zubem indicate they were used on a variety of materials. These traces, however, cannot be clearly associated with food preparation (Hardy – Svoboda 2009).

Considering the evidence from plant macroremains found within the archaeological context (see chapter 2.2.3), it is possible to observe particular plant species probably used. On the other hand, one should bear in mind that available evidence brings information concerning domestic preparation and consumption, since presented data come from the archaeological sites. Therefore, off-site practices may have been undervalued, particularly in case of species such as *Rubus* sp., *Rosa* sp., *Sambucus* sp., *Vaccinium* sp. etc., which may have been consumed on the hoof (Out 2008a, 92).

Special attention is paid to acorns as a food resource. Literature review dealing with current knowledge of acorns as a food resource in prehistoric Europe is presented. Furthermore, experimental work shedding light on the question of the taste of acorn products, which is closely linked to preparation methods, is included and reported below in chapter 3.1.

Archaeologically, some specific cooking techniques are associated with particular features. Those are summarized and discussed also with respect to archaeobotanical implications separately in chapter 3.2.

3.1. Acorns as a food resource

Acorns as a food resource. An experiment with acorn preparation and taste[1]

Tereza Šálková[1,2], Michaela Divišová[1], Štěpánka Kadochová*3*, Jiří Beneš[2], Kateřina Delawská[1], Eva Kadlčková[1], Lenka Němečková[1], Kamila Pokorná[2], Václav Voska[1], Andrea Žemličková[2]

[1]University of South Bohemia, Laboratory of Archaeobotany and Palaeoecology, Faculty of Science, Branišovská 31, 370 05 České Budějovice, Czech Republic; [2]University of South Bohemia, Department of archaeology, Faculty of Philosophy, Branišovská 31, 370 05 České Budějovice, Czech Republic; [3]Charles University, Department of Ecology, Faculty of Science, Viničná 7, 128 44, Prague 2, Czech Republic

Key words: acorns, prehistory, taste experiment, statistics

Abstract

This paper summarizes our current knowledge of acorns as a food resource in prehistoric Europe. It sheds light on the question of the taste of acorn products, which is closely linked to preparation methods. An experiment was conducted that consisted of the preparation of eight different acorn recipes, human tasters, a questionnaire-based survey, and statistical evaluation. The paper presents the various factors that testers indicated had an effect on the taste of differently prepared acorn products.

Introduction

Although oaks formed a significant component of European prehistoric landscape, their potential as a food resource has been underestimated relative to other plant foods. In spite of their characteristic taste, acorns have always been an attractive food resource, and exploited by humans. This contribution considers acorns and their importance in human diet throughout European prehistory. Additionally, the paper

[1] The main contribution of the author is the review of current knowledge of acorns as a food resource in prehistoric Europe, which is presented in this chapter. Further, the author contributed to the experiment, which is described in detail in Šálková et al. 2011 (http://www.iansa.eu/papers/IANSA-2011-02-salkova.pdf) and also briefly summarized as part of the chapter.

examines some methods of acorn processing and how various factors affect the taste of acorn products.

Oaks

From the beginning of the Holocene oak trees were an important element of the vegetation of much of Europe (Pokorný 2004; Dreslerová et al. 2007; Kuneš 2008). The common presence of oaks in forests throughout prehistory is evidenced by the numerous charcoal fragments found within the archaeological record of most prehistoric cultures (Vencl 1985, 535). In the Boreal period (Mesolithic, 11,500–8,900 BP), mixed oak forests (Quercetum mixtum) increasingly dominated the forest landscape. Mixed forests expanded from the floodplains to their current range and then gradually transformed to acidophilous oak forests. A new type of forest, in which beech and fir were the dominant species, spread and became dominant in the Subboreal period (Eneolithic – early Iron Age, 5700–2600 BP). However, the process of the degradation of mixed oak forest and the spread of modern forest communities was asynchronous (Dreslerová et al. 2007, 41-44).

Apart from acorns for food, oaks were exploited for numerous other purposes, including construction material, charcoal production, firewood, production of rope, and the extraction of tannin (Rosenberg 2008, 169). The use of oak (along with hazel, elm, ash, linden, willow, maple, alder and fir) as brush-wood fodder in winter during early prehistoric agricultural development was also of crucial importance (Dreslerová et al. 2007, 48; Hejcman et al. 2014).

Acorns as a food resource

Acorns are nutritionally comparable to cereals, being largely a source of carbohydrates, fats and fibres. Acorn also contains proteins, amino acids and vitamins, mostly A and C (Rosenberg 2008). The caloric value of acorn varies between species, but ranges between 265 and 520 calories per 100g (see Rosenberg 2008). Additionally it has been proven that acorns have antioxidant effects (Rakić et al. 2006). In the right conditions acorns may also be stored for long periods (Mason 1995; Cunningham 2011).

On the other hand, acorns also contain a high concentration of tannic acid, a mild toxin which gives them a bitter taste. The concentration of tannin varies between oak species and even between individual trees of one species (Mason 1995). Some oak species produce acorns low in tannin and all acorns are edible when properly prepared. Tannins can be removed by a variety of methods such as soaking in water, boiling, roasting or even simply burying them in the ground (see Vencl 1985 for further details).

Vencl (1996) notes several factors limiting the exploitation of acorns as food. First, individual oak species differ in their annual fruit production and acorn taste. Oak begins to bear fruit after about 25 years. Even though oak trees usually produce a plentiful crop of acorns, a rich crop does not occur annually, and the interval between good yields varies by species. Although this irregularity of availability could be compensated by the durability of acorns and the coexistence of diverse oak species within one area, it can be assumed that this was a factor that limited oak cultivation (Vencl 1996, 95). Both good and poor producers tend to be similarly represented in the fruiting population (Greenberg 2000). With regard to central European oaks (*Q. robur* and *Q. petraea*), which go through a 2 to 6 year cycle, Karg and Haas have suggested that these could have been managed in prehistory in order to increase the availability of nutrient resources and consequently to enlarge the yields (Karg – Haas 1996). Another factor limiting acorn exploitation for food includes the amount of work involved in preparation.

Acorns were also exploited by past communities for many other reasons. They were consumed in the form of bread, soups, porridge, or as a coffee substitute right up to modern times (Rakić et al. 2006). Since acorns are also a source of food for many domestic animal species, the occurrence of acorns in archaeological contexts may result from their use as livestock fodder (Vencl 1996, 96-97). The use of acorrns for pig food has also been well documented since medieval times (Le Goff 1991). It should also be mentioned that acorns could be used for the processing of animal hides or dyeing (Vencl 1985). With respect to medicine it has been reported that oak acorns can be used to reduce urination, treat wound and inflammation, stop bleeding and to treat kidney stones (Lev – Amar 2000; Lev 2002).

Acorns in prehistory

In evaluating the evidence for acorn use by ancient communities, we need to consider several issues. First, one should bear in mind that the recovery of plant remains depends on harvesting and processing methods, preservation conditions, and method of retrieval (Dennel 1976). In the case of acorns, poor preservation results from certain processing techniques, due to carbonization which usually destroys the thin-walled shells (Lev et al. 2005). Additionally, the manner and location of acorn processing may have been undertaken completely or partially off site (Lev et al. 2005). Moreover, a limited use of flotation techniques in Europe and significant national and regional differences in the intensity of archaeobotanical research (Vencl 1985; Mason 1995), result in an underestimation of acorns as a source of human nutrition in the past. On the other hand, it needs to be stressed that recent research has put acorns as food into a new perspective. Currently, there is no doubt about the extensive use of acorns as food in prehistory (e.g. Vencl 1985; 1996; Mason 1992; 1995; Karg – Haas 1996; Kubiak-Martens 1999; Bouby et al. 1999; Lev et al. 2005).

To summarize, acorns are a food resource that could have played an important role in prehistoric human subsistence in Europe. As already stated, finds of charred acorns are not exceptional, and occur from the Mesolithic through to modern times throughout Europe. A considerable body of research indicates that acorns were used both occasionally, in emergencies, and systemically. The archaeological record, however, cannot resolve whether the individual findings represented a staple or a sporadic food resource (Vencl 1985, 552). Acorn use has been widely investigated ethnographically, including a well-known ethnographic study of acorns use for human consumption in prehistoric California (e.g. Mason 1992). Aside from ethnographic research, finds of charred acorns in archaeological contexts have been examined and discussed by several authors (see for instance Vencl 1985, 1996; Mason 1992; De Hingh 2000).

Although plant remains are scare in the Palaeolithic, the oldest acorns have been found in a number of Palaeolithic sites in the Near East (e.g. Kislev et al. 1992; Goren-Inbar et al. 2002; Aura et al. 2005; Lev et al. 2005). In light of this, it is thought that acorns may have been a staple plant food long before the maximal spread of oak that occurred during the Atlantic period (late Mesolithic and Neolithic, 8900–5700 BP) (Vencl 1996, 100).

During the Mesolithic, finds of concentrations of charred acorns increase (Zvelebil 1994; Vencl 1996; Kubiak-Martens 1999; Aura et al. 2005), in accord with the spread of oak forests, which enabled intensive acorn gathering. Mason (2000) considered the possible role played by fire in the Mesolithic, and from ethnographic and ecological data suggested that fire could have been used to manipulate the acorn supply. This approach to Mesolithic forest burning challenges the traditional view that fire might have been used mainly to improve hunting by improving the productivity and nutritional quality of animal forage, or to attract animals or to improve visibility of animals by reducing their cover (Mason 2000, 139-140). Mason focuses on the manner in which burning contributes to acorn gathering. She posits that burning reduces competition for nutrients etc. from other species, and in so doing concentrates available resources to the acorn crop. In addition, removing ground cover facilitates the gathering of acorns.

It should be clear at this point that during the pre-agricultural period acorns were an important plant food resource for hunter-gatherers in Europe. One should also bear in mind that archaeological evidence supports the conclusion that acorns have always been an attractive food resource within various resource strategies, including agrarian societies. According to De Hing (2000, 200-202) acorns in prehistoric agricultural communities may have played a role as food substitute or reserve for bad times, reserved for emergencies, for example when cereal agriculture had failed.

Within the context of agricultural sites acorns are usually located close to fireplaces and in furnaces. Frequently they are accompanied by other crops (De Hingh 2000). In addition, acorns are common finds in vessels and storage pits. They are often shelled and mixed with cereals. Acorns also occur in shallow pits and are also found unshelled (Deforce et al. 2009). Acorns are found in graves, and their use as a sacrifice cannot be discounted (Vencl 1985).

There is no doubt that there is sufficient evidence for acorn use in human subsistence in prehistory, as proved above. The focus of this article is on the way in which acorns may have been processed to remove their tannins when using them for food. In order to do so we conducted an experiment, described below, the aim of which was to identify how preparation methods affect the final taste of the product.

Experiment: discussion and conclusions

Though acorns are considered to be unattractive as a food resource, previous studies have clearly demonstrated that acorns were very likely used as a food resource throughout prehistory. The present study brings a new perspective on the acorns as a food.

Our experiment found no substantial difference in the taste of pure acorn products, by preparation method (the way in which tannin is removed). On the other hand, not surprisingly, that taste of pure acorn products differed significantly from those with added wheat flour. This may be caused by the fact that tasters are used to the taste of wheat, contrary to acorns. Adding wheat flour likely mitigated the acorn taste and the mixed flour products were consequently thought tastier.

We should also consider the fact that samples processed by acorn shelling, grinding and subsequent roasting of acorn flour resulted in a less tasty product than other procedures. This result could indicate that the procedure failed to remove the tannins. Consequently, this preparation method appeared to be unsuitable in comparison to others used in the experiment.

Tasting results of the remaining samples varied depending upon the addition of wheat flour, acorn source, and the respondent (gender, field of study). According to these results it is reasonable to assume that final taste of acorn products may not have played a crucial role in the choice of preparation method. Rather, the amount of time, labour and energy invested in the procedure could have been of greater importance.

It is worth considering the variability in results found in relation to acorn source and tester. Since oak trees are tolerant to many different conditions, it seems that taste differs in relation to various environmental conditions under which oaks grow. In addition, some variability could be also explained by minor baking differences of the individual experimentators.

In summary, this paper clearly shows that modern humans are able to consume acorns after proper preparation. The statistical evaluation of test data shows that pure acorn products were rated between 4 and 5 on a scale of 1 (excellent) to 7 (disgusting). Interestingly, a common commercially available Czech rye wheat bread was evaluated as 4 on the same scale, by selected testers.

Taking into account that acorns are nutritionally comparable to cereals, the results support the hypothesis that acorns could have been a human staple, particularly in the preagricultural period. On the other hand, there are some factors limiting the possible exploitation of acorns (see Part 1.2 of the paper), including the amount of work involved in acorn preparation. These are of interest and will be the subject of authors' further investigations.

Acknowledgement

We are extremely grateful to Dr. Sabine Karg and Prof. Mirosław Makohonienko for thir critical reading and helpful remarks upon earlier version of this paper. We also thank Doc. Jaromír Beneš and the Laboratory of Archeobotany and Palaeoecology, University of South Bohemia, České Budějovice for support. We would like to express our appreciation to everyone who participated in the experiment. We would particularly like to thank Lucie Ambrožová, Jiří Bumerl, Tereza Hausteinová, Monika Hrušková, Jitka Kosňovská, Tomáš Kuneš, Hana Mácová, Eliška Maršálková, Martin Pták and Blanka Slabochová. We are also indebted to the Institute of Prehistory; Adam Mackiewicz University, Poznan. The work was supported by a grant from the Faculty of Science, University of South Bohemia (MSMT 6007665801 & GAJU 138/2010/P).

3.2. Food preparation practices in the European Mesolithic with emphasis on hearth-pits: an experimental approach

Food preparation practices in the European Mesolithic with emphasis on hearth-pits: an experimental approach (in preparation)

Michaela Divišová[1], Tereza Šálková[1,2], Petr Šída[3], Jaromír Beneš[1]
[1]University of South Bohemia, Laboratory of Archaeobotany and Palaeoecology, Faculty of Science, Branišovská 31, 370 05 České Budějovice, Czech Republic; [2]University of South Bohemia, Department of archaeology, Faculty of Philosophy, Branišovská 31, 370 05 České Budějovice, Czech Republic; [3]Department of Archaeology, Faculty of Philosophy and Arts, University of West Bohemia in Pilsen, Sedláčkova 38, 306 14 Pilsen, Czech Republic

Abstract

Food preparation practices in the European Mesolithic have been seriously understudied, particularly in view of the lack of data. Therefore, presented work attempts to shed some light on this issue on the basis of several lines of evidence. Selected archaeological features occurring within the European archaeological record, accompanied particularly by ethnoarchaeological and experimental data, are presented. Particular attention is paid to experimental work dealing with hearth pits.

Keywords: Mesolithic, cooking techniques, hearth-pits, experimental archaeology

Introduction

A study of food preparation practices in prehistoric European hunter-gatherer societies represents issue which has received little attention. Such situation may have arisen due to various issues such as scarce archaeological evidence and poor preservation conditions. Therefore, this paper aims to bring a clearer picture of Mesolithic cooking practices on the basis of encounter of several disciplines – archaeology, ethnoarchaeology, and experimental archaeology. Special attention is paid to the issues of recognition of selected features in the archaeological record and suitable methods of their research.

Mesolithic cooking techniques and associated archaeological features

With respect to a variety of cooking techniques and associated archaeological features, several lines of evidence are presented. This is not meant to be a complete review of the subject. Rather, some particular features and their illustrative examples are presented with regard to their visibility in the archaeological record. Therefore, procedures including pounding, grinding, sun-drying, eating raw foods etc. are not considered here.

Surface hearths

Surface hearths represent a common archaeological feature occurring at Mesolithic sites. They are generally assumed to have been used for preparing all kinds of food such as those reconstructed in Fig. 3.1, which displays roasting fish over the fire as well as on the hot stone, baking cakes made from cattail (*Typha latifolia*) and acorns (*Quercus robur*) using hot stone or smoke-drying of wild boar meat. Unfortunately, these surface hearths, particularly the non-structured ones, are seldom visible in the archaeological record mainly due to their short-time use, soil conditions etc. (Sergant et al. 2006). Moreover, organic remains recovered from these hearths are commonly interpreted as food remains. Nevertheless, one should bear in mind that these finds may represent waste thrown into the fire instead of evidence of specific cooking techniques.

Baking in clay

Another cooking technique that may have been performed using hot ash in surface hearth is baking of fish/meat in clay. However, this technique can be accomplished just as well using stone-lined pit or hearth-pit without heated stones (see below). Unfortunately, there is no direct evidence for this practice from the European Mesolithic and referring archaeological evidence in the form of stone-lined pit with a great amount of burnt clay comes for example from the following Neolithic and Bronze Age (e.g. Higgenbotham 1977). At this point it is important to note that baking in clay produce the amount of small fragments of amorphous, slightly burned clay, which can be mistakenly interpreted as daub when recovered from the archaeological record (Wood 2000).

Roasting hearths

Features interpreted as roasting hearths are known from the Mesolithic sites such as Duvensee in Northern Germany. Local roasting structures consist of pine and birch bark covered with a layer of sand mixed with ash, charcoal, hazelnut shells and lithic artefacts (Fig. 3.2a). These features have been interpreted as roasting facilities for hazelnuts (Holst 2007; 2010; 2011). The roasting process can be reconstructed as follows: hazelnuts were placed into shallow depressions with sand layer, where fire had burned out and the glowing charcoal was mixed into the sand. Hazelnuts were then buried and roasted using the hot sand. This is also supported by ethnographic data, since similar structures are well-known for roasting mongongo nuts (*Schinziophyton rautanenii*) by the Kalahari !Kung (Lee 1973). Hazelnuts roasted in such way are easy to transport by reducing the weight and storable for long periods. Furthermore, roasting facilitates hazelnut cracking and grinding, destroys contaminants, induces nutty flavour and digestion and last but not least enables their synchronous harvest (Mithen et al. 2001; Mears – Hillman 2007; Holst 2010). Above mentioned information are also confirmed by experimental work (Mithen – Score 2000; Mears – Hillman 2007, 22-28).

Boiling and steaming pits

Features interpreted as boiling pits represent other features occurring at Mesolithic sites. These could be describes as cattle-shaped pits, spatially associated with other hearths, and surrounded by heated pebbles. Such features have been revealed for instance at the North Bohemian rockshelter Okrouhlík, Czech Republic (Fig, 3.2b) (Svoboda et al. 2007; Svoboda 2008). Ethnographically and experimentally, these pits are lined with bark or animal hide and filled with water. Then, water is brought to the boil using stones, heated in nearby hearths, as heat accumulators. As the stones cool, they are replaced by hot ones as needed. Ethnographic record also brings evidence that most foods are cooked within the range from 15 to 30 minutes (Wood 2000; Thoms 2006). Furthermore, ethnographic and experimental data indicate that steaming pits should be distinguishable from boiling pits in the archaeological record primarily by the presence of large- and medium-size stones in comparison to small-size (less than 10 cm in diameter) stones expected to characterize boiling features. Also, pit steaming is referred to as being used for cooking plant and root foods in particular (Thoms 2006).

Hearth-pits

Firstly, the archaeological record brings evidence for cooking practices using hearth-pits in the form of sunken features lined with stones (Fig. 3.2c). These have been documented at Mesolithic sites such as Staosnaig, Scotland (Mithen – Finlay 2000, Fig. 5.2.35), or Dolský Mlýn, Czech Republic (Svoboda 2003, 94-95; Svoboda et al. 2007). The stone-lined shallow pits are also known ethnographically (Wandsnider 1997; Peacock 2002; Thoms 2006). According to the latter line of evidence, open stone-lined pits are used to process mostly plant tissues, whereas closed hearth pits with the stones are referred to as being used for processing of meat of any kind, as first step in drying process or for immediate consumption (Thoms 2006). Despite lack of direct evidence of such a process, cooking underground in this way can be reconstructed on the basis of experimental work as follows. Firstly, suitable rock element is put in a fire. When the rock is hot, a created hole in the ground is lined with it. Afterwards, meat, roots or other underground storage organs are placed straight on the hot rocks, followed by more hot rocks, mat of leaves and enclosing with earth. Archaeologically, this process results in sunken feature lined with stones, ash, and charcoal (Mears – Hillman 2007, 84-85).

The other kind of the Mesolithic hearth-pits is characterised by the absence of heating stones. These represent typical Mesolithic feature, especially in the sandy European regions. Numerous finds of these features come particularly from the area of northern Belgium, the Netherlands and neighbouring part of Germany. These hearth-pits can be defined as relatively small (generally < 1 m in diameter) and relatively deep (mean depth 0.4–0.5 m) bowl-shaped features with a round to oval outline, filled either entirely or partially with a dark charcoal-rich matrix (Fig. 3.2d). Most hearth pits are archaeologically sterile, as they only contain charcoal fragments and ash. Occasionally small amounts of (un)burnt lithics, bones, and hazelnut shells are reported (Groenendijk 1997; Crombé et al. 2005; 2013; Fries et al. 2013). However, similar structures are also known, for instance, from the site of Halsskov in Denmark, where shallow depressions and pits consisting of sandy clay, charcoal, ash and charred twigs were identified (Kubiak-Martens 2002, 30).

However, tough issue that remains to be answered is the function of the last mentioned features. Functions suggested in literature are summarized in Tab. 1. With respect to food preparation, ethnographic record evidences that animal as well as plant tissues were processed using hearth-pits (Davis et al. 1994; Wandsnider 1997, 19). However, these data include pit-hearths lined with stones as those without them.

Nevertheless, according to data concerning food processing and food preparation (length of cooking time and temperature) hearth-pits with no rock heating element are not suitable to hydrolyse inulin-bearing plants or fatty meats. Rather, seeds, roots, tubers, or lean meat could have been processed there (Wandsnider 1997, 29). The last option concerning lean meat processing using hearth-pit without stones was reconstructed by means of experiment presented below.

Tab. 1: Possible functions of the hearth-pits without heating stones. After Fries et al. 2013, modified.

Suggested function	**Reference**
Drying/smoking non-food items	Groenendijk 1987
Drying/roasting/smoking meat	Groenendijk 1987; Jansen – Peeters 2001
Plant processing	Perry 1999; Kubiak-Martens 2002
Charcoal production	Hermsen 2006
Resin production	Kubiak-Martens et al. 2011

Hearth-pit cooking: an experimental approach

The purpose of the conducted experiment was to find out whether a piece of meat can be processed in hearth-pit without the use of heating stones, since there is little archaeological, ethnographical, and experimental evidence for such cooking technique.

The experiment was conducted in Strakonice, Czech Republic, as follows (Fig. 3.3): Two pits (final size: 50 cm in diameter, depth 35 cm) were created in the ground. One of them was lined with 20 cm thick layer of sand serving as a heat conductor, since most such hearth-pits are archaeologically documented in sandy areas. A fire was lit in the pits and maintained till sufficient amount of hot ash and glowing charcoal was gained. For this purpose, pine wood was used. At this point a piece of wild boar meat of about 1kg was wrapped into soaked birch bark and put into each pit with hot ash and glowing charcoal. Immediately afterwards, the pits were covered with pieces of moss and turf to prevent material inside the pits from burning or charring. Since there was still observable rising smoke signifying burning, the pits were covered with the layer of clay. Afterwards, a fire was lit on the surface of the pits. After four hours, the pits were opened and meat was taken out.

Both pieces of meat were perfectly cooked – sufficiently roasted as well as juicy enough. This can indicate that such roasting features without heating stone can also occur in other regions, not only in the sandy areas. The presence of sand, however, may allow processing of larger amount of foods since sand acts as heat conductor instead of heating stones.

It is also important to note that the pits after removing meat contained only charcoal and pieces of burned clay. All other organic material consisting of bark, moss, and turf remained uncarbonised (Fig. 3.4). Ethnographic data also confirm that the only plant materials that came into direct contact with fire was firewood, whereas meat or plant foods processed in the hearth-pits are covered in foliage or bark to avoid burning (Peacock 2002).

On the basis of mentioned above, it is questionable if such object could be recognized in the archaeological record, in particular when revealed within previously unknown settlement. This experimental work has following implications for the design of research method when studying such objects in the archaeological record. It is important to bear in mind that the only feature detectable in the archaeological record remains shallow pit containing charcoal and fragments of slightly burned clay. Besides, archaeobotanical assemblage associated with these structures would be likely dominated by the carbonised remains of firewood. However, this may not be true in case of unsuccessful food processing. Also, depending on the preservation conditions, the presence of meat or plant foods could be tested on the basis of protein, fat, phytolith or starch residues analyses.

Conclusions

Review of selected archaeological features occurring in the archaeological record along with ethnoarchaeological and experimental work gives some evidence of food preparation practices in Mesolithic Europe. Moreover, experimental investigation of the heart-pits has brought important information concerning possible function of such features and also their detection within the archaeological record.

Fig. 3.1. Experimental roasting of fish over the fire as well as on the hot stone, baking cakes made from cattail (*Typha latifolia*) and acorns (*Quercus robur*) using hot stone and smoke-drying of wild boar meat. Photo provided by Sofie se baví festival.

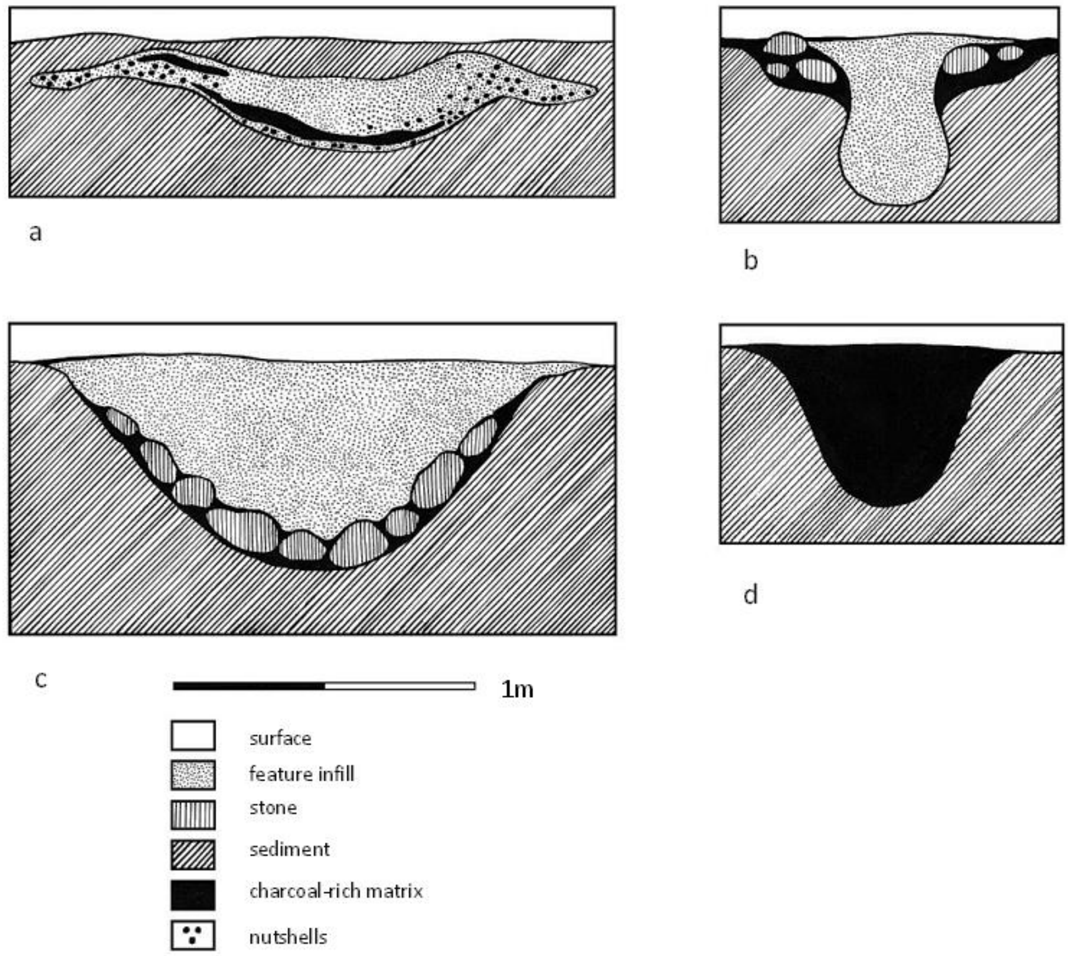


Fig. 3.2. Schematic illustration of archaeological features associated with food preparation. Modified after Holst 2010, Svoboda et al. 2007; Svoboda ed. 2003; Fries et al. 2013. (a – roasting pit, b – boiling pit, c – hearth-pit lined with stones, d – heart-pit without stones). Drawing by N. Vadlejchová.

Fig. 3.3. Hearth-pit cooking. An experimental approach. Photo: author.

Fig. 3.4. Remains after experimental hearth-pit cooking. Photo: author.

4. Archaeobotany of Schwarzenberg Lake, South Bohemia

4.1. Introduction

The former Schwarzenberg Lake site is located in the northern edge of the Třeboň Basin, South Bohemia, Czech Republic (49° 9' N, 14° 42' E) at 412 m a.s.l. (Fig. 4.1). The site was discovered in 1970s, when V. Jankovská identified lacustrine sediments under a peat layer in the wetland area adjacent to the present-day fishpond (Jankovská 1980). The uninterrupted sequence of deposited sediments is unique for its potential based on conditions suitable for both, palaeoenvrionmental and archaeological research. Therefore, investigations of the lake have brought important data on vegetation, landscape development and human occupation since the end of Last Glacial Maximum (Pokorný – Jankovská 2000; Pokorný et al. 2008; 2010). Fig. 4.2 presents situation plan of the study area with displayed cores, trenches, sections, and archaeological sites.

The chronology of the sedimentary record was based on radiocarbon dates and on relative palynostratigraphic dating. The central profile, whose lower 5 meters had arisen in the course of late glacial era, was used for reconstruction of the development of vegetation and geochemical changes in the catchment area of the lake in connection with the rapid global climatic changes at the turn of the Pleistocene and Holocene. It is interesting to note that there was success in correlating traces of aeolian activity detectable in the lake sediments to the appearance of aeolian sand dunes in the region, and in explaining this phenomenon as a reaction to climate deterioration which occurred at the beginning of the Younger Dryas (Pokorný – Růžičková 2000). With regard to the origin of the lake, it can be viewed as the remnant of some kind of a compound Late Glacial Maximum *pingo* (ground-ice lens) structure (Pokorný et al. 2008; 2010). Vegetation dynamics and the infilling process of the lake were studied by means of pollen analysis, algae remains, and macroremain analssis (see Pokorný – Jankovká 2000; Pokorný et al. 2010 for further details). According to the latest research Schwarzenberg Lake is not an isolated phenomenon in the region. The presence of other features of this kind was revealed in the area of present-day Velký Tisý pond (Šída – Pokorný 2011; Hošek et al. 2013). This area also shows signs of human occupation in the Mesolithic period.

Another point deserving attention is finding of exceptionally intensive settlement in the Early and Middle Holocene periods, which was first discovered indirectly based on the presence of pollen grains of anthropogenic indicators and large quantities of microscopic charcoal particles in lacustrine sediments (Fig. 4.3) (Pokorný 1999; Pokorný et al. 2008; 2009; 2010).

Mesolithic occupation was confirmed and further studied by means of archaeological research, focused on the wet shore of the former lake as well as on dry archaeological situations lying on the sandy peninsula adjacent to the original shore of the lake (see Fig.4.2). As already noted, wetland researched concentrated on the least disturbed southern section of the shore. This research fulfilled the potential of wet shore sections and provided the organic strata rich in pollen grains and vegetation remains including large pieces of fresh wood. Also, finds of plant macroremains of *Corylus avellana*, *Rubus idaeus*, and *Rubus saxatilis* within the lake sediments point to the Mesolithic settlement, likely representing gathered foodstuff. Moreover, the finds of *Corylus avellana* and *Trapa natans* are dated to the very beginning of the Holocene and could be related to their introduction to the region (Pokorný et al. 2008; 2009; 2010).

Dry archaeological research has taken place at location no. 7, sandy peninsula, which is characteristic by number of archaeological sunken features and abundant Mesolithic industry. Special attention needs to be paid to the feature 9 interpreted as Mesolithic hearth-pit, since its infill forms key material for macroremains analysis (see below). This unique feature has contained a large number of burnt argillaceous slabs, which likely constituted the hearths. Their interference indicates that the hearth was repeatedly renewed. The only exception is the uninterrupted situation located in the northwest end of the feature, which has interesting stratigraphy (Fig. 4.6). A burnt infill was found at the bottom of the sunken feature, which had to be dug into the sand in this position. Above that, diversified layers of sand, charcoal, and argillaceous slabs follow. At the top, two reddish clay structures mixed with charcoal were detected. This feature is interpreted as remains of special hearth for preparing food (Pokorný et al. 2010; Šída et al. 2010).

The primary aim of the analysis is to shed some light on the character of the infill of above mentioned archaeological feature, eventually to bring data enabling feature interpretation, hence unravel its function. A further aim is to get better understanding of taphonomy and depositional dynamics that could explain the assemblage composition.

4.2. Material and methods

For the archaebotanical analysis, material recovered from the archaeological features located at Schwarzenberg site 7 was used. A number of samples, from which 19 have been processed to date, were collected. For list of processed samples, their volumes and number of identified plant macroremains see Tab. 4.2. Unfortunately, only 4 samples contained plant macroremains, from which only 3 samples, all retrieved from one archaeological feature, comprises representative amount of plant macroremains.

The macroremains samples were processed by water flotation with a 0.25 mm sieve. All samples were dried at room temperature. The samples were processed in the entire volume. Plant macroremains and fungi sclerotia were picked out and microscopically (Arsenal SZP3112-T ZOOM, magnification 6.2 - 50x) determined according to Berggren (1981); Anderberg (1994); Cappers et al. (2006); and the reference seed collection from the Laboratory of Archaeobotany and Palaeoecology, Faculty of Science, University of South Bohemia. Plant names are according to Kubát and colleagues (2002).

The plant taxa were separated into ecological groups according to their specifications and environmental requirements (Hejný – Slavík eds. 1988-1992, Slavík ed. 1995-2000, Slavík – Štěpánková eds. 2004, Štěpánková ed. 2010). Ratios of ecological groups based on the abundance of particular subfossil and charred macroremains were plotted. Tab. 4.1 shows ecological groups that are distinguished. This classification is meant only as method to examine taxa composition within individual archaeological features. Nevertheless, it is important to bear in mind that the distinction between some groups is not precise, since some taxa commonly occur in more than one community. Moreover, modern plant ecology may have differed from that of ancient plant communities.

Tab. 4.1. Ecological groups used for the classification of macroremains

Ecological groups
1 Ruderals and taxa indicating disturbance
2 Taxa of grasslands
3 Taxa indicative of wet meadows, exposed pond bottoms, and banks
4 Taxa indicative of open water
5 Taxa that cannot be associated with specific ecological conditions

4.3.Results

A total of 835 plant macroremains belonging to 38 taxa have been identified. Tab. 4.4 shows the results of processed samples. Tab. 4.4 shows the number of macroremains and taxa of representative samples for each ecological group. The small numbers of samples significantly restrict the representativeness of the results, since most samples showed to be sterile. The assemblage consists of waterlogged and carbonised taxa. Unfortunately, macroremains of these two groups cannot be distinguished without their destruction, which may be attributable to their state of preservation in organic-rich sediment. The samples contain a large number of fungal sclerotia of *Fungi*. Also, carbonised bulbs/roots/tubers and fragments of mosses formed significant portion of the assemblage.

All representative samples containing plant macroremains show similar structure with respect to distinct ecological groups (Graph 4.3). A significant majority of identified plants indicate wet environments such as wet grasslands, exposed pond bottoms, and banks. Especially *Eleocharis ovata*, *Carex bohemica* and *Ranunculus sceleratus* are well represented. The presence of taxa associated with open water in case *of Batrachium* sp. and *Potamogeton* sp. was also detected. On the other hand, *Rumex acetosella* and *Hypochaeris glabra* can be associated with grasslands. Finally, the rather scarce occurrence of *Chenopodium album*, *Potentilla anserina*, and *Stellaria media* point to disturbance of the vegetation, probably due to anthropogenic influence.

For radiocarbon dates obtained from feature 9 see Tab. 4.3, Fig. 4.5.

Tab.4.2. List of processed samples providing information on their location (see Fig. 4.4), number and concentration of plant macroremains.

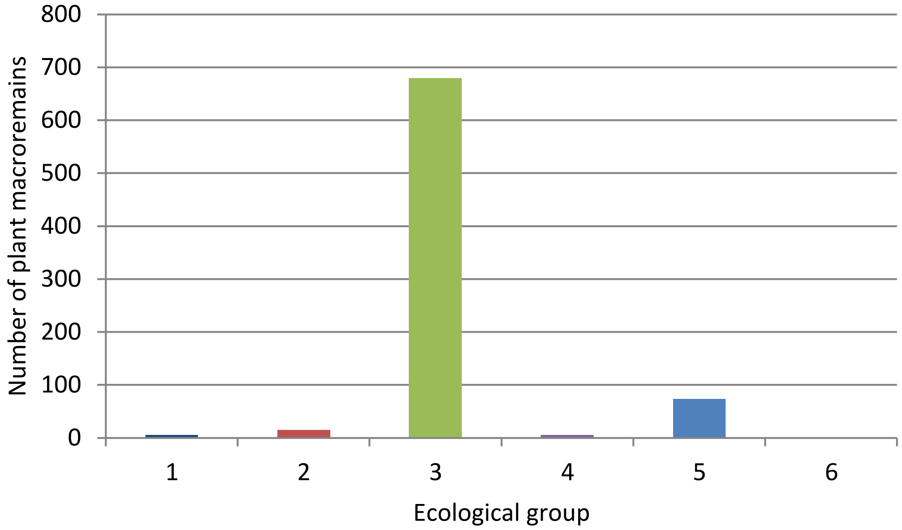
Sample	Location	context	Volume	Number of plant macroremains	Macroremains concentration (number/l)
1	G1A C	feature 9, layer 1	12 l	713	59.4
2	G1A C	feature 9, layer 2	12 l	59	4.9
3	G2B A	feature 9, layer 1	10 l	59	5.9
4	G2B A	feature 9, layer 2	12 l	4	0.3
5	G4C B	layer 1	20 l	_	_
6	G4C B	layer 2	20 l	_	_
7	G4C B	layer 3	20 l	_	_
8	G4C B	layer 4	20 l	_	_
9	G5D B	layer 1	20 l	_	_
10	G5D B	layer 2	20 l	_	_
11	G5D B	layer 3	20 l	_	_
12	G5C A	layer 1	20 l	_	_
13	G5C A	layer 2	20 l	_	_
14	G5C D	layer 3	20 l	_	_
15	G2B D	feature 9; argillaceous slab	1.4 l	_	_
16	G2B D	feature 9; argillaceous slab	2 l	_	_
17	G2B D	feature 9; argillaceous slab	1.1 l	_	_
18	G2B C	feature 9; argillaceous slab	3.5 l	_	_
19	G2B C	feature 9; argillaceous slab	0.25 l	_	_

Tab. 4.3. Radiocarbon date obtained from feature 9, calibrated with OxCal v. 4.2.3. (Bronk Ramsey 2009).

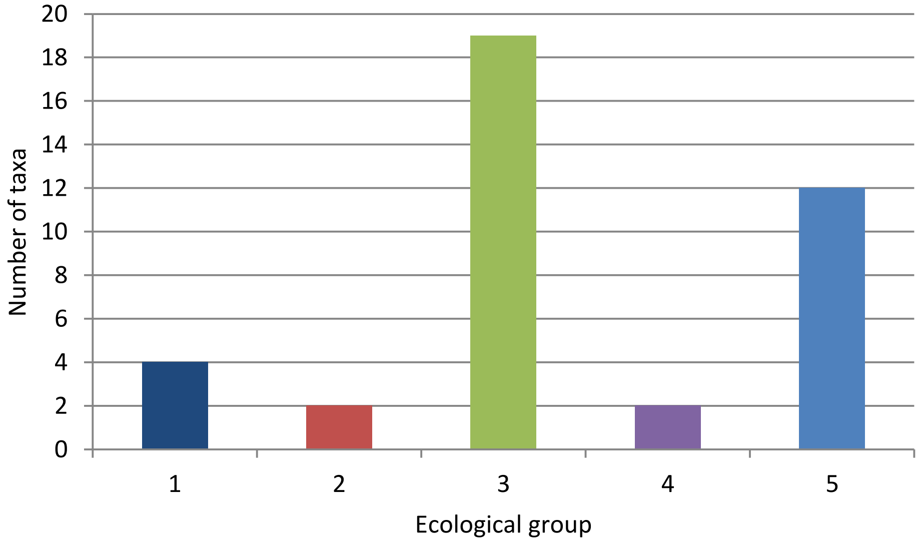
Name	Location	Material dated	Lab code	C14 age BP	Range	Probability %	Calibrated age (AD)
Schwarz 1	Feature 9; sample 1	seed	UGAMS 15458	50	25	95.4	1695-1728, 1812-1854, 1867-1919
Schwarz 2	Feature 9; surface	charcoal	Poz-22171	115	30	95.4	1680-1764, 1801-1939

Tab. 4.4. Results of plant macroremains analysis. Number of plant macroremains ordered by ecological group (fr. = fragment)

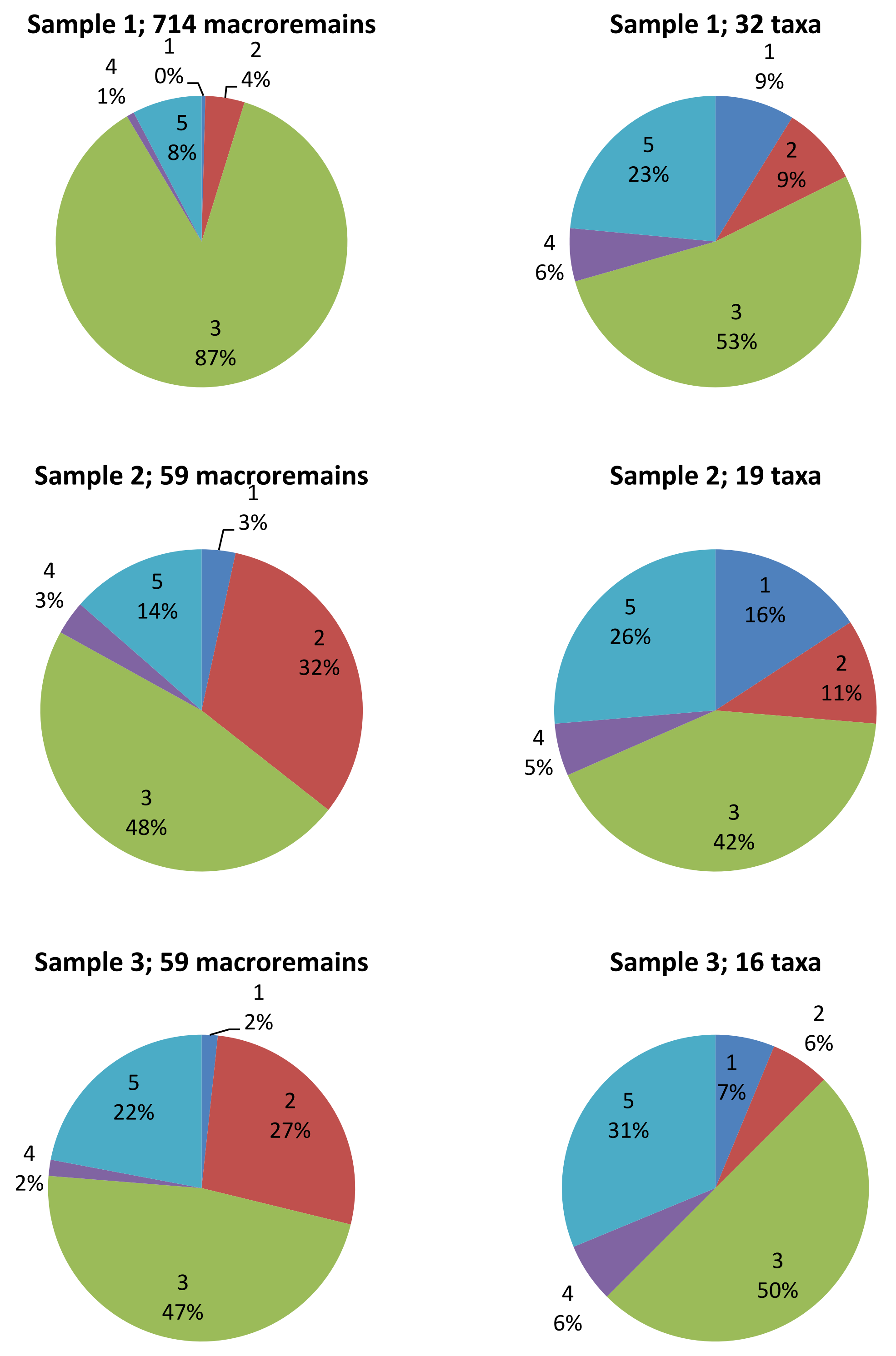
Sample	1	2	3	4
Group 1				
Chenopodium album	1	-	-	-
Chenopodium sp.	-	1	-	-
Potentilla anserina	1	1	-	-
Stellaria media	-	-	1	-
Group 2				
Hypochaeris glabra fr.	7, 6fr.	1	-	-
Rumex acetosella	18	18	16	-
Trifolium repens	1	-	-	-
Group 3				
Alisma plantago-aquatica	4	1	4	-
Callitriche cf. palustris		-	-	-
Carex bohemica	44	6	1	-
Carex cf. hirta	4	2	-	-
Carex nigra	9	-	-	1
Cyperaceae	9	-	-	-
Eleocharis ovata	476	13	18	-
Eleocharis sp.	2	-	-	-
Glechoma hederacea	1	-	-	-
Juncus sp.	2	1	2	-
Linum catharticum	10	1	-	-
Lycopus europaeus	4	-	-	-
Menyanthes trifoliata	1	-	-	-
Montia fontana/arvensis	1	-	-	-
Persicaria lapathifolia	1	-	-	-
Ranunculus sceleratus	40	3	3	-
Rumex cf. maritimus	1	-	-	-
Sparganium cf. erectum	2	1	-	-
Sparganium cf. natans	9	-	-	-
Sparganium emersum	-	-	-	1
Group 4				
Batrachium sp.	3	2	-	-
Potamogeton sp.	3	-	1	-
Group 5				
Apiaceae	-	-	1	-
Asteraceae	-	1	-	-
Carex sp.	16	3	6	2
Lepidium sp.	-	1	-	-
Poaceae	22	-	3	-
Poaceae stem fr.	-	1	3	-
Ranunculus sp. fr.	1	-	-	-
Rumex sp.	10	-	-	-
Sparganium sp.	-	2	-	-
Trifolium sp.	3	-	-	-
cf. Trifolium sp.	1	-	-	-



Graph 4.1. Schwarzenberg Lake, site no. 7. The overall number of plant macroremains, sum of samples 1-5.



Graph 4.2. Schwarzenberg Lake, site no. 7. The overall number of taxa, sum of samples 1-5.



Graph 4.3. Schwarzenberg Lake, site no. 7. Number of plant macroremains/taxa: samples 1, 2, and 3, ordered by ecological group (see Tab 4.1).

4.4. Discussion

The vast majority of taxa identified within the feature infill indicate wet environment (Graph 4.1 and 4.2). Moreover, the assemblage most likely reflect the presence of fishpond, constructed directly on the site between 1698 and 1701, since most abundant identified taxa such as *Eleocharis ovata* and *Carex bohemica* possibly indicate exposed pond bottoms. This is also confirmed by radiocarbon dates (Tab. 4.3, Fig. 4.5). Furthermore, this interpretation is in accordance with data reported from profiles (trench 3 and 4) investigated using pollen and macroremains analysis. Within these profiles, particular identified taxa are found in the context of modern fishpond (Žáčková 2008; Pokorný et al. 2010).

The structure of the assemblage in terms of affiliation to ecological group did not vary considerably among individual samples recovered from the investigated feature (Graph 4.3). The only observable phenomenon is the stronger prevalence of wetland taxa recorded in sample 1, retrieved from upper layer of the feature infill. This may represent signs of disturbance or contamination, which can be expected to a greater extent closer to the surface.

At this point, it is important to note that the archaeobotanical assemblage may reflect the results of human activities as well as natural processes, which are extremely difficult to distinguish (Fuller – Weber 2005). Particular important role is very likely played by postdepositional agents. In the case of studied assemblage recovered from sandy peninsula of Schwarezenberg Lake, several agents should be taken into account. Firstly, one should bear in mind that examined features and cultural layers are very shallow at the site. Moreover, the presence and movement of water may easily transport seeds, which is especially important factor in case of shallow sandy sediments present at the site. Last but not least, action of plant roots and disturbance caused by rodents needs to be considered.

The feature itself is interpreted as remains of special hearth for preparing food on the basis of stratigraphy and artefact presence, namely a number of chipped stone industry, from which some is burnt. Unfortunately, archaeobotanical analysis may neither confirm nor reject this interpretation. According to the plant macroremains analysis, three possible explanations concerning character of the investigated feature could be offered:

1) The existence of the feature can be associated with its infill connected with the existence of modern fishpond, which used to be summer-drained. Nevertheless, no clear interpretation or function of the feature can be suggested in this case. Moreover, stratigraphic evidence and the fact that a number of chipped stone industry found at greater abundance within the feature than in the surrounding area does not support this hypothesis.

2) The feature is of the Mesolithic age, as suggested by archaeological findings and vertical stratigraphy. If the feature represents hearth-pit associated with food preparation, it would be improbable that such an object would detectable by means of macroremains analysis, as confirmed by experimental work (see chapter 3.2). In this case, archaeobotanical assemblage could reflect contamination related to modern fishpond.

3) Also, the possibility of mixed assemblage reflecting both, Mesolithic human action as well as contamination from younger periods needs to be taken into account. Taxa composition signifying former lake would not likely be specific enough to be detected and interpreted in this way if forming only part of the archaeobotanical assemblage. Unfortunately, macroremains analysis cannot solve this issue itself, since individual plant macroremains are impossible to be distinguished with respect to their origin.

Furthermore, assemblage consisting of taxa of several ecological groups within one feature may imply that found taxa do not merely reflect natural processes occurring at the site and some other agent may have entered the process of deposition. The presence of ruderals such as *Chenopodium album* and *Potentilla anserina* further indicate that some disturbance, possibly of anthropogenic origin, occurred, although these assumptions should be considered as rather tentative due to extremely scarce data.

The presence of significant amount of charred bulbs/roots/tubers is also interesting. These underground plant parts are reported to be of great importance when dealing with past hunter-gatherers, since such parenchymous foods could have played substantial role in hunter-gatherer diets (Mason et al. 2002). However, the identification of parenchymous tissues requires the use of scanning electron microscopy (SEM), which needs to be systematically applied in hunter-gatherer archaeobotany in future research (see chapter 2).

More importantly, with respect to above mentioned assumptions, the presence of charred bulbs/roots/tubers and also mosses may shed some light on the depositional dynamics. Instead of representing gathered foodstuff, underground plant parts may more likely indicate that plants may have been carbonised directly in the place of their recovery, namely within the investigated feature. Also the other option, however, needs to be considered. The bulbs/roots/tubers could have easily been transported by some agent, most likely water during the existence of fishpond. The last mentioned option seems to be more likely, since the significant amount of bulbs/roots/tubers have been recovered and detected from another feature of medieval age at the same site by the author of the thesis.

Mention should also be made of samples 15 – 19. These were retrieved from five burnt argillaceous slabs and all were sterile in terms of plant macroremains. This suggests that argillaceous slabs situated in the investigated feature have different origin than the rest of the feature infill and the fact that the slabs are burnt may have prevented them from contamination by younger material.

Moreover, assemblages dominated by uncarbonised wetland taxa, retrieved from the hearth, are also reported from Dutch Mesolithic and Neolithic sites such as the Neolithic camp at Bergschenhoek, the Netherlands (Out 2012). The presence of uncarbonised wetland species is discussed in various ways. Mostly they are considered to post-date the use of hearth or in connection with natural deposition with no anthropogenic input. Nevertheless, carbonised remains of both dry land and wetland taxa are commonly interpreted as food remains. When considering reflected variation in plant use and depositional processes, one should be cautious about proposed interpretations, since the depositional processes and plant use, which do not involve fire, remain to be understood and systematically studied. Thus, this variety can be related to many factors such as the natural vegetation, preservation, geomorphology, site function, seasonality, hearth function etc. (Out 2012).

Finally, it is important to note that the site of Schwarzenberg Lake is not unique with respect to the issues with sampling materials and sampled contexts situated in bioturbated sandy sediments. Similar problems in the Mesolithic archaeology are reported for example from the coversand regions of North Bohemia (Svoboda et al. 2007) or northern Belgium and Netherlands (Strydonck et al. 2001; Crombé et al.

2012). Last mentioned authors suggest that intensive radiocarbon dating of samples from various contexts can considerably contribute to understanding of formation processes of unstratified open-air settlements as well as occupation chronology.

4.5. Conclusion

To conclude, archaeobotanical analysis revealed that infill of investigated feature comprises quite uniform taxa composition with prevailing wetland herbs in all samples. Unfortunately, these results did not allow either confirming or rejecting the interpretation of the feature as remains of special hearth for preparing food. On the other hand, presented study brings information concerning taphonomy and depositional dynamics. To summarize, societal as well as depositional/postdepositional factors cannot be ignored when dealing with archaeobotanical assemblages, particularly with those recovered from sandy sediments. The implications for Mesolithic archaeobotany are twofold. Firstly, special attention should be paid to factors affecting composition of archaeobotanical remains in future research. Secondly, current knowledge of plant use reported on the basis of finds of plant macroremains recovered from Mesolithic sites with no regard to the archaeological context and formation processes need to be re-evaluated, since a critical overview of indications for plant use is lacking.

Fig. 4.1. Location of the Schwarzenberg Lake projected on map of Bohemia. After Pokorný et al. 2010.

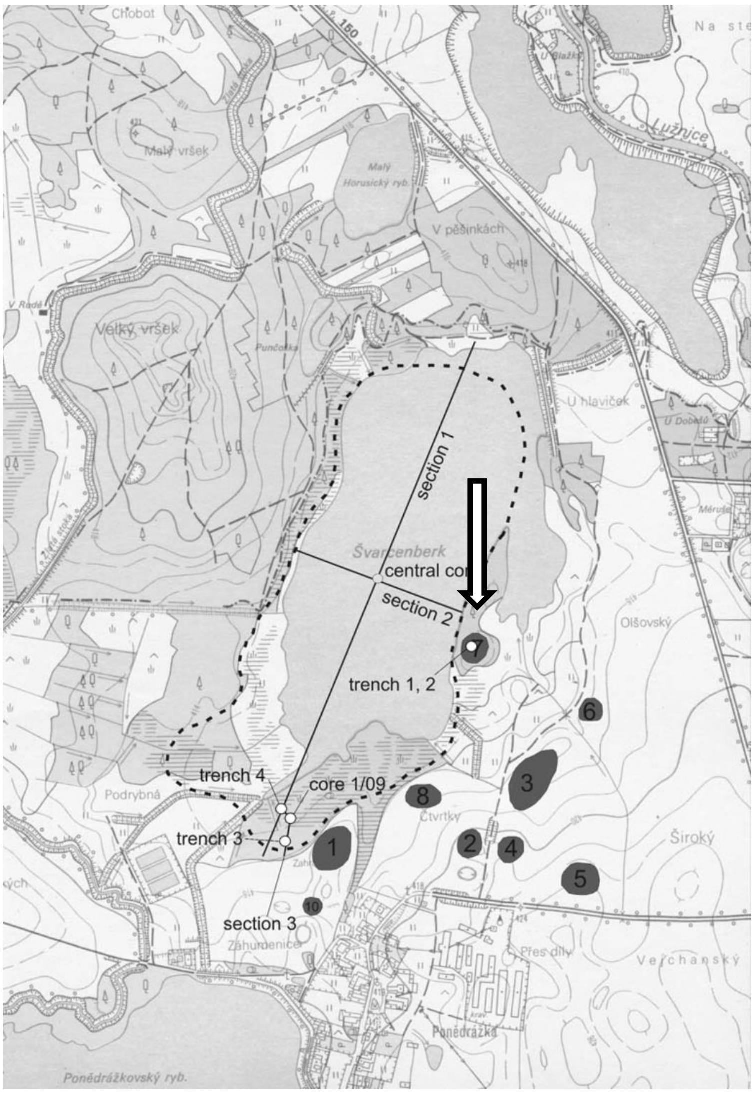


Fig. 4.2. Situation plan of the study area with cores, trenches, sections and archaeological sites. Arrow shows site no. 7. Drawing by P. Šída. After Pokorný et al. 2010.

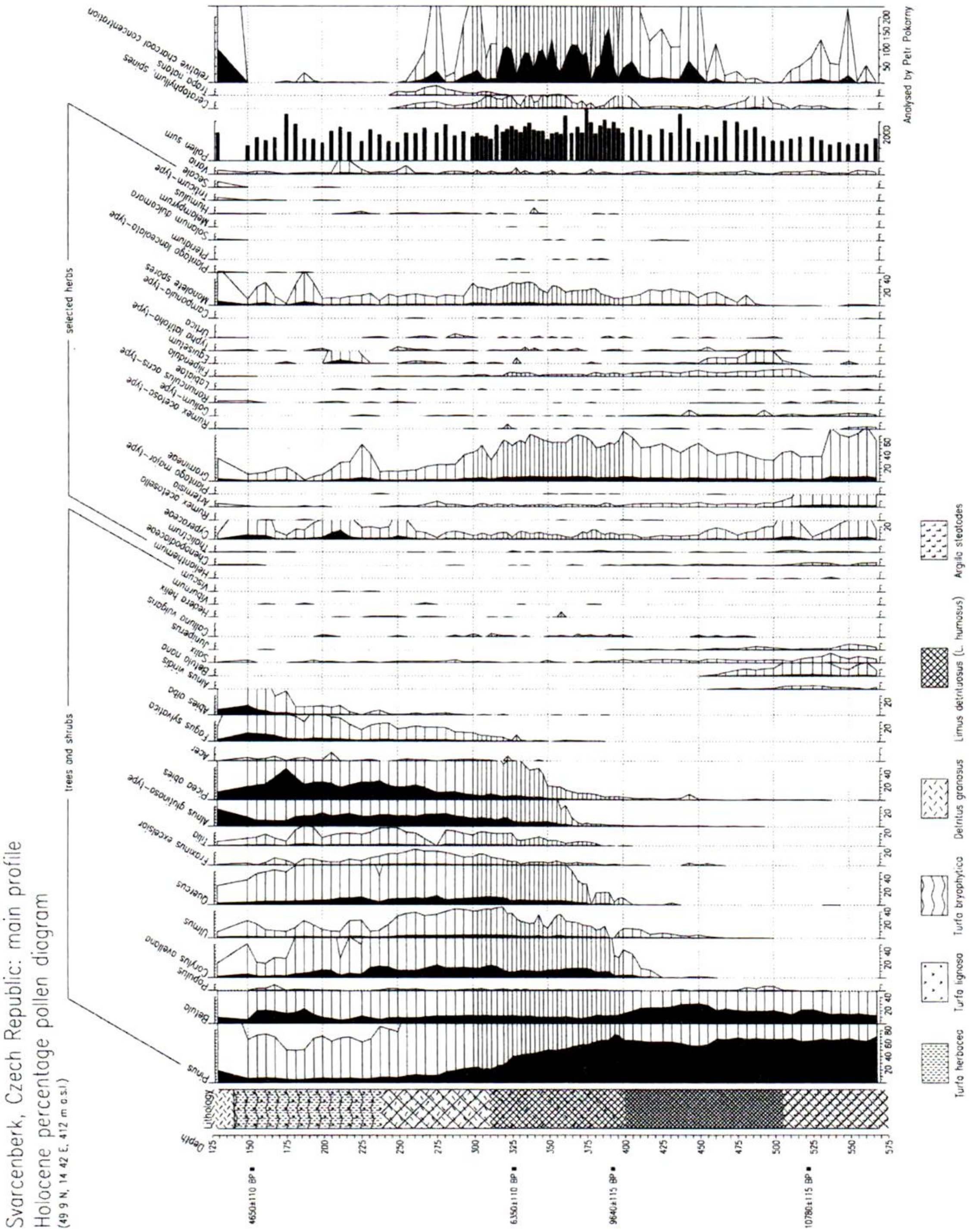


Fig. 4.3. Pollen diagram from the centre of the lake basin (core 1), upper part. The diagram represents the Holocene period. After Pokorný et al. 2008, 156.

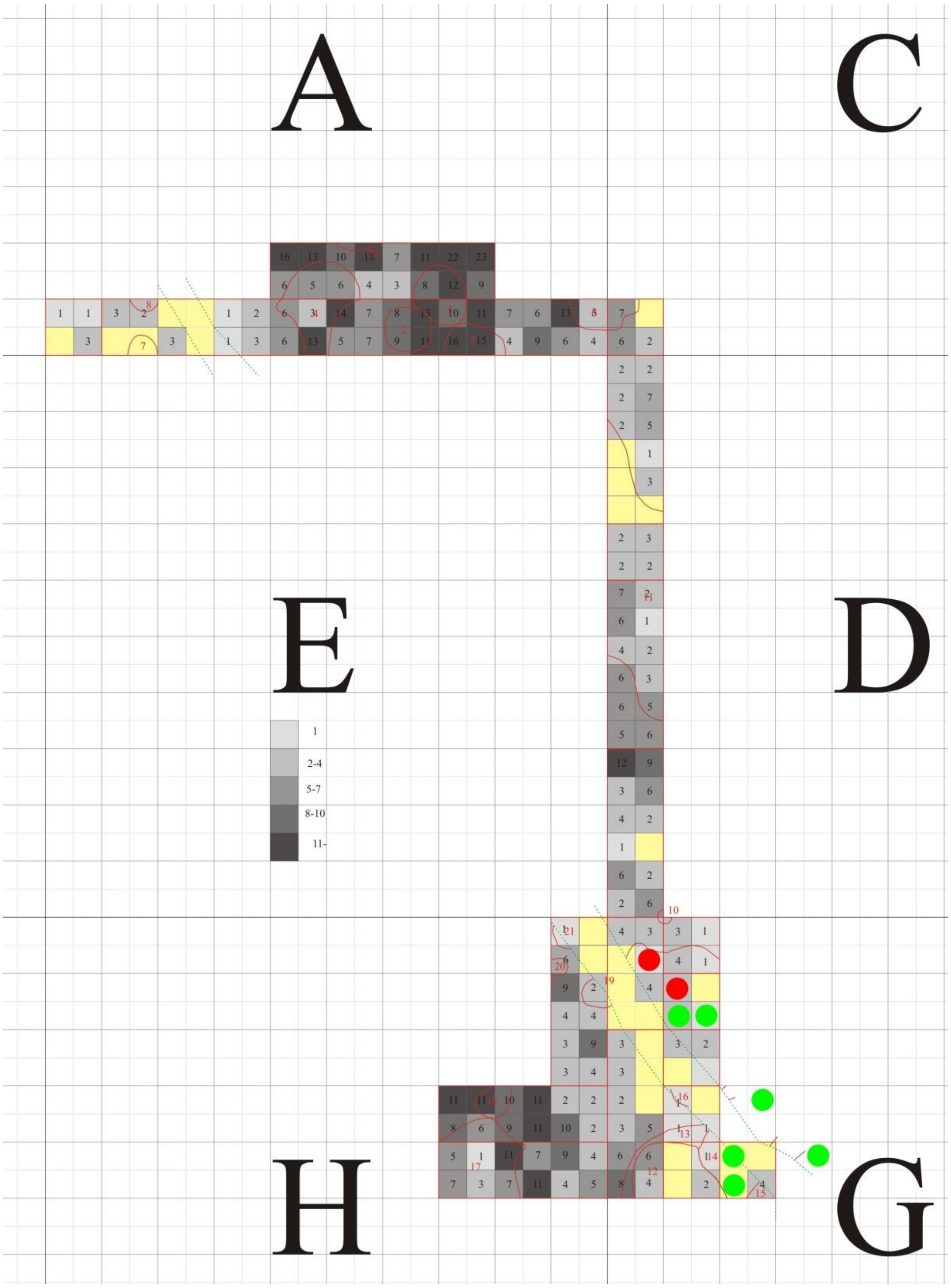


Fig. 4.4. Location of processed samples projected on a map of the site no. 7 (red circles – positive samples, green circles – negative samples). The different grey scale signifies the concentration of stone industry in particular squares. Plan by P. Šída.

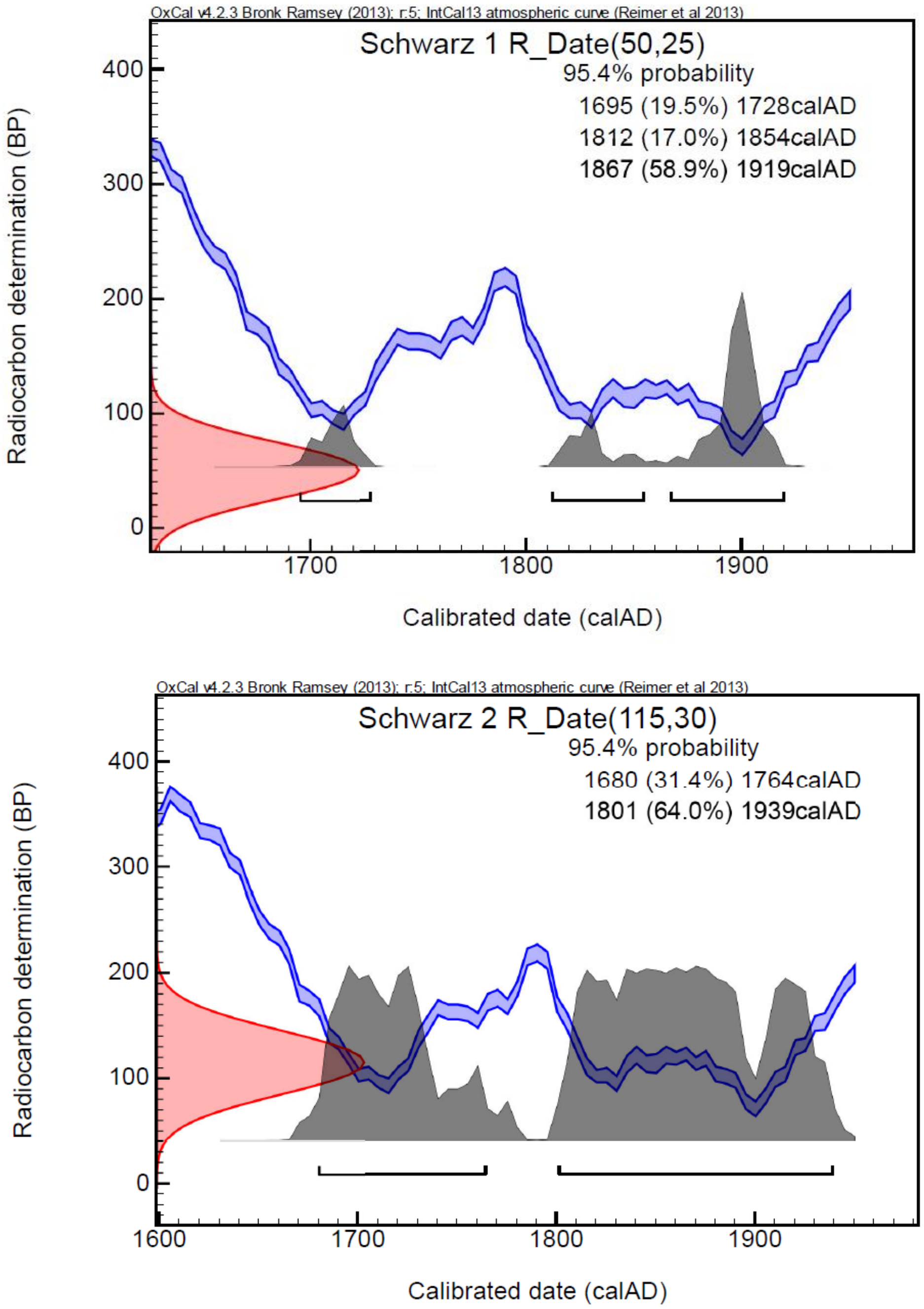


Fig. 4.5. Schwarzenberg Lake, the calibration diagrams of the radiocarbon dates, using OxCal v. 4.2.3.

Fig. 4.6. Complex structure of an archaeological feature no. 9 interpreted as hearth pit. Site no. 7. Photo P. Pokorný.

5. Archaeobotany of Dvojitá Brána u Rohlin, North Bohemia

5.1. Introduction

The site Dvojitá Brána u Rohlin represents small rock gate (Fig. 5.1), which lies in the area of pseudokarst of the Bohemian Paradise (Fig. 5.2). Since the Bohemian Paradise represents an area without recognized Late Palaeolithic and Mesolithic settlement for a long time, investigation of the Mesolithic within the region has been neglected in spite of numerous collections of Mesolithic industry obtained before the Second World War, which were mistakenly dated to the Eneolithic due to the that time research methods. Nevertheless, according to current state of research, the Mesolithic occupation of the area of the Bohemian Paradise seems to be much more intensive (see Šída – Prostředník 2007, Fig. 1) having implications for the issues of further landscape development and the Neolithisation process (Šída – Prostředník 2007; Šída – Prostředník 2010).

The site itself was partially excavated by means of small test in 1947, when L. Jisl and F. Prošek obtained a small assemblage of Mesolithic stone industry. A further excavation in the same trench followed in spring 2011 and spring/autumn 2012, led by P. Šída (Fig. 5.3). During this excavation, four Mesolithic hearths in superposition were revealed at base (Fig. 5.4.) (Filip 1947; Šída 2004; Prostředník – Šída 2006; Šída – Prostředník 2007; Šída – Prostředník 2010; Šída et al. 2011). Two radiocarbon dates were obtained. (see Tab. 5.1., Fig. 5.5).

Tab. 5.1. Overview of radiocarbon dates obtained. All samples calibrated with OxCal v. 4.2.3. (Bronk Ramsey 2009).

Sample	Location	Material dated	Lab code	C14 age BP	Range	Calibrated age (BC)	Proba bility	Reference
Dvo 1	Hearth 1, layer depth 60-70 cm	Hazelnut shell	UGAM S 9516	6730	30	5711-5573	95.4	Šída et al. 2011
Dvo 2	Layer under hearth 4; depth 80-90cm	Hazelnut shell	UGAM S 11223	7900	30	7023-6648	95.4	Novák et al. in prep.

An interesting finding at the site, as in the whole region, is the use of local raw materials, particularly Jizera-type metabasites, which are typical primarily as a material used for the Neolithic polished stone industry. In the Mesolithic, they are used for the chipped stone industry (Šída – Prostředník 2007). Nevertheless, the issue of polished stone industry at least in the Bohemian region and its chronological and cultural affiliation needs more attention, since many of these artefacts represent isolates finds without further archaeological context. Consequently, they are commonly ascribed to the Neolithic according to the traditional point of view associating polished stone industry with the Neolithic period (Šída 2011). As an interesting example, chipped stone axe head from Babí Pec, abri in the northern part of the Bohemian Paradise, can be mentioned. The axe, long believed to be Neolithic, is made of Jizera-type metabasite pebble and it substantially differs from the Neolithic axes in its design (Šída – Prostředník 2007, 450-452; Šída – Prostředník 2011). Also, the use of Jizera-type metabasite in the Mesolithic and its quick and extensive dispersion let the authors to conclude that there is an indication of contact between the Mesolithic communities and first farmers (Šída – Prostředník 2007).

Apart from lithics and pottery, the investigations at the site included the analysis of charcoal remains (Novák et al. in prep.), malacofauna, animal bones, and plant macroremains. The results of the analysis of plant remains are presented separately below.

5.1.1. Environmental settings

The region under study is formed by quarzitic sandstones of the Březno and Teplice formations (Upper Turonian-Santorian) (Cháb et al. 2007). The soil cover is formed of dystric cambisol (Tomášek 2004). Actual elevations in immediate proximity to the site range between 350 and 370 m a.s.l. Based on a map of potential natural vegetation Luzulo-Fagetum beech forests are reconstructed (Neuhänslová et al. 1998).

5.2. Material and methods

For the archaebotanical analysis, material recovered from the trench 0.5 x 0.3 m (D4B), collected in 5 cm mechanical layers to a depth of 120 cm was used. The volume of all samples can be estimated to 7.5 litres. All retrieved layers were investigated. The macroremains samples were selected in two ways. The first class of samples consists of material collected from the coarse mesh width of 2 mm of the field sieving procedure, which was subsequently flotation-sieved on a 2 mm and 1 mm sieve (Samples 350-373). Second class of samples comprises material that passed through the 4 mm sieve, which was further processed using flotation with a 0.25 mm sieve (Samples 374-397).

All samples were dried at room temperature. Subsequently, plant remains, animal bones and teeth, malacofaunal remains, and lithics were separated from floating component and residues under a stereo-microscope (Arsenal SZP3112-T ZOOM, magnification 6.2 - 50x). The samples were processed in the entire volume. Plant macroremains were picked out and microscopically determined according to Berggren (1981); Anderberg (1994); Cappers et al. (2006); and the reference seed collection from the Laboratory of Archaeobotany and Palaeoecology, Faculty of Science, University of South Bohemia. Species were associated to general eco-groups according to the specifications and environmental requirements of each species (Hejný – Slavík eds. 1988-1992, Slavík ed. 1995-2000, Slavík – Štěpánková eds. 2004, Štěpánková ed. 2010). The diagram was created using Tilia 1.7.16. software (Grimm 2011).

Only the carbonised plant remains are included in the diagram and discussed below, since the uncarbonised remains may represent recent/subrecent contamination. Primary data including uncarbonised remains are presented in Tab 5.2. The diagram (Graph 5.1) shows absolute numbers of macroremains. Plant names are according to Kubát and colleagues (2002).

5.3.Results

Analysis comprises 48 samples obtained from 24 mechanical layers. A total of 847 plant macroremains belonging to 15 taxa have been identified, from which 691 are carbonised. Sieving through a 0.25 mesh turned out to be essential, since most macroremains come from samples sieved through the fine mesh and would not be captured by means of field coarse sieving procedure. The samples contained carbonized and uncarbonised material. Plant remains preserved by desiccation are commonly found in dry rock shelters (Jacomet – Kreuz 1999). Therefore, some of uncarbonised remains may represent fossil material. However, some remains clearly represent recent/subrecent contamination (marked in Tab. 5.2|).

The whole profile also contains a large number of fungal sclerotia of *Fungi*. Last but not least, it is important to note that crop plants are absent in the whole profile, despite the presence of pottery sherds in some layers. Special attention is paid to the Mesolithic section of the profile, since it represents main topic of the thesis.

Fig. 5.1 shows the macroremains diagram from Dvojitá brána u Rohlin. The sections of the profile listed below were defined on the basis of archaeological findings and available radiocarbon dates.

- *60 – 120 cm*

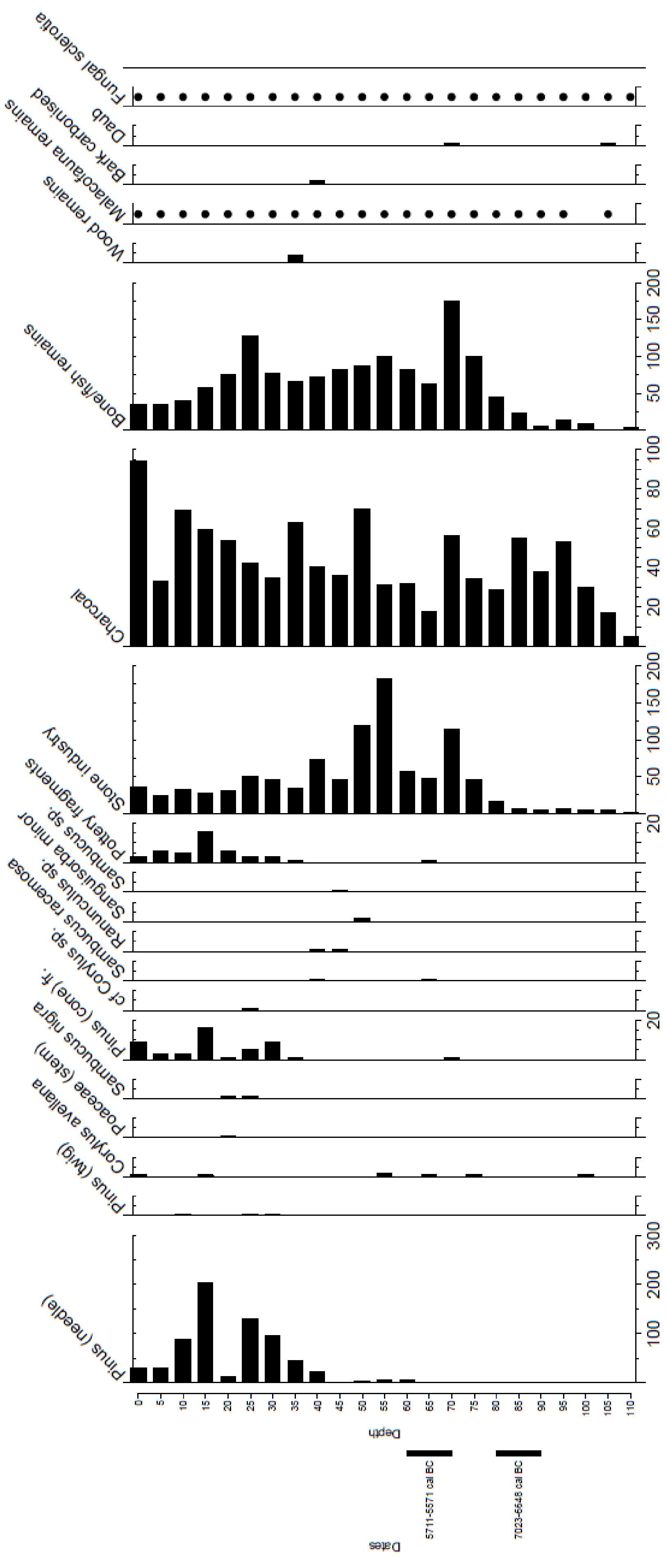
According to archaeological dating, based on the presence of Mesolithic chipped stone industry supported by radiocarbon date, layers from 60 cm to the profile base belong to the Mesolithic. From these layers, carbonised plant macoremains of following taxa were retrieved and determined. These are the pine needles (*Pinus* sp.), fragments of hazelnut shells (*Corylus avellana*), and the seeds of elderberry (*Sambucus racemosa*). Plant remains are accompanied by a number of burnt animal bones, lithics, and charcoal in this section.

- *40 – 60 cm*

The layers between 40 cm and 60 cm are interpreted to originate during the Late Mesolithic and Neolithic period. Archaeologically, in this stratum ceramics are not present. The similarity with the preceding section can also be visible in terms of plant remains, since the assemblage is dominated by *Pinus* sp. accompanied by individual seeds of *Sambucus racemosa*, *Ranunculus* sp., and *Sanguisorba minor*.

- *0 - 40 cm*

The layers between 30 cm and 40 cm attributable to the Eneolithic contained only the remains of *Pinus* sp. The following unit between 10 and 30 cm, belonging to the Bronze and Iron Age, contained apart from *Pinus* sp., fragments of hazelnut shells (*Corylus avellana*), a stem of Poaceae family, and seeds of *Sambucus nigra*. The remaining upper section of the profile representing Medieval period comprises a fragment of *Corylus avellana* and *Pinus* sp.



Graph 5.1. Dvojitá Brána u Rohlin, macroremains diagram.

5.4. Discussion

5.4.1. Reconstruction of the vegetation in the Mesolithic period and question of human impact

Due to a small number of identified taxa, one can only make highly tentative assumptions. Identified taxa may represent natural vegetation near the site. This could be the case of pine (*Pinus* sp.), which strongly prevails in the whole assemblage. Also the hazelnut shells and elderberry seeds indicate the presence of *Corylus avellana* and *Sambucus racemosa* close to the site. This is also in accordance with charcoal data (Novák et al. in prep.). Pine grows well on the exposed, rocky slopes and poor sandy substrates, whereas hazel prefers warmer and sunny stands. Red elderberry then occurs in forests, forest edges and openings, bushy slopes and ravines.

On the other hand, two last mentioned taxa may have been gathered for consumption or other use. This may be especially the case of *Corylus avellana*, staple food in the plant diet of Mesolithic people. Consequently, one should bear in mind selective nature of the assemblage. With respect to the Mesolithic period, an interesting find is the seed of *Sambucus racemosa*. For more information on this taxon, particularly from the perspective of archaeobotany and ethnobotany, see chapter 2.2.3.

Importantly, the human impact at the site is undoubtedly evidenced in the form of hearths found at the profile base. It is very likely that abovementioned carbonised plant remains as well as burnt animal bones, charcoal, and lithic industry are associated with these structures and human activity. Therefore, the data most likely reflect taxa brought to the site and burn by humans and ecological interpretations cannot be drawn.

During the Upper Mesolithic/Neolithic period, the same taxa composition accompanied by *Sanguisorba minor* is recorded. Ethnobotanically, *Sanguisorba minor* is known to be associated with medicinal use as well as for consumption (Slavík ed. 1995, 244; Camejo-Rodrigues et al. 2003; Łuczaj 2012).

5.4.2. Dvojitá Brána u Rohlin within the context of North Bohemian Mesolithic archaeobotany

Mesolithic sites in the Bohemian Paradise are significant for their good preservation of charcoal, macroremains as well as osteological material (Šída – Prostředník 2007). Unfortunately, there is lack of systematic environmental archaeological research and presented analysis represents one of pioneer studies concerning this area. On the other hand, the assemblage can be set in the context of the Mesolithic of North Bohemia, where a representative sample of sites has been studied, some of them also in terms of archaeobotany (Svoboda ed. 2003).

On the basis of available plant macroremains and charcoal data from sandstone rockshelters in North Bohemian, the dominance of *Pinus sylvestris* is reported (Opravil 2003). E. Opravil goes on to reconstruct landscapes of the Dicrani-Pinion society on the sandstone plains and rock edges, with debris of the Tilio-Acerion society on the slopes, transitional units towards the Vaccinio-Pineon society on the moister slopes, and likely the Pruno-Fraxinetum (or Carici elongatae-Alnetum society) at the valley floors. The forest is reconstructed as compact, interrupted by open areas, as indicated by the finds of *Corylus avellana* and related faunal record. This reconstruction is in agreement with pollen data from Jestřebské blato – Doksy (Jankovská 1992).

With respect to potentially gathered taxa, carbonised remains of *Corylus avellana* are known from a number of sites such as Máselník, Okrouhlík, or Pod Zubem (Opravil 2003, 41; Svoboda et al. 2007). Furthermore, the assemblage comprising cf. *Rubus idaeus*, *Rubus* sp., *Sambucus nigra*, and *Chenopodium album* was retrieved at Jezevčí převis (Pokorný 2003). The presence of *Sambucus racemosa* at Dvojitá Brána u Rohlin thus represents the first Mesolithic find of this taxon in the region.

5.4.3. Seasonality

Carbonised macroremains are believed to provide information on the season of occupation at the site. In this regard, the presence of carbonised *Corylus avellana* may suggest that site was occupied during September/October, even though it is important to bear in mind that nuts could have been stored when roasted (see chapter 3.2) and these finds may consequently point to false seasonality indication. Further, the carbonised remains of the fruits of *Sambucus racemosa* may indicate occupation between July and September. In this case, however, the possibility of dried fruits storing needs to be taken into account. To summarize, carbonized plant macroremains point to occupation during summer and autumn. Nevertheless, the data are extremely scarce, and the issue of seasonality is particularly difficult to address on the basis of these finds.

5.5. Conclusion

Archaeobotanical analysis of Dvojitá Brána u Rohlin represents one of the pioneer studies on plant macroremains in the North Bohemian Mesolithic, and also one of the few studies concerning hunter-gatherer archaeobotany in the Czech Republic. Presented data are extremely scarce and conclusions should be therefore seen as rather tentative. On the other hand, the study may be reflected as beneficial in terms of providing new data, since the Mesolithic archaeobotany lacks systematic attention and the research must necessarily start with data collection, applying diverse research methods in Mesolithic archaeology respectively. Thereafter, it will be possible to address various issues regarding Mesolithic hunter-gatherers.

Most identified taxa may represent natural vegetation near the site, but it cannot be ruled out that some of them were gathered for consumption or other use. The presence of *Pinus* sp., *Corylus avellana*, and *Sambucus racemosa* associated with the Mesolithic and *Sanguisorba minor* associated with Upper Mesolithic/Neolithic was detected.

The identified taxa composition indicates unusual uniformity throughout the whole profile ranging from the Mesolithic to the Middle Ages. The absence of domestic crops seems especially interesting in connection with the study of Mesolithic-Neolithic transition and may suggest continuing of hunter-gatherer tradition to the following periods. This is particularly remarkable with respect to the fact the Bohemian Paradise is considered as key area in terms of the study of this issue, since it is known for its Mesolithic as well as Early Neolithic settlement, which is unique situation within the Czech Republic. Also, the issue of continuous use of Jizera-type metabasite plays into the idea of the cultural contacts between the Mesolithic hunter-gatherers and first farmers.

Fig. 5.1. The site of Dvojitá Brána u Rohlin. Photo: P. Šída.

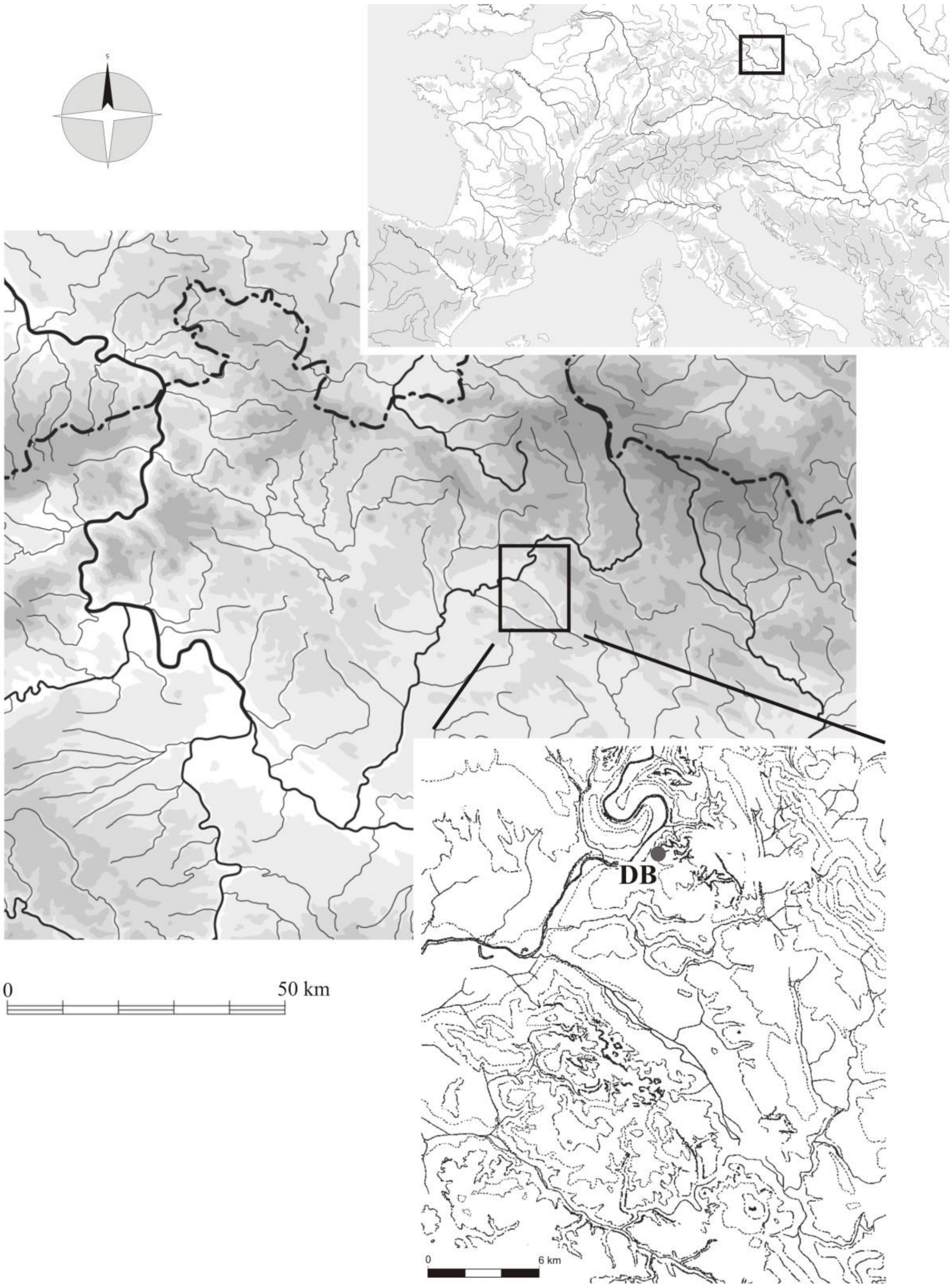


Fig. 5.2. Map of Bohemian Paradise showing location of Dvojitá Brána u Rohlin. Map created by P. Šída.

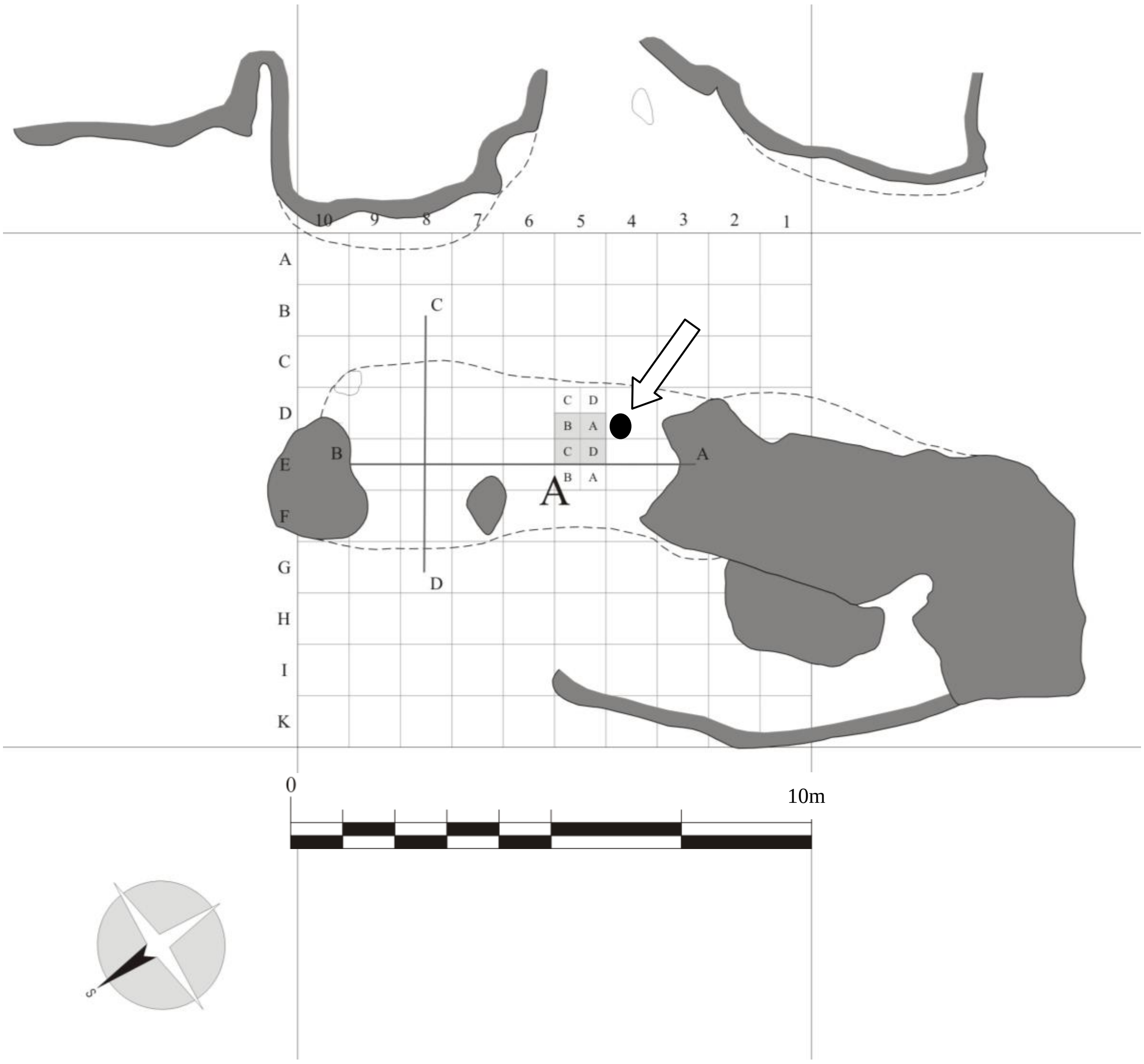


Fig. 5.3. Plan of the site of Dvojitá Brána u Rohlin. Arrow shows location of profile sampled for analysis of plant macroremains. Drawing by P. Šída.

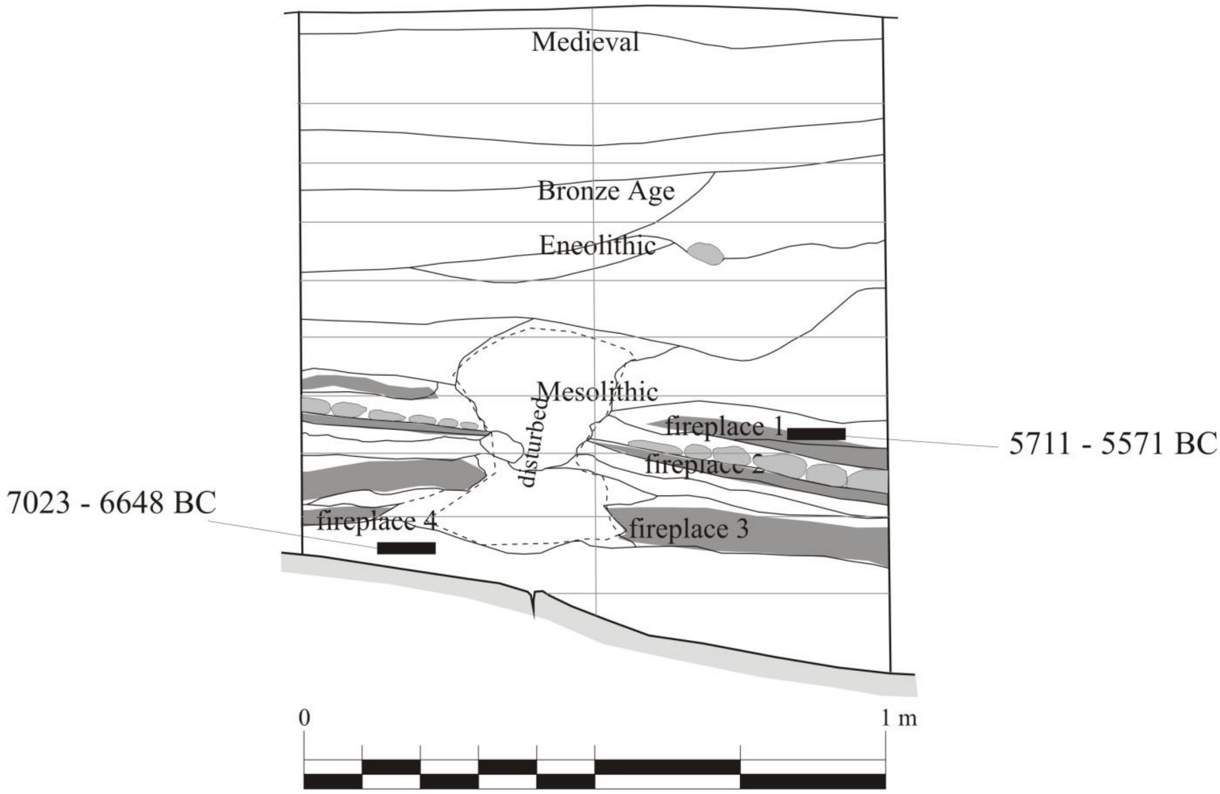


Fig. 5.4. Dvojitá Brána u Rohlin. Trench 1, eastern section. Drawing by P. Šída.

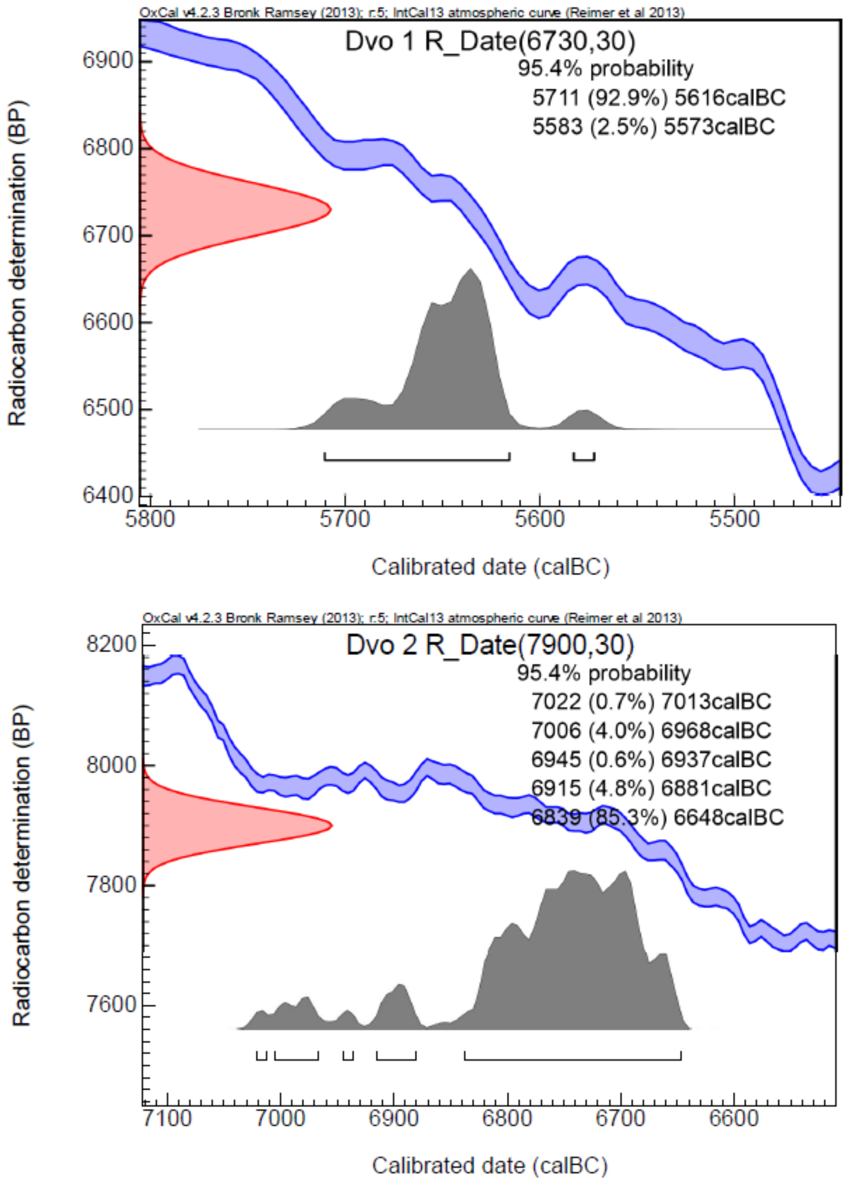


Fig. 5.5. Dvojitá Brána u Rohlin, the calibration diagrams of the radiocarbon dates, using OxCal v. 4.2.3.

sample	**350**	**374**	**351**	**375**	**352**	**376**	**353**	**377**	**354**	**378**	**355**	**379**	**356**	**380**	**357**	**381**	**358**	**382**	**359**	**383**	**360**	**384**	**361**	**385**
depth cm	0-5		**5-10**		10-15		15-20		20-25		25-30		30-35		35-40		40-45		45-50		50-55		55-60	
taxon																								
***Pinus* sp. (needle fr.)**	4c	47, 19c	**6c**	4, 24c	8c	76c	8c	192, 185c	1c	9c	4c	120, 118c	1c	83, 82c	–	40c	1	19c	–	1	–		2, 1c	7, 4c
***Pinus* sp. (needle apex)**	–	10, 3c	–		–	1	–	5, 2c	–	1c	–	6, 5c	–	6, 4c	–	3c	–	2c	–	–	–	1c	–	–
***Pinus* sp. (needle base)**	–	4c	–	1c	1c	4c	1c	10c	–	1c	–	4c	–	9c	–	2c	–	3c	–	–	–	1c	–	1c
***Pinus* sp. (cone fr.)**	9c	–	**3c**	–	3c	–	16c	–	1c	–	4c	1c	9c	–	1c	–	–	–	–	–	1	–	–	–
***Pinus* sp. (twig)**	–	–	–	–	–	1c	–	–	–	–	–	1c	–	1c	–	–	–	–	–	–	–	–	–	–
***Corylus avellana* fr.**	1c	–	–	–	–	–	–	1c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2c	–
cf. *Corylus avellana* fr.	–	–	–	–	–	–	–	–	–	–	–	1c	–	–	–	–	–	–	–	–	–	–	–	–
Poaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
***Poaceae* (stem)**	–	–	–	–	–	–	–	–	–	1c	–	–	–	–	–	–	–	–	–	–	–		–	–
Sambucus nigra	–	–	–	–	–	–	–	–	–	1c	–	1c	–	–	–	–	–	–	–	–	–	–	–	–
Sambucus racemosa	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1c	–	–	–	–	–	–
***Sambucus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Ranunculus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1c	–	1c	–	–	–	–
Sanguisorba minor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2c	–	–
Astragalus glycyphyllos	–	3r	–	–	–	1r	–	–	–	–	–	–	–	–	–	1r	–	2r	–	–	–	–	–	–
***Sorbus* sp.**	–	1r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Juncus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1r
Oxalis acetosella	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carum carvi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Apiaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Vicia* sp.**	–	–	–	–	–	–	–	–	1r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rubus idaeus	–	–	–	–	–	–	–	–	–	2r	–	4r	–	–	–	1r	–	–	–	1r	–	–	–	–
Indet.. (cone fr.)	–	–	–	–	–	–	–	–	–	–	2c	–	–	–	–	–	–	–	–	–	–	–	–	–
Indeterminata	–	–	–	–	–	–	–	1c	–	1c	–	1c	–	–	–	–	–	–	–	–	–	–	–	–

Tab. 5.2. Plant macroremains from Dvojitá Brána (c = carbonised; x, yc = x macroremains, from which y are carbonised; r = recent/subrecent contamination; fr. – fragment). Part 1.

sample	362	386	363	387	364	388	365	389	366	390	367	391	368	392	369	393	370	394	371	395	372	396	373	397
depth (cm)	60-65		65-70		70-75		75-80		80-85		85-90		90-95		95-100		100-105		105-110		110-115		115-120	
taxon																								
***Pinus* sp. (needle fr.)**	–	5c	–	–	–	–	–	–	–	2, 1c	–	–	–	–	–	–	–	–	–	1	–	–	–	–
***Pinus* sp. (needle apex)**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Pinus* sp. (needle base)**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Pinus* sp. (cone fr.)**	–	–	–	–	2c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Pinus* sp. (twig)**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Corylus avellana* fr.**	–	–	1c	–	–	–	1c	–	–	–	–	–	–	–	–	–	1c	–	–	–	–	–	–	–
cf. *Corylus avellana* fr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poaceae	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Poaceae* (stem)**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sambucus nigra	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sambucus racemosa	–	–	–	1c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Sambucus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Ranunculus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sanguisorba minor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Astragalus glycyphyllos	–	1r	–	1r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Sorbus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***Juncus* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis acetosella	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1r	–	–	–	–	–	–
Carum carvi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1r	–	–	–	–
Apiaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1r	–	–	–	–
***Vicia* sp.**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rubus idaeus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Indet. (cone fr.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Indeterminata	–	1c	–	–	–	1c	–	–	–	–	–	–	–	1c	–	–	–	–	–	–	–	–	–	–

Tab. 5.2. Plant macroremains from Dvojitá Brána (c = carbonised; x, yc = x macroremains, from which y are carbonised; r = recent/subrecent contamination; fr. – fragment). Part 2.

6. Conclusion

The main conclusions, specific to each issue, have been mentioned in individual chapters. Here, some concluding remarks are drawn:

1) Archaeobotany of Mesolithic hunter-gatherers represents seriously understudied research topic. However, some patterns including woodland clearance or utilisation of selected plant taxa could be observed. A conclusion that can be drawn at this point is that by the Late Mesolithic, the patterns of plant use support the notion of controlled, regular, and intensive use of plant resources on a scale which left an imprint on the landscape instead of the incidental and opportunistic use of plants for food.

2) Some methodological implications can be drawn, of which the most important seems to be the identification of parenchymatous issue, since there is growing evidence for consumption of roots, tubers, bulbs or rhizomes among past as well as recent hunter-gatherer communities.

3) Data concerning food preparation and consumption are very scarce and methodology often coarse. However, review of selected archaeological features occurring within the European archaeological record, accompanied particularly by ethnoarchaeological and experimental data can shed some light on food preparation practices. In this manner, archaeological features including surface hearths, roasting hearths, boiling and steaming pits, and last but not least hearth pits can be perceived.

4) The thesis also brings new original data from the Czech Republic. Since systematic research in terms of plant macroremains analysis is still lacking here, new data, although extremely scarce, should be considered as valuable in terms of starting point for further research. In addition to that, assemblage from Dvojitá Brána u Rohlin provides hints towards the study of the Neolithisation process in the Czech Republic.

5) Case study from the Schwarzenberg Lake has brought considerable focus on the issue of depositional/postdepositional processes, especially when dealing with shallow sandy sediments. On the basis of this case, one should be cautious in interpreting archaeobotanical assemblages as well about assessment of already existing published data.

6) Finally, the thesis strongly reflects the growing need for interdisciplinary work to address issues related to Mesolithic hunter-gatherers. That is required both from a perspective of archaeobotany itself, which has to apply a full range of techniques such as pollen, macroremains, wood and charcoal, phytolith, and starch analyses as well as by means of incorporating various approaches including reflection of overall archaeological context, analysis of stable isotopes, use-wear analyses, and last but not least integration of ethnobotanical and experimental work, which is also of crucial importance.

7. References

Anderberg, A. L. 1994: Atlas of Seeds and Small Fruits of Northwest - European plant species with morphological descriptions. Part 4 Resedaceae–Umbelliferae. Stockholm: Swedish Museum of Natural History.

Aura, J. E. – Carrión, Y. – Estrelles, E. – Peréz Jordà, G. 2005: Plant economy of hunter-gatherer groups at the end of the last Ice Age: plant macroremains from the cave of Santa Maira (Alacant, Spain) ca. 12000–9000 B.P. Vegetation History and Archaeobotany 14, 542-550.

Bakels, C. C. 2006: Pollen analysis and the reconstruction of the former vegetation. In: L. P. Louwe Kooijmans – P. F. B. Jongste eds., Schipluiden. A Neolithic settlement on the Dutch North Sea Coast c. 3500 cal BC, Leiden, Analecta Praehistorica Leidensia 37/38, 305-315.

Bánffy, E. 2005: Mesolithic-Neolithic contacts as reflected in ritual finds. Documenta Praehistorica 32, 73-86.

Behre, K.-E. 1981: The interpretation of anthropogenic indicators in polledn diagrams. Pollen et Spores 23, 225-245.

Behre, K.-E. 2007: Evidence for Mesolithic agriculture in and around Central Europe? Vegetation History and Archaeobotany 16, 203-219.

Beneš, J. 2004: Palaeoecology of the LBK: the earliest agriculturalists and the landscape of Bohemia. In: A. Lukes – M. Zvelebil eds., LBK Dialogues: studies in the formation of the Linear Pottery Culture. BAR International Series 1304, Oxford: Archaeopress, 143-150.

Beneš, J. 2008: Archeologie rostlin. In: J. Beneš – P. Pokorný eds., Bioarcheologie v České republice, České Budějovice – Praha: Jihočeská univerzita v Českých Budějovicích – Archeologický ústav AV ČR, 39-72.

Beneš, J. 2013: Počátky zemědělství. Nepublikovaná habilitační práce. Praha: Fakulta životního prostředí, Česká zemědělská univerzita v Praze.

Berggren, G. 1981: Atlas of seeds and small fruits of Northwest-European plant species with morphological descriptions. Part 3 Salicaceae - Cruciferae. Stockholm: Swedish Museum of Natural History.

Binford, L. R. 1967: Archaeology smudge pits and hide smoking: the use of analogy in archaeological reasoning. American Antiquity 32, 1-12.

Bos, J. A. A. – Urz, R. 2003: Late glacial and early Holocene environment in the middle Lahn river valley (Hessen, Central-west Germany) and the local impact of early Mesolithic people – pollen and macrofossil evidence. Vegetation History and Archaeobotany 12, 19-36.

Bouby, L. - Leroy, F. – Carozza, L. 1999: Food plants from Late Bronze Age lagoon sites in Languedoc, southern France: Reconstruction of farming economy and environment. Vegetation History and Archaeobotany 8, 53-69.

Bronk Ramsey, C.2009: Bayesian analysis of radiocarbon dates. Radiocarbon 51, 337-360.

Brown, T. 1997: Clearances and clearings: deforestation in Mesolithic/Neolithic Britain. Oxford Journal of Archaeology 16, 133-146.

Burov, G. M. 1998: The use of vegetable materials in the Mesolithic of northeast Europe. In: M. Zvelebil – R. Dennel – L. Domanska eds., Harvesting the sea, farming the forest, Sheffield: Sheffield Archaeological Monographs, 53-63.

Camejo-Rodrigues, J. – Ascensão, L. – Bonet, M. – Valles, J. 2003: An ethnobotanical study of medicinal and aromatic plants in the Natural Park of "Serra de São Mamede"(Portugal). Journal of Ethnopharmacology,89, 199-209.

Cappers, R. T .J. – Bekke,r R. M. – Jans, J. E. A. 2006: Digitale Zadenatlas van Nederland. Digital Seed Atlas of the Netherlands. Groningen: Barkhuis Publishing.

Cârciumaru, M, 1978: L'analyse pollinique des coprolithes de la station archéologique de Vlasac. In: M. Garašanin ed., Vlasac, A Mesolithic Settlement in the Iron Gates (II Geology – Biology – Anthropology), Beograd: Srpska akademija nauka i umetnosti, 31-34.

Cháb, J. – Stráník, Z. – Eliáš, M. 2007: Geologická mapa České republiky 1: 500 000. Praha: Česká geologická služba.

Clarke, D. 1976: Mesolithic Europe: the economic basis. In: G. de G. Sieveking – I. H. Longworth – K. E. Wilson eds., Problems in economic and social archaeology, London: Duckworth, 449-481.

Cordain, L. – Miller, J. B. – Eaton, S. B. – Mann, N. – Holt, S. H. A. – Speth, J. D. 2000: Plant-animal subsistence ratios and macronutrient energy estimates in worldwide hunter-gatherer diets. American Journal of Clinical Nutrition, 2000; 71, 682-692.

Crombé, P. – Perdaen, Y. – Sergant, J. 2005: Features. In: P. Crombé ed., The last hunter–gatherer-fishermen in Sandy Flanders (NW Belgium). The Verrebroek and Doel excavation projects, part 1: palaeo-environment, chronology and features. Archaeological Reports 3, Ghent: Ghent University, 141-179.

Crombé, P. – Robinson, E. – Strydonck van, M. – Boudin, M. 2013: Radiocarbon dating of Mesolithic open-air sites in the coversand area of the north-west European plain: problems and prospects. Archaeometry 55, 545-562.

Čuláková, K. – Eigner, J. – Metlička, M. – Přichystal, A. – Řezáč, M. 2012: Horské mezolitické osídlení u Javoří Pily, obec Modrava, okr. Klatovy. Archaeologie ve středních Čechách 16, 19-28.

Cunningham, P. 2011: Caching your savings? The use of small-scale storage in European prehistory. Journal of Anthropological Archaeology 30, 135-144.

Danuyne-Peaty, L. 2001: Human impact on vegetation. In: D. R. Brothwell – A. M. Pollard eds., Handbook of Archaeological Sciences, Wiley: London, 379-392.

Danuyne-Peaty, L. 2001: Human impact on vegetation. In: D. R. Brothwell – A. M. Pollard eds., Handbook of Archaeological Sciences, Wiley: London, 379-392.

Davies, P. – Robb, J. G. – Ladbrook, D. 2005: Woodland clearance in the Mesolithic: the social aspects. Antiquity 79: 280-288.

Davis, L. B. – Aaberg, S. A. – Cummings, L. S. 1994: Northern Rocky Mountain Paleoecology in Archeological, Paleobotanical, and Paleoethnobotanical Perspective. In: D. Despain ed., Plains and Their Environments: Proceedings of the First Biennial Scientific Conference on the Greater Yellowstone Ecosystem, U. S. Department of the Interior, National Park Service, 113-130.

De Hingh, A. E. 2000: Food production and food procurement in the Bronze Age and Early Iron Age (2000-500 BC). Ph.D. thesis. Leiden: Leiden University.

Deforce, K. – Bastiaens, J. – Van Calster, H. – Vanhoutte, S. 2009: Iron Age acorns from Boezinge (Belgium): The role of acorn consumption in Prehistory. Archäologisches Korrespondenzblatt 39, 381-392.

Deforce, K. – Bastiaens, J. – Van Neer, W. – Ervynck, A. – Lentacker, A. – Sergant, J. – Crombé, P. 2013: Wood charcoal and seeds as indicators for animal husbandry in a wetland site during the late mesolithic–early neolithic transition period (Swifterbant culture, ca. 4600–4000 BC) in NW Belgium. Vegetation History and Archaeobotany 22, 51-60.

Dénes, A. – Papp, N. – Babai, D. – Czúcz, B. – Molnár, Z. 2012: Wild plants used for food by Hungarian ethnic groups living in the Carpathian Basin. Acta Societatis Botanicorum Poloniae, 81, 381-396.

Dennel, R.W. 1979: The economic importance of plant resources represented on archaeological sites. Journal of Archaeological Science 3, 229-247.

Dietsch, M. F. 1996: Gathered fruits and cultivated plants at Bercy (Paris), a Neolithic village in a fluvial context. Vegetation history and archaeobotany 5, 89-97.

Dreslerová, D. – Horáček, I. – Pokorný, P. 2007: Přírodní prostředí Čech a jeho vývoj. In: M. Kuna ed., Archeologie pravěkých Čech 1: pravěký svět a jeho poznání, Praha: Archeologický ústav AV ČR, 23-50.

Evans, C. – Pollard, J. – Knight, M. 1999: Life in woods: three throws, „settlement“ and forest cognition. Oxford Journal of Archaeology 18, 241-254.

Filip, J. 1947: Dějinné počátky Českého ráje. Praha: Státní archeologický ústav.

Filipović, D. Z. – Allué, E. A. – Borić, D. R. 2010: Integrated carpological and anthracological analyses of plant record from the Mesolithic site of Vlasac, Serbia. Journal of the Serbian Archaeological Society 26, 145-161.

Fischer, A. – Richards, M. – Olsen, J. – Robinson, D. E. – Bennike, P. – Kubiak-Martens, S. – Heinemeier, J. 2007: The composition of Mesolithic food. Evidence from the submerged settlement on the Argus Bank, Denmark. Acta Archaeologica 78, 163-178.

Fisher, P. – Bender, A. 1970: The Value of Food. Oxford: Oxford University Press

Fries, J.E. – Jansen, D. – Niekus, M. J. Th. 2013: Fire in a hole! First results of the Oldenburg-Eversten excavation and some notes on Mesolithic hearth pits and hearth-pit sites. Settlement and Coastal Research in the Southern North Sea Region 36: 99-110.

Fuller, D. Q. – Weber, S. A. 2005: Formation processes and paleoethnobotanical interpretation in South Asia. Journal of Interdisciplinary Studies in History and Archaeology 2, 93-115.

Fuller, D. Q. 2007: Archaeological science in field training. In: P. Ucko – Q. Ling – J. Hubert eds., From concepts of the past to practical strategies: the teaching of archaeological field techniques, London: Saffron Books, 183-205.

Goren-Inbar, N. – Sharon, G. – Melamed, Y. – Kislev, M. 2002: Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. Proceedings of the National Academy of Science 99, 2455-2460.

Gray, J. P. 1999: A corrected ethnographic atlas. World Cultures 10, 24-85.

Greenberg, C. H. 2000: Individual variation in acorn production by five species of southern Appalachian oaks. Forest Ecology and Management 132, 199-210.

Grimm, E. C. 2011: TILIA 1.7. 16. Springfield: Illinois state museum.

Groenendijk, H. 1987: Mesolithic hearth-pits in the Veenkoloniën (prov. Groningen, the Netherlands), defining a specific use of fire in the Mesolithic. Palaeohistoria 29, 85-102.

Hardy, B. L. – Svoboda, J. A. 2009: Mesolithic stone tool function and site types in Northern Bohemia, Czech Republic. In: M. Haslam – G. Robertson – A. Crowther-Smith – S. Nugent – L. Kirkwood eds., Archaeological science under a microscope: studies in residue and ancient DNA analysis in honour of Thomas H. Loy, Canberra: ANU E Press, 159-174.

Hardy, B. L. 2010: Climatic variability and plant food distribution in Pleistocene Europe: Implications for Neanderthal diet and subsistence. Quaternary Science Reviews 29, 662-679.

Hardy, K. 2007: Where would be without string? Ethnographic and prehistoric evidence for the use, manufacture and role of string in the Upper Palaeolithic and Mesolithic of Northern Europe. In: V. Beugnier – P. Crombé eds., Plant processing from a prehistoric and ethnographic perspective. BAR International Series 1718, Oxford: John and Erica Hedges Ltd., 9-22.

Hardy, K. 2008: Prehistoric string theory. How twisted fibres helped to shape the world. Antiquity 82, 271-280.

Hather, J. G. – Mason, S. L. R. 2002: Introduction: some issues in the archaeobotany of hunter-gatherers. In: J. G. Hather – S. L. R. Mason eds., Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone, London: University College London, 1-14.

Hather, J. G. – Mason, S. L. R. eds. 2002: Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone. London: University College London.

Hather, J. G. 1991: The identification of charred archaeological remains of vegetative parenchymous tissue. Journal of Archaeological Science 18, 661-675.

Hather, J. G. 1993: An archaeobotanical guide to root and tuber identification. Volume 1. Europe and South West Asia. Oxford: Oxbow books.

Hather, J. G. 2000: Archaeological parenchyma. London: Archetype Publications.

Hejcman, M. – Hejcmanová, P. – Stejskalová, M. – Pavlů, V. 2014: Nutritive value of winter-collected annual twigs of main European woody species, mistletoe and ivy and its possible consequences for winter foddering of livestock in prehistory. The Holocene, 0959683614526904.

Hejný, S. – Slavík, B. eds. 1988–1992: Květena České republiky. Vol. 1 (1988), 2 (1990), 3 (1992). Praha: Academia.

Hermsen, I. 2006: Zwolle. Mesolithische haardkuilen of houtskoolmeilers aan de Vrouwenlaan. Verslag van een noodopgraving met brandkuilen en vuursteen uit de tijd van jagers en verzamelaars in Zwolle. Archeologische Rapporten Zwolle 39.

Higgenbotham, E.A.K. 1977: Excavations at Wooley Barrows, Morwenstow, Cornwall. Cornish Archaeology 16, 10-16.

Hodder, I. 1990: The domestication of Europe. Oxford: Blackwell.

Holden, T. G. – Hather, J. G. – Watson, J. P. N. 1995: Mesolithic plant exploitation at Roc del Migdia, Catalonia. Journal of Archaeological Science 22, 769-778.

Holst, D. 2007: Subsistenz und Lanndschaftnutzung im Frühmesolithikum: Nussröstplätze am Duvensee. Unpublished PhD dissertation, Johannes Gutenberg-Universität Mainz.

Holst, D. 2010: Hazelnut economy of early Holocene hunter-gatherers: a case study from Mesolithic Duvensee, northern Germany. Journal of Archaeological Science 37, 2871-2880.

Holst, D. 2011. Spatial organisation and settlement dynamics of Mesolithic nut processing sites in the Duvensee bog (Northern Germany). In: S. Gaudzinski-Windheuser – O. Jöris – M. Sensburg – M. Street – E. Turner eds., Site-internal spatial organization of hunter-gatherer societies: case studies from the European Palaeolithic and Mesolithic, Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 187-211.

Hošek, J. – Pokorný, P. – Šída, P. – Prach, J. 2013: Nově objevená pozdně gkaciální jezera na Třeboňsku. Zprávy o geologických výzkumech v roce 2012, 126-131.

Hurcombe, L. 2000: Plants as the raw materials for crafts. In: A. S. Fairbairn ed., Plants in Neolithic Britain and beyond, Oxford: Oxbow, 155-173.

Hurcombe, L. 2007: Plant processing for cordage and textiles using serrated flint edges: new *chaînes operatoires* suggested by combining ethnographic, archaeological and experimental evidence for bast fibre processing. In: V. Beugnier – P. Crombé eds., Plant processing from a prehistoric and ethnographic perspective. BAR International Series 1718, Oxford: John and Erica Hedges Ltd., 41-66.

Innes, J. B. – Blackford, J. J. – Davey, P. J. 2003: Dating the introduction of cereal cultivation to the British Isles. Early palaeoecological evidence from the Isle of Man. Journal of Quaternary Science 18, 603-613.

Jacobi, R. M., Tallis, J. M. – Mellars, P. 1976: The south Pennine Mesolithic and the ecological record. Journal of Archaeological Science 3, 307-320.

Jacomet, S. – Kreuz, A. 1999: Archäobotanik. Aufgaben, Methoden und Ergebnisse vegetations- und agrargeschichtlicher Forschungen. Stuttgart: Ulmer.

Jankovská, V. 1980: Paläobotanische Rekonstruktion der Vegetationsentwicklung im Becken Třeboňská pánev während des Spätglazials und Holozäns. Vegetace ČSSR A11. Praha: Academia.

Jankovská, V. 1992: Vegetationsverhältnisse und Naturumwelt des Beckens Jestřebská kotlina am Ende des Spätglazials und im Holozän (Doksy-Gebiet). Folia Geobotanica et Phytotaxonomica 27: 137-148

Jansen, J.B.H. – Peeters, J. H. M. 2001: Geochemische aspecten – verkenningen in enkele toepassingsmogelijkheden. In: J. W. H. Hogestijn – J. H.M. Peeters eds., De Mesolithische en Vroeg-Neolithische vindplaats Hoge Vaart-A27 (Flevoland) (=Rapportage Archeologische Monumentenzorg 79). Amersfoort.

Jenike, M. R. 2001: Nutritional ecology: diet, physical activity and body size. In: C. Panter-Brick – R. H. Layton – P. Rowley-Conwy eds., Hunter-gatherers. An interdisciplinary perspective, Cambridge: Cambridge University Press, 205-238.

Jochim, M. 1976: Hunter-gatherer subsistence and settlement. London: Academic Press.

Juan, J. 1997: Font del Rós (Berga). Estudio de residuos conservados en el instrumental lítico de molido y triturado. Unpiblished manuscript.

Karg, S. – Haas, J. N. 1996: Indizien für den Gebrauch von mitteleuropäischen Eicheln als prähistorische Nahrungsressource. Tübinger Monographien zur Urgeschichte 11, 429-435.

Karg, S. 2006: The water chestnut (*Trapa natans* L.) as a food resource during the 4th to 1st millennia BC at Lake Federsee, Bad Buchau (southern Germany). Environmental Archaeology 11, 125-130.

Kelly, R. L. 1995: The foraging spectrum: diversity in hunter-gatherer lifeways. Washington DC: Smithsonian Institution Press.

Kislev, M. E. – Nadel, D. – Carmi, I. 1992: Epipalaeolithic (19000 BP) cereal and fruit diet at Ohalo II, Sea of Galiee, Izrael. Review of Palaeobotany and Palynology 73, 161-166.

Klassen, L. 2004: Jade und Kupfer: Untersuchungen zum Neolithisierungsprozess im westlicheno Ostseeraum unter besonderer Berücksichtigung der Kulturentwicklung Europas 5500-3500 BC. Jutland Archaeological Society publications 47. Aarhus: Aarhus University Press.

Klimenko, S. 2004: The Cornelian cherry (*Cornus mas* L.): collection, preservation, and utilization of genetic resources. Journal of Fruit and Ornamental Plant Research12, 93-98.

Knörzer, K.-H. - Gerlach, R. - Meurers-Balke, J. – Kalis, A. J. - Tegtmeier, U. – Becker, W. D. – Jürgens, A. 1999: PflanzenSpuren. Archäobotanik im Rheinland. Agrarlandschaft und Nutzpflanzen in Wandel der Zeiten. Köln: Rheinland-Verlag.

Komárková, V. 2005: A report on plant macroremains from Kristova jeskyně. Deposited in Laboratory of Archaeobotany and Palaeoecology, Faculty of Science,České Budějovice.

Kozlowski, J. K. – Kozlowski, S. K. 1986: Foragers of Central Europe and their acculturation. In: M. Zvelebil ed., Hunters in transition, Cambridge: Cambridge University Press, 95-108.

Kubát K. – Hrouda L. – Chrtek J. – Kaplan Z. – Kirschner J. – Štěpánek J eds. 2002: Klíč ke květeně České republiky. Praha: Academia.

Kubiak-Martens, L. – Kooistra, L. I. – Langer, J. J. 2011: Mesolithische teerproductie in Hattemerbroek. In: E. Lohof – T. Hamburg – J. Flamman eds., Steentijd opgespoord. Archeologisch onderzoek in het tracé van de Hanzelijn-Oude Land. Archol-Rapport 138. ADC-Rapport 2576, Leiden, Amersfoort, 497-512.

Kubiak-Martens, L. 1996: Evidence for possible use of plant foods in Palaeolithic and Mesolithic diet from the site of Całowanie in the central part of the Polish Plain. Vegetation History and Archaeobotany, 5, 33-38.

Kubiak-Martens, L. 1999: The plant food component of the diet at the Late Mesolithic (Ertebølle) settlement at Tybrind Vig, Denmark. Vegetation History and Archaeobotany 8, 117-127.

Kubiak-Martens, L. 2002: New evidence for the use of root foods in pre-agrarian subsistence recovered from the late Mesolithic site at Halsskov, Denmark. Vegetation History and Archaeobotany 11, 23-31.

Kubiak-Martens, L. 2008: Voedseleconomie: parenchym en andere plantaardige macroresten (Hanzelijn Oude Land – Knooppunt Hattemerbroek). BIAXiaal 386, Zaandam.

Kuna, M. – Černý, V. – Dreslerová, D. – Vařeka, P. 2007: Metody archeologického výzkumu. In: M. Kuna ed., Archeologie pravěkých Čech 1: pravěký svět a jeho poznání, Praha: Archeologický ústav AV ČR, 89-127.

Kuneš, P. – Pokorný, P. – Šída, P. 2008: Detection of the impact of early Holocene hunter-gatherers on vegetation in the Czech Republic, using multivariate analysis of pollen data. Vegetation History and Archaeobotany 17, 269-287.

Kuneš, P. 2008: Human-driven and natural vegetation changes of the last glacial and early Holocene. Ph.D. Thesis. Praha: Univerzita Karlova v Praze.

Le Goff, J. 1991: Kultura středověké Evropy. Praha: Odeon.

Lee, R. B. 1968: What hunters do for a living, or, how to make out on scarce resources. In: R. B. Lee – I. DeVore eds., Man the hunter, Chicago: Aldine, 30-48.

Lee, R. B. 1973: Mongongo: the ethnography of a major wild food resource. Ecology of Food and Nutrition 2, 307-321.

Lev, E. – Amar, Z. 2000: Ethnopharmacological survey of traditional drugs sold in Israel at the end of the 20th century. Journal of Ethnopharmacology 72, 191-205.

Lev, E. – Kislev, M. E. – Bar-Yosef, O. 2005: Mousterian vegetal food in Kebara Cave, Mt. Carmel. Journal of Archaeological Science 32, 475-484.

Lev, E. 2002: Reconstructed *materia medica* of the Medieval and Ottoman al-Sham. Journal of Ethnopharmacology 80, 167-179.

López-Dóriga, I. L. 2012: Reconstructing food procurement in prehistory through the study of archaeological plant macroremains (seeds and fruits). In: J. Cascalheira – Gonçalves, C eds., Actas das IV Jornadas de Jovens em Investigação Arqueológica-JIA 2011: Faro, 11 a 14 de maio de 2011. Universidade do Algarve. Faculdade de Ciências Humanas e Sociais. Núcleo de Arqueologia e Paleoecologia, 167-172.

Losey, R. J. – Stenholm, N. – Whereat-Phillips, P. – Vallianatos, H. 2003: Exploring the use of red elderberry (*Sambucus racemosa*) fruit on the southern Northwest Coast of North America. Journal of archaeological science 30, 695-707.

Ložek, V. 2007: Zrcadlo minulosti. Česká a slovenská krajina v kvartéru. Praha: Dokořán.

Łuczaj, Ł. 2012: Ethnobotanical review of wild edible plants of Slovakia. Acta Societatis Botanicorum Poloniae 81, 271-281.

Marinova, E. – Filipovic, D. – Obradović, D. – Allué, E. 2013: Wild plant resources and land use in the Mesolithic and early Neolithic south-east Europe: Archaeobotanical evidence from the Danube catchment of Bulgaria and Serbia. Offa 69.

Martinez-Moreno, J. – Mora Torcal, R. 2011: Spatial organization at Font del Ros, a Mesolithic settlement in the south-eastern Pyrenees. In: S. Gaudzinski-Windheuser – O.

Jöris – M. Sensburg, – M. Street. – E. Turner eds., Site-internal spatial organization of hunter-gatherer societies: case studies from the European Palaeolithic and Mesolithic. Papers submitted at the session (C58) "Come in.and find out: opening a new door into the analysis of hunter-gatherer social organisation and behaviour", held at the 15th U.I.S.P.P. conference in Lisbon, September 2006, Mainz: Verlag des Römisch-Germanischen Zentralmuseums Mainz, 213-231.

Mason, S. L. R. – Hather, J. G. – Hillman, G. C. 2002: The archaeobotany of European huter-gatherers: some preliminary investigations. In: J. G. Hather – S. L. R. Mason eds., Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone, London: University College London, 188-196.

Mason, S. L. R. – Hather, J. G. 2000: Parenchymatous plant remains. In: S. Mithen ed., Hunter–Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988–1998. Volume 2, Cambridge: McDonald Institute, 415-425.

Mason, S. R. L. 1992: Acorns in human subsistence. Ph.D. thesis. London: University College London.

Mason, S. R. L. 1995: Acornutopia? Determining the role of acorns in past human subsistence. In: J. Wilkins – D. Harvey – M. Dobson eds., Food in Antiquity, Exeter: University of Exeter Press, 12-24.

Mason, S. R. L. 2000: Fire and Mesolithic subsistence – managing oaks for acorns in northwest Europe? Palaeogeography, Palaeoclimatology, Palaeoecology 164, 139-150.

McGlone, M. S. – Wilmshurst, J. M. – Leach, H. M. 2005: An ecological and historical review of bracken (*Pteridium esculentum*) in New Zealand, and its cultural significance. New Zealand Journal of Ecology 29, 165-184.

Mears, R. – Hillman, G. C. 2007: Wild foods. London: Hodder & Stoughton.

Mellars, P. 1976: Fire ecology, animal populations and man: a study of some ecological relationships in prehistory. Proceedings of the Prehistoric Society 42, 15-45.

Messer, E. 1979: Cultivation and cognition: Plants and archaeological research strategies. In: C. Kramer ed., Ethnoarchaeology: Implications of Ethnography for Archaeology, New York: Columbia University Press, 247-264.

Miller, N. F. 1997: The analysis of archaeological plant remains. In: C. R. Ember – M. Ember – P. N. Peregrine eds., Research frontiers in anthropology, Upper Saddle River, New Jersey: Prentice Hall, 229-244.

Mithen, S. – Finlay, N. – Carruthers, W. – Carter, S. – Ashmore, P. 2001: Plant Use in the Mesolithic: Evidence from Staosnaig, Isle of Colonsay, Scotland. Journal of Archaeological Science 28, 223-234.

Mithen, S. – Finlay, N. 2000: Staosnaig, Colonsay: Excavations 1989-1995. In: S. Mithen ed., Hunter–Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988–1998. Volume 2, Cambridge: McDonald Institute, 359-441.

Mithen, S. 1996: The prehistory of the mind. A search for the origins of art, religion and science. London: Thames and Hudson.

Mithen, S. J. – Score, D. 2000: Experimental roasting of hazelnuts. In: S. Mithen ed., Hunter–Gatherer Landscape Archaeology: The Southern Hebrides Mesolithic Project 1988–1998. Volume 2, Cambridge: McDonald Institute, 507-512.

Moerman, D: E. 1998: Native American ethnobotany. Portland Oregon: Timber Press.

Moore, J. 2003: Enculturation through fire: beyond hazelnuts and into the forest. In: L. Larson – H. Kindgren – K. Knutsson – D. Loeffler – A. Åkerlund eds., Mesolithic on the move. Papers presented at the sixth international conference on the Mesolithic in Europe, Stockholm 2000, Oxford: Oxbow books, 139-144.

Murdock, G. P. 1967: Ethnographic atlas. Pittsburgh: University of Pittsburgh Press.

Neuhäuslová Z. – Blažková D. – Grulich V. – Husová M. – Chytrý M. – Jeník J. – Jirásek J. – Kolbek J. – Rybníčková E. – Sádlo J. 1998: Mapa potenciální přirozené vegetace České republiky. Praha: Academia.

Norton, H. H. 1979: Evidence for bracken fern as a food for aboriginal peoples of Western Washington. Economic Botany 33, 384-396.

Novák, J. – Svoboda, J. A. – Šída, P. – Prostředník, J. – Pokorný, P. in prep: Charcoal record of Holocene woodland succession from sandstone rock shelters of North Bohemia (Czech Republic).

Nováková, K. – Novák, J. – Šafránková, J. 2008: Paleoekologický výzkum Velanské cesty u Českých Velenic: zachycení lidské činnosti. In: J. Beneš – P. Pokorný eds., Bioarcheologie v České republice, České Budějovice – Praha: Jihočeská univerzita v Českých Budějovicích – Archeologický ústav AV ČR, 99-114.

Opravil, E. 2003: Rostlinné makrozbytky. In: J. Svoboda ed., Mezolit severních Čech. Komplexní výzkum skalních převisů na Českolipsku a Děčínsku, 1978-2003, Brno: Archeologický ústav AV ČR, 38-42.

Out, W. A. – Verhoeven, K. 2014: Late Mesolithic and Early Neolithic human impact at Dutch wetland sites: the case study of Hardinxveld-Giessendam De Bruin. Vegetation History and Archaeobotany 23, 41-56.

Out, W. A. 2008a: Gathered food plants at Dutch Mesolithic and Neolithic wetland sites. In: S. Baker – M. Allen – S. Middle – K. Poole eds., Food and drink in archaeology I. Nottingham: Prospect Books, 84-95.

Out, W. A. 2008b: Selective use of *Cornus sanguinea* L. (red dogwood) for Neolithic fish traps in the Netherlands. Environmental Archaeology 13, 1-10.

Out, W. A. 2009: Sowing the seed? Human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500-3400 cal BC). PhD. thesis. Leiden: Leiden University Press.

Out, W. A. 2012: What’s in a hearth? Seeds and fruits from the Neolithic fishing and fowling camp at Bergschenhoek, The Netherlands, in a wider context. Vegetation History and Archaeobotany 21, 201-214.

Panter-Brick, C. – Layton, R. H. – Rowley-Conwy, P. 2001: Lines of enquiry. . In: C. Panter-Brick – R. H. Layton – P. Rowley-Conwy eds., Hunter-gatherers. An interdisciplinary perspective, Cambridge: Cambridge University Press, 1-11.

Pavlů, I. 2004: The origins of the Early Linear Pottery Culture in Bohemia. In: A. Lukes – M. Zvelebil eds., LBK Dialogues: studies in the formation of the Linear Pottery Culture. BAR International Series 1304, Oxford: Archaeopress, 83-90.

Pavlů, I. ed. – Zápotocká, M. 2007: Archeologie pravěkých Čech 3: neolit. Praha: Archeologický ústav AV ČR, 124-164.

Peacock, S. L. 2002: Perusing the pits: the evidence for prehistoric root resource processing on the Canadian Plateau. In S. L. R. Mason – J. G. Hather eds., Hunter-gatherer archaeobotany: perspectives from the northern temperate zone, London: University College London, 44-61.

Perry, D. 1999: Vegetative tissues from Mesolithic sites in the Northern Nertherlands. Current Anthropology 40, 231-237.

Perry, D. 2002: Preliminary results of an archaeobotanical analysis of Mesolithic sites in the Veenkoloniën, Province of Groningen, the Netherlands. In: J. G. Hather – S. L. R. Mason eds., Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone, London: University College London, 108-116.

Pohl, R. W. 1955: Toxicity of ferns and equisetum. American Fern Journal 45, 95-97.

Pokorný, P. – Jankovská, V. 2000: Long-term vegetation dynamics and the infilling process of a former lake (Švarcenberk, Czech Republic). Folia Geobotanica 35, 433-457.

Pokorný, P. – Kuneš, P. – Šída, P. – Chvojka, O. – Světlík, I. 2009: Environmental archaeology of the Mesolithic period in Bohemia. Fines Transire 18, 165-171.

Pokorný, P. – Růžičková, E. 2000: Changing environments during the Younger Dryas climatic deterioration: correlation of aeolian and lacustrine deposits in southern Czech Republic. Folia Geobotanica et Phytotaxonomica 35, 43-58.

Pokorný, P. – Sádlo, J. 2008: Kolapsy v českém pravěku. In M. Bárta – P. Pokorný eds., Něco překrásného se končí, Praha: Dokořán, 89-105.

Pokorný, P. – Šída, P. – Chvojka, O. – Žáčková, P. – Kuneš, P. – Světlík, I. – Veselý, J. 2010: Palaeoenvironmental research of the Schwarzenberg Lake, southern Bohemia, and exploratory excavations of this key Mesolithic archaeological area. Památky archeologické 101, 5-38.

Pokorný, P. – Šída, P. – Kuneš, P – Chvojka, O. 2008: Mezolitické osídlení bývalého jezera Švarcenberk (jižní Čechy) v kontextu vývoje přírodního prostředí. In: J. Beneš – P. Pokorný eds., Bioarcheologie v České republice, Praha: Archeologický ústav AV ČR, 145-176.

Pokorný, P. 1999: Vliv mezolitických populací na krajinu a vegetaci: nové nálezy ze staršího holocénu Třeboňské pánve. Zprávy ČAS 38, 21-22.

Pokorný, P. 2003: Rostlinné makrozbytky. In: J. Svoboda ed., Mezolit severních Čech. Komplexní výzkum skalních převisů na Českolipsku a Děčínsku, 1978-2003, Brno: Archeologický ústav AV ČR, 272-273.

Pokorný, P. 2004: Postglacial vegetation distribution in the Czech Republic and its relationship to settlement zones: review. In: M. Gojda ed., Ancient landscape, settlement dynamics and non-destructive archaeology, Praha: Academia, 395-414.

Poska, A. – Saarse, L. 2006: New evidence of possible crop introduction to north-eastern Europe during the Stone Age. Cerealia pollen finds in connection with the Akali Neolithic settlement, East Estonia. Vegetation History and Archaeobotany 15, 169-179.

Price, D. 1978: The Mesolithic of western Europe. Journal of World Prehistory 1: 225-305.

Prošek, F. 1951: Mesolitická chata v Tašovicích. Archeologické rozhledy 3, 12-15.

Prostředník, J. – Šída, P. 2006: Mezolitické osídlení pseudokrasových skalních dutin v Českém ráji. In: Sborník z konference 50. let CHKO Český Ráj, Z Českého ráje a Podkrkonoší, Supplementum 11, 83-106.

Rakić, S. – Povrenović, D. – Tešević, V. – Simić, M. – Maletić, R. 2006: Oak acorn, polyphenols and antioxidant activity in functional food. Journal of Food Engineering 74, 416-423.

Rasmussen, L. R. 2003: Ptaquiloside – an environmental hazard? Ph.D. Thesis, The Royal Veterinary and Agricultural University, Denmark.

Regnell, M. – Gaillard, M.-J. – Bartholin, T. S. – Karsten, P. 1995: Reconstruction of environment and history of plant use during the Late Mesolithic (Ertebølle culture) at the inland settlement of Bökeberg III, southern Sweden. Vegetation History and Archaeobotany, 4, 67-91.

Regnell, M. 2011: Plant subsistence and environment at the Mesolithic site Tågerup, southern Sweden: new insights on the “Nut Age”. Vegetation History and Archaeobotany 21, 1-16.

Renfrew, C. 1973: Palaeoethnobotany. The prehistoric food plants of the Near East and Europe. New York: Columbia University Press.

Roberts, N. 1989: The Holocene. An environmental history. Oxford: Blackwell.

Robinson, D. E. – Harild, J. A. 2002: Archaeobotany of an early Ertebølle (Late Mesolithic) site at Halsskov, Zealand, Denmark. In: J. G. Hather – S. L. R. Mason eds., Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone, London: University College London, 84-95.

Robinson, M. A. 2000: Further considerations of Neolithic charred cereals, fruits and nuts. In: A. S. Fairbairn ed., Plants in Neolithic Britain and beyond,. Neolithic Studies Group Seminar Papers 5, Oxford: Oxbow Books, 85-90.

Rösch, M. 2000: Pflanzenreste. In: P. Kieselbach, C. – J. Kind - A. M. Miller – D. Richter eds, Siebenlinden 2. Ein mesolithischer Fundplatz bei Rottenburg am Neckar, Kreis Tübingen. Materialhefte zur Archaologie in Baden-Württemberg 51, Stuttgart: Konrad Theiss, 59-63.

Rosenberg, D. 2008: The possible use of acorns in past economies of the Southern Levant: A staple food or a negligible food source? Levant 40, 167-175.

Rymer, L. 1976: The history and ethnobotany of bracken. Botanical Journal of the Linnean Society 73, 151-176.

Sádlo, J. – Pokorný, P. – Hájek, P. – Dreslerová, D. – Cílek, V. 2008: Krajina a revoluce. Významné přelomy ve vývoji kulturní krajiny českých zemí. Praha: Malá skála.

Šálková, T. – Divišová, M. – Kadochová, Š. – Beneš, J. – Delawská, D. – Kadlčková, E. – Němečková, L. – Pokorná, K. – Voska, V. – Žemličková, A. 2011: Acorns as a food resource. An experiment with acorn preparation and taste. Interdisciplinaria Archaeologica. Natural Sciences in Archaeology 2, 139-147

Schiffer, M. B. 1978: Methodological issues in ethnoarchaeology. In R. A. Gould ed., Explorations in Ethnoarchaeology, Albuquerque: University of New Mexico Press, 229-247.

Sealy, J. 2001: Body tissue chemistry and palaeodiet. In D. R. Brothwell – A. M. Pollard eds., Handbook of archaeological sciences, Chichester: John Wiley and Sons, 269-279.

Sergant, J. – Crombé, Ph. – Perdaen, Y. 2006: The invisible ‘hearths’: a contribution to the discernment of Mesolithic non-structured surface hearths. Journal of Archaeological Science 33, 999-1007.

Šída, P. – Pokorný, P. – Chvojka, O. – Kuneš, P. 2010: Výzkum okolí jezera Švarcenberk v letech 2005 až 2008. In: P. Krištuf – P. Vařeka eds., Opomíjená archeologie 2007 – 2008, Plzeň: Západočeská univerzita v Plzni, 36-45.

Šída, P. – Pokorný, P. 2011: Zjišťování archeologického potenciálu krajiny pomocí kvartérně geologického mapování na příkladu Třeboňska, Archeologické Rozhledy 63, 485-500.

Šída, P. – Prostředník, J. – Kuneš, P. 2011: New radiocarbon data for the North Bohemian Mesolithic. Interdisciplinaria Archeologica Natural Sciences in Archaeology 2, 151-157.

Šída, P. – Prostředník, J. 2007: Mezolit a pozdní paleolit Českého ráje: perspektivy poznání regionu, Archeologické rozhledy 59, 443-460.

Šída, P. – Prostředník, J. 2010: Předneolitické osídlení pseudokrasu Českého ráje. In: P. Krištuf – P. Vařeka eds., Opomíjená archeologie 2007 – 2008, Plzeň: Západočeská univerzita, 38-55.

Šída, P. – Prostředník, J. 2011: Současný stav poznání neolitické těžby a zpracování metabazitu v Jizerských horách. In: M. Popelka – R. Šmidtová eds., Otázky neolitu a eneolitu našich zemí: sborník referátů z 28. zasedání badatelů pro výzkum neolitu a eneolitu (nejen) Čech, Moravy a Slovenska: Mělník 28. 9. - 1. 10. 2009. Praehistorica 29, Praha: Karolinum, 369-380.

Šída, P. 2004: Neolitická a eneolitická kamenná industrie v oblasti horního Pojizeří. In: M. Lutovský ed., Otázky neolitu a eneolitu našich zemí 2003, 377-408.

Šída, P. 2011: Přechod mezolit–neolit. Existuje kulturní kontinuita či diskontinuita? A klademe si vůbec správné otázky? In: M. Popelka – R. Šmidtová eds., Otázky neolitu a eneolitu našich zemí: sborník referátů z 28. zasedání badatelů pro výzkum neolitu a eneolitu (nejen) Čech, Moravy a Slovenska: Mělník 28. 9. - 1. 10. 2009. Praehistorica 29, Praha: Karolinum, 359-367.

Simmons, I. G. – Innes, J. B. 1987: Mid-holocene adaptations and later Mesolithic forest disturbance in Northern England. Journal of Archaeological Science 14, 385-394.

Simmons, I. G. 1996: The environmental impact of later Mesolithic cultures. The creation of Moorland landscape in England and Wales. Edinburgh: Edinburgh University Press.

Slavík, B ed. 1995: Květena České republiky. Vol. 4. Praha: Academia.

Slavík, B. – Štěpánková, J. eds. 2004: Květena české republiky. Vol. 7. Praha: Academia.

Slavík, B. ed. 1995–2000: Květena České republiky. Vol. 4 (1995), 5 (1997), 6 (2000). Praha: Academia.

Speth, J. D. – Widdowson, E. M. – Oftedal, O. T. – Foley, R. A. – Van Soest, P. 1991: Protein selection and avoidance strategies of contemporary and ancestral foragers: unresolved issues. Philosophical Transactions of the Royal Society of London B34, 265-270.

Štěpánková, J. 2008: Květena České republiky. Vol. 8. Praha: Academia.

Strydonck van, M. J. – Crombé, P. – Maes, A. 2001: The site of Verrebroek'Dok'and its contribution to the absolute dating of the mesolithic in the low countries. Radiocarbon 43, 997-1005.

Svoboda, J. A. – Cílek, V. – Jarošová, L. – Peša, V. 1999: Mezolit z perspektivy regionu: výzkumy v ústí Pekla. Archeologické rozhledy 51, 243-279.

Svoboda, J. A. - Hajnalová, M. – Horáček, I. – Novák, M. – Přichystal, A. – Šajnerová, A. – Yaroshevich, A. 2007: Mesolithic settlement and activities in rockshelters of the Kamenice river canyon, Czech Republic. Eurasian Prehistory 5, 95-127.

Svoboda, J. A. – Novák, J. – Novák, M. – Sázelová, S. – Demek, J. – Hladilová, Š. – Peša, V. 2013: Palaeolithic/Mesolithic stratigraphic sequences at Údolí samoty and Janova zátoka rock shelters (Northern Bohemia). Archäologisches Korrespondenzblatt 43, 469-707.

Svoboda, J. A. 2008: The Mesolithic of the Middle Danube and Upper Elbe Rivers. In: G. Bailey – P. Spikins eds., Mesolithic Europe, Cambridge: Cambridge University Press, 221-237.

Svoboda, J. A. ed. 2003: Mezolit severních Čech. Komplexní výzkum skalních převisů na Českolipsku a Děčínsku, 1978-2003. Dolnověstonické studie 9. Brno: Archeologický ústav AV ČR.

Thoms, A.V. 2006: Ethnographically documented land-use patterns and archaeological expectations. In A. V. Thoms – P. A. Clabaugh eds., Sites and Site Formation Processes in the Tobacco River Plains and Vicinity: Archaeological Investigations in the Middle Kootenai River Valley, Northwest Montana (Reports of Investigation 7), Center for Ecological Archaeology. College Station: Texas A&M University, 59-75.

Tilley, C. 1994: A phenomenology of landscape. Places, paths and monuments. Oxford: Berg Publishers.

Tinner, W. – Nielsen, E. H. – Lotter, A. F. 2007: Mesolithic agriculture in Switzerland? A critical review of the evidence. Quaternary Science Reviews 26, 1416-1431.

Tomášek, M. 2004: Půdy České republiky. Praha: Český geologický ústav.

Tringham, R. 2000: Southeastern Europe in the transition to agriculture in Europe: bridge, buffer or mosaic. In: T. D. Price ed., Europe's first farmers, Cambridge: Cambridge University Press, 19-56.

Veen van der, M. 2007: Formation processes of desiccated and carbonized plant remains – the identification of routine practice. Journal of Archeological Science 34: 968-990.

Vencl, S. 1985: Žaludy jako potravina. K poznání významu sběru pro výživu v pravěku. Archeologické Rozhledy 37, 516-565.

Vencl, S. 1990: K otázkám časoprostorových rozdílů v intenzitě paleolitických a mezolitických osídlení ve střední Evropě. Památky archeologické 81, 448-457.

Vencl, S. 1992: Mesolithic settlement on cadastral territory of Sopotnice, district Ústí nad Orlicí. Památky archeologické 83, 7-40.

Vencl, S. 1996: Acorns as food: again. Památky Archeologické 87, 95-111.

Vencl, S. 2007: Mezolit. In S. Vencl ed. – J. Fridrich, Archeologie pravěkých Čech 2: paleolit a mezolit, Praha: Archeologický ústav AV ČR, 124-164.

Vencl, S. ed. 2006: Nejstarší osídlení jižních Čech. Paleolit a Mesolit. Praha: Archeologický ústav AV ČR.

Vera, F. W. M. 2000: Grazing ecology and forest history. Wallingford: CABI Publishing.

Wandsnider, L. 1997: The roasted and the boiled: food composition and heat treatment with special emphasis on pit-hearth cooking. Journal of Anthropological Archaeology 16, 1-48.

Warren, G. 2003: Life in the trees: Mesolithic people and the woods of Ireland. Archaeology Ireland 17, 20-23.

Westropp, H. 1866: Analogous forms of implements among early and primitive races. Memoirs of the Anthropological Society 2, 288-293.

Wood, J. 2000: Food and drink in European prehistory. European Journal of Archaeology 3, 89-111.

Wood, J. 2011: Daily practices of prehistoric Europe during the Mesolithic/Neolithic transition. In: D. Gheorghiu ed., Experiments with past materialities, BAR International Series 2302, Oxford: Hadrian Books, 9-17.

Žáčková, P. 2008: Rekonstrukce paleoekologických poměrů při zazemňování jezer metodou analýzy rostlinných makrozbytků. Nepublikovaná diplomová práce. Praha: Přírodovědecká fakulta Univerzity Karlovy v Praze.

Zapata, L. – Cava, A. – Iriate, M. J. – Baraybar, J. P. – De La Rua, C. 2002: Mesolithic plant use in the western Pyrenees: implications for vegetation change, use of wood and human diet. In: J. G. Hather – S. L. R. Mason eds., Hunter-gatherer archaeobotany. Perspectives from the northern temperate zone, London: University College London, 96-107.

Zhilin, M. G. – Karhu, A. A. 2002: Exploitation of birds in the early Mesolithic of Central Russia. Acta Zoologica Cracoviensia 45, 109-116.

Zvelebil, M. 1994: Plant use in the Mesolithic and its role in the transition to farming. Proceedings of the Prehistoric Society 60, 35-74.

8. List of figures

9. Appendix

Divišová, M. 2012: Current knowledge of the neolithisation process: a Central European perspective. Interdisciplinaria Archeologica. Natural Sciences in Archeology 3, 141-153.

Volume III • Issue 1/2012 • Pages 141–153

INTERDISCIPLINARIA ARCHAEOLOGICA
NATURAL SCIENCES IN ARCHAEOLOGY

homepage: http://www.iansa.eu

News and views

Current Knowledge of the Neolithisation Process: a Central European Perspective

Michaela Divišová[a*]

[a]*Laboratory of Archaeobotany and Paleoecology, Faculty of Science, University of South Bohemia. Branišovská 31, 37005, České Budějovice, Czech Republic*

ARTICLE INFO

Article history:
Received: 14 May 2012
Accepted: 27 August 2012

Keywords:
Neolithisation process
Mesolithic
Neolithic
LBK
genetics
stable isotopes
chipped stone industry
demography
Vedrovice

ABSTRACT

The present work provides a literature review of the Neolithisation process in Central Europe. Certain particular aspects including genetics, stable isotope analysis, lithic studies, and demography have been dealt with in order to obtain the clearest possible picture of the process. It has become clear that the spread of agriculture involved a variety of mechanisms and cannot be merely explained by a simple model of migration or acculturation. In conclusion it will be argued that there is evidence which points to contact and interaction between local hunter gatherers and the earliest farming communities. It has recently become increasingly apparent that such a scenario provides a plausible explanation for the situation in the Czech Republic, where the spread of farming had traditionally been accepted as an example of agricultural colonization by farmers of LBK.

1. Introduction

At the end of the 19th century, it was generally accepted that a hiatus occurred between the Palaeolithic and the Neolithic. Therefore, the appearance of the Neolithic in Europe was associated with the arrival of new people, colonists from the south-east (Vencl 2007*,* 124–125). Since that time, the Mesolithic period and the emergence of farming in the Near East and its spread to Europe has received broad attention among researchers, particularly in the English-speaking world (Zvelebil, ed. 1986; Gronenborn 2007*,* 73–75). Thus, a large number of hypotheses regarding the process of Neolithisation have been suggested, which can be divided into three main groups, based on the relative contribution of local hunter-gatherers and newcomers, early farming communities, to the European Neolithic.

The first group of models consists of **migration hypotheses** which argue that the Neolithic arrived in Central Europe along with the first farmers from the Near East and south-eastern Europe. The second group, in contrast, explains the arrival of the Neolithic through **the acculturation theories** suggesting that the local hunter-gatherers played the decisive role and accepted the Neolithic way of life themselves only through the spread of information and the plant-animal package. Finally, the most recent group of models, **the integrationist view**, suggests that both the indigenous Mesolithic population and the neighbouring Neolithic societies played an important role in the Neolithisation of Central Europe.

1.1 The migration theories

According to Marek Zvelebil, the notion of farmers as our ancestors is one of the pervading claims regarding national and European identity. He argues that there was traditionally a tendency for European prehistorians to place a major emphasis on the Neolithic. Zvelebil considers three particular reasons for this tendency. The first is the prejudice against savage, primitive and barbarian foragers, particularly in contrast to civilised, ordered and cultured farming communities. The second arose from the rise of urbanism which resulted in the idealization of the pastoral and rural way of life. The last one is the need on the part of certain nation-states, including

*Corresponding author. E-mail: MDivisova@seznam.cz

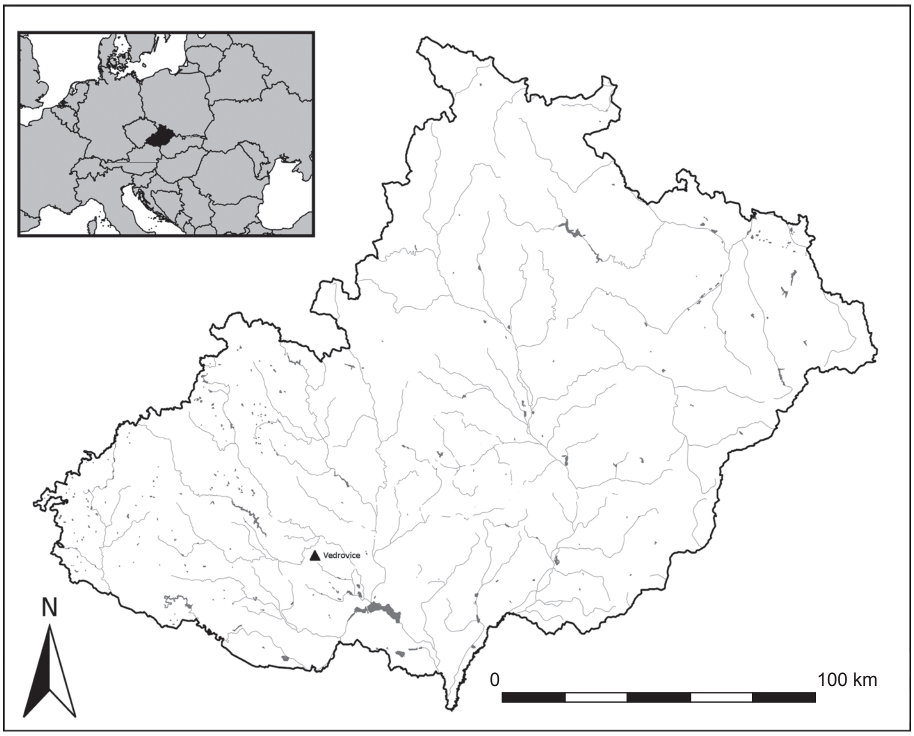


Figure 1. A location of the Vedrovice site at a map of Moravia.

former Czechoslovakia, to construct a national identity. Apart from archaeology, this theme, which Zvelebil calls "*farmers our ancestors*", can also be found in literature or in popular culture (Zvelebil 1995a, 145–147).

In archaeology, these views were supported by Vere Gordon Childe, who offers the *ex oriente lux* interpretation of agricultural dispersal. In his book *The Dawn of European Civilisation*, published in London in 1925, he argues that the transition from foraging to farming in Europe was the result of immigration of populations from the Near East, who brought with them advanced and superior technology and culture, and replaced the indigenous Mesolithic hunter-gatherers. He believes that this process was a major turning point in human history and referred to it as the "Neolithic revolution". On the other hand, he emphasises that the term "Neolithic revolution" amounts to a gradual, rather than radical, but transformational process (Childe 1925; 1936).

An entire series of authors have substantiated these diffusionist and migration models (*e.g.* Clark 1966; Tringham 1971; Runnels, van Andel 1995; Bogucki 2003). Furthermore, these hypotheses have been supported by genetic studies. The pioneering works of Albert Ammerman, an archaeologist, and L. L. Cavalli-Sforza, a population geneticist (1984), are well-known, however, their model has been intensely criticised (see below). A special contribution to this hypothesis has been provided by Colin Renfrew, who has added a linguistic aspect to the discussion and linked the Neolithic colonisation of Europe to the advent of the first agrarian populations speaking Indo-European languages (Renfrew 1987, 145–152).

Traditionally, the spread of farming across Central Europe has been accepted as an example of agricultural colonisation by farmers of LBK (Vencl 1986; Bogucki 2001; Neustupný 2004). In the Czech Republic, one of the most notable studies of the Neolithisation of Central Europe has been carried out by Slavomil Vencl (1982). On the basis of anthropological, demographic, botanical, ecological and last but not least archaeological evidence, he has supported the notion that the Neolithisation of Central Europe involved several waves of colonisation, in which the colonists settled in practically unoccupied land. Vencl assumes that the indigenous Mesolithic population played a negligible role in the transition, apart from certain peripheral regions, where the quality of the environment was insufficient for the advancing agriculture societies. Vencl has also considered certain parallels from ethnography and antique sources and has pointed out that the first farmers were mentally more advanced than the indigenous hunter-gatherers and that such a difference could lead to some hostile violent conflicts (Vencl 1982, 665–678; Vencl 1986). In terms of the further development of research into the nature of the transition to agriculture, a special offshoot of the models has been applied by Petr Květina (2007). On the basis of anthropological and ethnographic evidence, Květina makes an attempt to reconstruct the encounter between early farmers and local hunter-gatherers and suggests possible violent clashes between the domestic and incoming populations. Květina, however, considers only the first contact between the communities.

Despite the fact that the migration theories appeared to be compatible with the rate of the spread of the Neolithic measured from radiocarbon dates (Ammerman, Cavalli-Sforza 1984), there are several implications for this immigrationist explanation. The first is that this process had to be driven by the rapid population growth experienced by the emergence of Neolithic farming populations (*e.g.*

Renfrew 1987). However, such a population growth as an explanation for agriculture transition has been criticised for a lack of evidence by a number of scholars (*e.g.* Zvelebil 2002). Secondly, this approach fails to consider the role of the original hunter-gatherer population. Unfortunately, extremely sparse evidence concerning late Mesolithic settlement in Central Europe may support these hypotheses (Mateiciucová 2008, 34–36; Zvelebil 1986a, 9).

1.2 The acculturation theories

The acculturation theories represent the opposite perspective to the migration hypotheses. The adoption of farming in Europe and the origins of the Neolithic are viewed exclusively as the uptake of the so-called "*Neolithic package*", including a sedentary way of life, the first permanent villages, domesticated crops and animals, and new skills such as polished stone production and pottery, by local forager populations. These hypotheses do not credit that migration from the Near East played any important role. Consequently, the transition of hunters and gatherers to agriculture is primarily explained by the reduction of available resources with an emphasis on the fact that hunter-gatherers adopted farming under pressure. A further emphasis is placed on the sedentary way of life, which is perceived as the crucial aspect leading to the farming (Binford 1968; Zvelebil 1981; 1986a; Rowley-Conwy 1983; Mateiciuciová 2008). Authors such as Dennel (1983), Barker (1985), Tillmann (1993), Pavúk (1994), Kind (1998), or the later work of Tringham (2000) may be placed in this group.

These authors argue that domesticated animals and plants were acquired via trade with the Neolithic population of the Near East, and subsequently with agriculturalists living in the Balkans and the Mediterranean area. This idea is supported by accumulating archaeobotanical evidence pointing out agricultural activity in Central and Northern Europe well before the onset of the Neolithic (Erny-Rodmann *et al*. 1997; Gehlen, Schön 2003; Innes *et al*. 2003; Poska, Saarse 2006; Behre 2007; Tinner *et al*. 2007). On the basis of these results, the authors suggest that agriculture developed locally throughout the late Mesolithic and Neolithic.

Mention should also be made of A. Whittle (1996), who provides a view of the acculturation process from a social perspective and suggests the local adoption of non-local resources and technologies, facilitated through contacts and interactions outside of Central Europe. In his view, however, the original forager population was motivated by existing social ethics, instead of accepting the notion of population growth leading to the colonisation of new territories.

1.3 The integrationist theories

Apart from the previous two groups of hypotheses, a number of scholars have regarded both types of processes, involving migration and acculturation, as playing an important role in the transition to farming in Central Europe. This intermediate model, described by Zvelebil (2002) as "*integrationism*", sees the agricultural transition in terms of selective colonization by fairly small groups through mechanisms such as "leapfrog colonisation", frontier mobility, and contact (Zvelebil 1986a; 1986b; Gronenborn 1994; Mateiciucová 2004; 2008). The availability model, suggested by Zvelebil and Rowley-Conwy (1984; 1986; Zvelebil 1986a; Zvelebil 1986b), placed a great deal of emphasis, in contrast to the earlier ones, on the members of the Mesolithic societies. Therefore, this theory is based on the assumption that there is not a substantial difference between Mesolithic foragers and the early farming population. Consequently, the entire zone of foraging-farming interactions is assumed as the frontier, rather than as merely the line of forager-farmer contact. The availability model is divided into three phases depending on the relationship between incoming farmers and indigenous Mesolithic populations within a region and on the intensity of farming practises:

1. *the availability phase*
   The availability phase exists in the early stages of the agricultural frontier, when farmers and foragers are developing contacts but are still two culturally and economically independent units. During this phase, the agricultural way of life is known to the Mesolithic population through a certain exchange of materials and information. The availability phase ends with the adoption of some elements of farming by foragers or with the settlement of farmers in the territory used by hunter-gatherers.
2. *the substitution phase*
   The substitution phase is divided into two forms: external, in which farmers settled in the forager territory and competed with the remaining hunter-gatherers for land and resources, and internal, in which the foragers add certain elements of farming into their range of subsistence strategies. In both cases, the key concept is the competition between two mutually incompatible ways of life.
3. *the consolidation phase*
   This consolidation phase, the final stage in the transition to farming, is the first phase with a predominantly Neolithic economy, marked by extensive and intensive growth of food production: having occupied the best soils, extending to new, secondary areas, and having exhausted, the possibilities of the extensive form of land-use, more intensive farming practices are employed. The use of wild resources is merely complementary, and its role increases only as an emergency strategy. This phase ends when the socio-economic conditions in the area become indistinguishable from those in areas settled earlier and the effects of the transition disappear (Zvelebil 1986a, 10–13).

This third group of hypotheses is supported by an analysis of the isotope of strontium and sulphur contained in the bones and teeth of early farmers, revealing that not all the people buried within the same place spent their childhood or adulthood there. Thus, they are likely to have been immigrants from an area where the isotopic values correspond to those found in the previously hunting-gathering regions (Bentley *et al*. 2002; Richards *et al*. 2008). Arguments supporting the integrationist model of the transition to agriculture have also been provided by genetic researchers discussing the ancestry of Europeans (Richards 2003), and an analysis of chipped stone artefacts, indicating that early farmers of Central Europe partly continued in the traditions of the local forager populations (Tillmann 1993; Mateiciucová 2004; 2008). Excellent evidence for interaction between farming communities and adjacent groups practising hunting and gathering is also offered from prehistoric Poland. According to this evidence, many hunter-gatherers had produced and used pottery long before they took up farming. Moreover, these hunter-gatherer groups appeared to have incorporated some elements of Neolithic group's technology into their existing ceramic traditions (Nowak 2009).

The availability model introduced space, time, and regional variability into the transition and this model has been widely referred to. However, there are also certain problems related to this complex view of the Neolithisation process. Firstly, the transition is basically seen as a one-way process, populations are defined within it according to the stage they have reached towards a pre-defined end, farming. Thus, particular difficulties derive from the application of the general model in certain areas. Another problem involves the fact that the model assumes both the general process and the end result as constant, despite the huge diversity in space and time, which the transition from foraging to farming represents (Pluciennik 1998, 68–69; Pavlů 2005, 295).

Turning now to the nature of the transition to farming, it is worth pointing out that a number of authors have also considered contacts that took place within the farmer/forager transition on the social level (Zvelebil, Dolukhanov 1991; Zvelebil 1995b). Certain models even stress the significance of deeper symbolic meanings in the process of Neolithisation. Previously mentioned factors leading to the Neolithisation such as climate, environment, and population pressure have been relegated to the background. Instead, an emphasis is placed on the study of the social and ideological components of the "Neolithic package". According to J. Cauvin, the Neolithisation process led to a shift in human thinking, culminating in the increasing sophistication of human symbolic and ritual behaviour (Cauvin 2003). Similarly, I. Hodder (1990) draws attention to the transition to farming as a process, in which the wild and natural was transformed into the domesticated. This means that the transition from a society living in the wild (*agrios*) to a domestic economy (*domus*), which he calls the domestication of society.

2. The Neolithisation process: various approaches

Apart from the models and hypotheses, further aspects of the transition to farming and the origin of the LBK such as genetics, stable isotope analysis, lithic studies, and demography are also considered and presented. In addition to trying to answer questions such as how farming was introduced to Europe, they aim at increased exploration of the nature of the agricultural transition.

2.1 Genetic aspects of the transition to farming

The nature of agricultural transition is a matter of continuing debates not only in archaeology, but also in population genetics. The genetic history of past populations has mostly been drawn from modern-day Eurasian populations. Recently, however, ancient DNA studies, which allow for the direct comparison of archaeological and modern populations, have also enabled the answering of the question as to whether early European farmers were immigrants or descendants of resident hunter-gatherers who had adopted farming (Richards 2003; Haak *et al.* 2005). These methods are still being verified and tested, however, and are, as yet, not extensive enough to provide conclusive results regarding the genetic contribution of SW Asian farmers to the European gene pool. Thus, they cannot solve this question themselves (Bellwood 2001).

2.1.1 Modern human DNA

The subject of the genetic history of Europe was primarily created by Luca Cavalli-Sforza and his colleagues in the 1970s. His pioneering work, carried out in collaboration with the archaeologist Albert Ammerman, was the first sustained attempt to apply genetic data to a question of archaeological interest. Their work *The Neolithic Transition and the Genetics of Population in Europe*, published in 1984, offered a scientific model explaining the origins and spread of farming in western Eurasia, accepting the central role of sedentism, population growth, and resource pressure in the early farming communities. Cavalli-Sforza and Ammerman measured the rate of spread of farming into Europe, drawing on radiocarbon dates provided by Clark (1965), and concluded that the entire process of the spread of the Neolithic, from Greece to the British Isles, took place over about 2500 years, at a uniform rate of approximately one kilometre per year. They compiled synthetic gene maps which demonstrate geographic clines by principal component analysis. The genetic map produced by the first principal component, accounts for 27% of the total variation in classical marker frequencies across Europe and the Near East, indicating a gradient from the south-east to the north-west. They thus introduced the expression "*demic diffusion*" to illustrate the immigration of farmers themselves, in contrast to "*cultural diffusion*", the spread of farming as an idea through the indigenous hunter-gatherers (Ammerman, Cavalli-Sforza 1973; 1984; Cavalli-Sforza *et al*. 1994).

Moreover, they suggested a different model known as "*wave of advance*", instead of the traditional model of migration and colonization. The wave of the advance model assumes the population growth resulting from agricultural surpluses, and either displacing or absorbing the less numerous Mesolithic hunter-gatherer population. This process leads to a radial expanding population wave, in which the culture spreads with the expansion of people. Not only did the wave of the advance model seem to be compatible with the available radiocarbon dates from Neolithic sites, but also the introduction of genetic data including allele frequencies for blood groups, the tissue antigen HLA system, and certain enzymes, into the question of agricultural transition supported this notion (Ammerman, Cavalli-Sforza 1973; 1984; Richards 2003). It is worth pointing out that although Ammerman and Cavalli-Sforza (1984) predict that a major component of the modern European gene pool is derived from Near-Eastern farmers, they acknowledge the role of indigenous people in the spread of the Neolithic. A number of recent publications (Barbujani, Dupanloup 2002; Chikhi 2002), however, seem to not credit any role to local foragers and argue that the Neolithic must have spread into the continent exclusively by population movement (Thomas 2006*,* 52).

Nevertheless, the wave of the advance model introduced by Ammerman and Cavalli-Sforza (1984) has been substantially criticised (*e.g.* Zvelebil 1986a; 1989; 1998; 2002; Thomas 1996; Pluciennik 1998; Price 2000). Firstly, there has been no evidence for identifying the first principal component with the Neolithic expansion. Instead, the gradients might have be the result of numerous other dispersals. Another problem derives from the fact that the items of the Neolithic package, used by Ammerman and Cavalli-Sforza to identify a settlement as the Neolithic, might often be exchanged into Mesolithic communities. Finally, there is broad agreement among archaeologists that there is no evidence for large scale continent-wide migration. Also, 25 years later at a conference in Venice in 1998, one of the authors, A. Ammerman, looked back and debated how his and Cavalli-Sforza's ideas developed and influenced further research (see Ammerman, Biagi 2003).

In the 1980s, apart from the principal component analysis of the classical markers such as blood groups, HLA antigens, and enzymes, it became possible to analyse the DNA sequences of the genes themselves. In particular, attention has been drawn to the two non-recombining loci in humans: the mitochondrial DNA (mtDNA), which is inherited only down the maternal line, and the Y chromosome, which is only present in males and inherited from father to son. The mitochondrial genome and the Y chromosome are ideal for reconstructing evolutionary trees or networks, which can be put into a time frame, and the age of the molecules at their nodes can be estimated (Richards 2003*,* 144–145).

Mitochondrial DNA analysis indicates a similar trend as the principal component analysis of the classical markers but accounts for only 10–20% of the mitochondrial sequences all throughout Europe (Richards *et al*. 1996; 1998). The first results from European mtDNA concluded that the ancestors of the great majority of modern lineages entered Europe during the Upper Palaeolithic, whereas the incoming lineages were in the minority (Richards *et a*l. 1996; 1998). These results have been further supported by numerous studies (Torroni *et al*. 1998; Richards *et al.* 2000; Richards 2003) also indicating that on the maternal line of descent, only a minority of European ancestors were Near Eastern farmers. The majority, however, were indigenous European hunter-gatherers, who adopted farming at a later point. It is also worth mentioning that these results provide information about female heritage, therefore, men could be of foreign origin (Ammerman *et al.* 2006). Nevertheless, the mtDNA work has been criticised by a number of authors in the field of traditional population genetics, using a different methodological protocol (Cavalli-Sforza, Minch 1997; Barbujani *et al*. 1998; Chikhi *et al*. 2002; Barbujani, Bertorelle 2001).

Y-chromosomal DNA analysis suggests that the frequency of haplotypes originating in the Near East averages about 20–25%, similar to the estimates from mtDNA (Semino *et al.* 1996; 2000; Underhill *et al*. 2000; but see Chikhi *et al*. 2002). The contribution of Palaeolithic hunter-gatherers as opposed to Neolithic agriculturalists to the colonisation of Europe has also been recently studied in the Czech population (Kračmarová *et al.* 2006). The results indicate that the haplogroups (I, R1a, R1b) linked to the post-glacial recolonisation of Europe reached frequencies of 80.6%. In contrast, haplogroups (E3b, G, J2) likely brought to Europe by agriculturalists from the Near East occurred in 15% of the test sample. (Kračmarová *et al.* 2006*;* see Zvelebil, Pettit 2006 for further discussion).

In spite of the fact that the above-mentioned genetic studies have led to conflicting results, it is possible to see a congruence in the results of all three systems (autosomal, mtDNA, Y-chromosome) in relation to the demic expansion of Neolithic Near Eastern farmers into Europe (Lell, Wallace 2000). All would suggest the contribution of south-west Asian populations into the European gene pool and report similar south-east-north-west clines across Europe. On a continental scale, the above-mentioned genetic evidence can be summarised as follows (Table 1).

Table 1. Summarised genetic evidence.

Source	**Contribution of Near Eastern farmers to the European gene pool**
Ammermann, Cavalli-Sforza 1984	75–90%
Chikhi *et al.* 2002	50–65%
King, Underhill 2002	2–40%
Richards *et al.* 1996; 2000	20–25%
Semino *et al.* 2000	20–25%

To sum up, the authors of recent studies of modern human DNA tend to support the integrationist view that the first farmers of Central Europe made only a small contribution to the genetic heritage of present-day Europeans (Richards *et al*. 1996; 1998; 2000; Semino *et al*. 1996; 2000; Torroni *et al.* 1998; Simoni *et al*. 2000; Underhill *et al*. 2000; 2001; Richards 2003; Kračmarová *et al*. 2006).

Furthermore, the difference between greater male (Y-chromosomal DNA) and lesser female (mtDNA) genetic contribution to the Neolithisation process might indicate male exogamy and long-distance travel on the one hand, and female matrilocality and regional endogamy on the other (Zvelebil 2002).

According to Marek Zvelebil (2002), four major processes are involved with the arrival of the Neolithic and contributed to the generation of south-east-north-west genetic gradient patterns:

1. The pattern of small-scale population movements progressing from south-east Europe to the north-west over millennia.
2. At the onset of the Neolithic, "targeted", "leapfrog" or "pioneer" settlement of selected and targeted optimal areas by small numbers of incoming farmers from the Near east/Anatolia to south-east, Central and Mediterranean Europe, resulting in the foundation of agricultural "enclaves" within landscapes occupied by hunter-gatherers.
3. The adoption of farming by indigenous foragers through contact, intermarriage, and socially regulated mobility between hunter-gatherers and farmers within frontier zones.
4. A consequent regional demic expansion, infilling of locally available niches by a genetically mixed population involving local hunter-gatherers and some immigrant farmers (Zvelebil 2002*,* 385–386).

2.1.2 Ancient human DNA

Genetic studies carried out on modern European populations have led to conflicting results (see above). Ancient DNA studies, however, seem to support gene admixture on a regional scale (Haak *et al*. 2005; Ammerman *et al*. 2005; Bramanti 2008; Bramanti *et al*. 2009). Haak *et al.* (*2005*) analysed mtDNA of Neolithic skeletons from Central Europe and concluded that those first farmers did not have a strong genetic influence on modern European female lineages. The likely explanation for these results offered by authors suggests that the female early Neolithic farmers could have been genetically diluted by resident native hunter-gatherers, since a particular mtDNA haplotype (N1a) found in early Neolithic skeletons is comparatively rare among modern Europeans (see Ammerman *et al*. 2006; Burger *et al*. 2006 for further discussion). This conclusion is supported by the above-mentioned studies of modern human DNA, archaeologically (*e.g.* Gronenborn 1999; 2007), and also by stable isotope studies (Bentley *et al*. 2002).

In contrast, a number of more recent ancient mtDNA studies (Bramanti *et al.* 2009; Haak *et al*. 2010) have suggested that the LBK populations shared an affinity with the modern-day Near East and Anatolia, supporting a major genetic input from this area during the advent of farming in Europe. These data are compatible with a model of Central Europe in the early Neolithic of indigenous populations plus major genetic inputs from expanding populations in the Near East. Thus, on a regional scale, these results support the "leapfrog" colonization model, where early farmers initially targeted the economically favourable loess plains in Central Europe. Nevertheless, the LBK populations also showed unique genetic characteristics including a clearly distinct distribution of mitochondrial haplogroup frequencies, implying that further significant genetic changes took place in Europe after the early Neolithic (Haak *et al*. 2010). Moreover, despite the fact that discontinuity seems to be an important feature of the prehistoric mitochondrial record of Central Europe, one should bear in mind that there are major problems with sample size, population substructure, and, of course, the danger of sample contamination (Soares *et al*. 2010). In the Czech Republic, Bramanti (2008) has carried out ancient mtDNA analysis of an early LBK population from Vedrovice (see below).

2.2. Stable isotope analysis

Stable isotope analysis helps directly answer frequently discussed questions concerning former diet, demography, residence patterns, and diseases. Stable isotopes find their way into organisms through diet, and are consequently gradually integrated into the tissue of bones and teeth. Bioarchaeology primarily uses the following isotopes and their ratios: $^{13}C/^{12}C$, $^{14}N/^{15}N$, $^{87}Sr/^{86}Sr$, $^{18}O/^{16}O$, and $^{34}S/^{32}S$. Their natural sources are atmosphere, water, and a geological base, from where they enter the plant and animal bodies and participate in their tissue building. To analyse for stable isotopes, collagen or hydroxyapatite is extracted from the bone with the resulting material providing a relative abundance of the different isotopes present (Mays 1998*,* 182*;* Kovačiková, Brůžek 2008*)*. In order to investigate the nature of the agricultural transition, an emphasis is placed on analysis concerning mobility and dietary patterns carried out by examining human skeletons from Mesolithic and early Neolithic Central Europe.

2.2.1 Mobility patterns

Measuring of strontium and sulphur isotopes in human skeletons can directly, in contrast to DNA analysis, examine human mobility on a regional and local scale. Migrant individuals who moved between geologic regions can be identified by comparing the isotope signature in adult teeth, composed over the first years of life, with that in the bones, which preserve the isotopic profile corresponding to the last years of life. Therefore, if the teeth and bones of an adult have different signatures, then that individual spent his or her final years in different geological areas. These ratios are further compared with the values from the local geology and indicate whether an individual moved into the region during later life (Bentley *et al*. 2002; Bentley 2007; Bickle, Hofmann 2007; Katzenberg 2008; Richards *et al*. 2008).

A strontium isotope analysis of skeletal remains from LBK sites in south-west Germany has indicated a high incidence of migration in these Neolithic communities (Price *et al.* 2001; Bentley *et al*. 2002; 2003a; 2003b; Bentley 2006; Bickle, Hofmann 2007). A high incidence of non-locals was revealed, for example, at LBK cemeteries of Flomborn (64%) and Schweitzingen (25%) in the Rhine Valley, Dillingen (65%) along the Danube Valley, and Vaihingen (30%) in the Neckar Valley. The authors have dealt with the pattern of migration of farmers into Central Europe at the beginning of the Neolithic and have offered a derivation from or interaction with hunter-gatherers as a likely explanation. In addition, the results from Schweitzigen have demonstrated that migration was dominated by females having grown up in the uplands on either side of the Rhine Valley and joining the agricultural community through marriage (Price *et al*. 2001; Bentley *et al*. 2002; Bentley 2007; Zvelebil, Pettitt 2008). This is a common pattern observed and discussed in ethnographic and anthropological literature (Zvelebil 1986a; Zvelebil, Pettitt 2008).

2.2.2 Dietary patterns

Stable carbon, nitrogen, and sulphur isotope analysis has been successfully applied to address questions of subsistence and diet during the transition to farming (*e.g.* Richards, Hedges 1999; Bocherens *et al*. 2007; Fischer *et al*. 2007; Nehlich *et al*. 2010). It is based on the assumption that differences in the isotope ratios of elements reflect the fact that each organism is a component of global geochemical cycles and the concentration of isotopes deposited in human and animal bones and teeth during life inform us about climate and food web position by means of the isotope ratios which increase at each trophic level. Consequently, the ratio of $^{13}C/^{12}C$ ($\delta^{13}C$) can be used to distinguish between marine and terrestrial ecosystems or C_3 (a number of temperate plant species) and C_4 (*e.g.* maize, sorghum, millet, sugar cane) plants, which fix carbon by different photosynthetic pathways. In combination with the stable nitrogen isotope ratio ($\delta^{15}N$), it is possible to identify categories of plants and separate herbivores from carnivores. The ratio of $^{34}S/^{32}S$ ($\delta^{34}S$) provides evidence of the proportion of terrestrial, freshwater, and marine sources in a diet, and is complementary to that of the carbon and nitrogen ratios (Mays 1998, 183; Sealy 2001, 270–271; Katzenberg 2008, 423–424; Kovačiková, Brůžek 2008).

As mentioned above, recent research has focused on stable isotope analysis, which provides strong evidence of a sharp shift in subsistence practice during the transition to farming from various corners of the continent such as Denmark (Tauber 1981; Fischer *et al*. 2007), Portugal (Lubell *et al*. 1994), Great Britain (Richards, Hedges 1999; Schulting, Richards 2002; Richards *et al*. 2003), and the Danube Gorges (Nehlich *et al*. 2010). All of the citied studies have reached the same conclusion, stating that there was a large input of marine and riverine food in the human diets of the Mesolithic period, while with the onset of the Neolithic, humans started consuming primarily terrestrial food (see Milner *et al*. 2004; Richards, Schulting 2006 for further discussion). The scholars mainly explain this pattern either by agricultural colonisation by new people, whose diet was based on domesticates, or by the rapid adoption of Neolithic culture and domesticates by the indigenous people.

In contrast, it is worth mentioning that a stable isotope analysis cannot distinguish between wild and domesticated resources, consequently the shift from marine and freshwater resources may not indicate that they were replaced by domesticates, but it is possible that this pattern is connected with subsistence diversity as well. Cereals could not be used as staples in the Neolithic, but in a range of different ways such as special-purpose food or alongside wild foods (Thomas 2003; 2007). Julian Thomas (2003*,* 69–70) further argues that Neolithic people had access to a rich source of food in the form of fishing and that the shift in dietary preferences can be explained by a cultural prohibition on marine food, a new relationship between humans and the sea, a certain kind of cultural identification, or the marker of taking on a new identity – "being Neolithic".

2.3 Lithic studies

The potential of the lithic studies for the question of the Mesolithic studies of the Mesolithic-Neolithic transition in Central Europe has been emphasised by an entire range of authors (recently Gronenborn 1999; Mateiciucová 2003; 2004; 2008), since analysis of chipped stone artefacts is one of the few sources to be used by both the Mesolithic hunter-gatherers, as well as by the early farmers. Inna Mateiciucová (2003; 2004; 2008), whose studies build on the work of S. Vencl (1960) and D. Gronenborn (1997), has concentrated her study on the following features of the chipped stone industry: the technology of blade production, the distribution of raw stone sources, and the occurrence of so-called "culturally specific" tool types (trapezes, borers, and retouched blades) in order to answer questions concerning LBK origin and dispersals into a vast area of Central Europe with an emphasis on the local Mesolithic background.

On the basis of the identification of different techniques of regular blade production at Mesolithic and Neolithic sites, Mateiciucová suggests that the process of Neolithisation in Central Europe was not unified. Furthermore, indigenous Mesolithic populations played an important part in certain regions, and were gradually acculturated. Moreover, the Balkan cultural complex (including the Starčevo and Körös culture) most likely participated in the Neolithisation of Central Europe through mediation, the transfer of information via contacts in the exchange of raw materials, products, and partners. Consequently, the participation of the indigenous Mesolithic population in the formation of the Körös and possibly also the Starčevo culture is indicated by the Danubian tradition of blade production which originated in the late Mesolithic period as a local response to technological changes in the Mediterranean, which Mateiciucová calls "a variation on the Mediterranean tradition" (Mateiciucová 2004, 91–96; 2008*,* 57–110; 165–166).

The second focus of her study has been placed on the issue of the distribution of stone raw materials with special attention to the raw materials that may have played an important role in the Neolithisation process in Central Europe (Szentgál radiolarite, Carpathian obsidian, Krakow Jurassic silicites). Mateiciucová suggests that the earliest LBK may have spread through pre-existing networks in Central Europe, since the distribution of raw materials indicates that a network of contacts already existed in certain areas of Central Europe at the end of the Early Mesolithic. These networks, connecting areas of Central Europe with areas in the Balkans, enabled the flow of information and formed an ideal basis for the later rise of the Neolithic. In addition, certain features of distribution typical for the Mesolithic period also continued to appear in the Early Neolithic period. Attention should be especially drawn to the network of Transdanubian radiolarites, the dispersion of which corresponds with the west and north-west spread of the earliest phase of the LBK culture (Mateiciucová 2004, 96–98; 2008, 111–155; 165–167).

On the basis of the information noted above, Mateiciucová concludes that the LBK culture developed autochthonously from the local Mesolithic substrate in the region of Transdanubia and immediately adjacent areas, but under the influence of contacts and partial mixing with the Starčevo culture communities (Mateiciucová 2004, 99–101; 2008; 165–167). Her hypotheses also emphasises the psychological implications of the Neolithisation process by suggesting that initially, there was a Neolithisation of the hunter-gatherers' soul or psyche, followed by the Neolithisation at the material level (Mateiciucová 2004*,* 99–100).

2.4 Demographic aspects of the Neolithic transition

Although many different disciplines have been involved in explaining the mechanism of Neolithic dispersal, surprisingly little attention has been paid to the demographic aspects of the agricultural transition (Galeta, Brůžek 2009). Given the fact that the crucial prerequisite of colonisation would have been a high rate of population growth, LBK farmers would have had to reproduce at a rate approaching the theoretical maximum for human population (Brůžek 2003; Galeta, Brůžek 2009).

A population growth rate from 2.0% to 3.5% per year has been established as the input value in the models of Ammerman and Cavalli-Sforza (1973). Since that time, E. Neustupný (1983), using life tables from LBK skeletons from Germany, and J. Petrasch (2001), employing data acquirated from the function of exponential growth and input variables derived from the distribution of LBK settlement and radiocarbon dates, have estimated the growth rate at 1–2%. Recently, Galeta and Brůžek (2009, 141) have, in contrast, argued that these estimates do not account for the uncertainty connected with adopting input parameters from archaeological sources. Instead, they have developed their demographic model of the Neolithic transition in Central Europe.

In their study, Galeta and Brůžek (2009) estimated the level of fertility (around 6–13 children per woman) and growth rate (0.64–1.96% per year) of the LBK population via demographic modelling in order to assess whether such a level of fertility and population growth rate would be high enough to allow the LBK farmers to spread across Central Europe within less than 200 years without any admixture with indigenous hunter-gatherers. On the basis of data from human demography, archaeology, and human ecology, they constructed a stochastic demographic model of changes in farming population size and concluded that the establishment of farming communities in Central Europe without an admixture with foragers may be rejected in 92% of the simulations. Their study thus provides a strong argument against the colonization hypothesis and supports the integrationist view of the Neolithic transition in Central Europe.

3. Vedrovice: a case study in South Moravia

The site Vedrovice is located in South Moravia in the Czech Republic, within the drainage basin of the rivers Jihlava and Svratka (figure 1). Sections of the site were excavated between 1961 and 2001, and have yielded a settlement, three enclosures as well as two cemeteries: the early LBK cemetery "Široká u lesa" and that called "U Vinklerovy cihelny" (Ondruš 2002). The conditions on site provided excellent preservation. Therefore the site of Vedrovice encompasses a significant range of material culture including ceramic vessels, figurine fragments, housing structures, construction pits, ovens, ceramic weights, flaked and polished stone tools, grinding stones, faunal remains as well as bones and bone tools and last but not least human skeletal remains (Podborský, ed. 2002).

Recently, there has been a comprehensive international collaborative research programme focused on the human skeletal remains recovered from the cemetery "Široká u lesa" with an emphasis on two key goals: first, to establish comprehensive holistic bioarchaeological research, and secondly, to generate new knowledge about the emergence of the LBK culture and the transition to farming in Central Europe in the broader context of European Neolithisation. To do so, multiple bioarchaeological approaches have been applied including AMS radiocarbon dating, palaeopathology studies, dental microwear studies, material culture studies, and also ancient DNA analysis as well as chemical trace analyses (Lukes *et al*. 2008).

3.1 The origins and ancestry of the Vedrovice community: isotopic and ancient DNA analyses

Although the Vedrovice samples are not among the genetically best preserved ones, Bramanti (2008) has successfully sequenced ancient mitochondrial DNA polymorphism from three male and three female individuals. She observed a prevalence of T2 (2 individuals) and K (2 individuals) sequences, whose founders are proposed to have been introduced into Europe during the Lower Upper Palaeolithic. These have also been observed in another LBK sample from north-central Europe (Haak *et al*. 2005). The remaining two individuals belong to the haplogroup H, also deriving from the European Upper Palaeolithic, and haplogroup J1c, which might be associated with the spread of the Neolithic (Richards *et al*. 2000; Zvelebil, Pettitt 2008). It is also worth noting that Bramanti (2008) has thus supported the results of a recent study by Kračmarová *et al*. (2006), who have claimed that modern Czech male ancestry shows about a 80% predominance of the Palaeolithic genetic markers as indicated by Y-chromosome polymorphisms.

To reconstruct human mobility, strontium and sulphur isotope analyses of skeletal remains have also been undertaken. The results indicate that most of the humans buried at Vedrovice spent their childhood, as indicated by the strontium isotope values, and adulthood, indicated by the sulphur isotope value, at or near Vedrovice. In contrast, there are eight individuals with different isotopic values, which means, that they spent their childhood or adulthood elsewhere, so they are likely to have been immigrants to the site. These results thus suggest that a small percentage of the Vedrovice community were allochtonous and derived from areas at all points of the compass (Richards *et al*. 2008). As observed by Zvelebil and Pettitt (2008*,* 199), these migrants may have derived from or interacted with hunter-gatherers from the upland areas. This is a pattern that has been observed elsewhere, for instance by Price *et al*. (2001).

It can be seen quite clearly that ancient DNA and isotopic analyses have contributed to our understanding of the transition to agriculture in Central Europe. Additionally, the results of bioarchaeological research at Vedrovice have provided information about the health condition, palaeodemography and nutrition of Vedrovice inhabitants, their social status, and the transmission of cultural traditions (Zvelebil, Pettitt 2008). On the basis of all these results, Zvelebil and Pettitt (2008*,* 213–214) have concluded that Vedrovice was likely a Neolithic "gateway community", both receiving individuals from afar and maintaining long-distance contacts, and also serving as a founder community for other early LBK settlements. They propose that Vedrovice was founded by a small community of incomers, who probably originated in western Hungary, since links with western Hungary are evident in the material culture. Soon after Vedrovice was founded (at some point prior to 5300 BC), it attracted people from hunting-gathering communities within the region of the Bohemian-Moravian Uplands and north-east Bohemia. Zvelebil and Pettitt go on to suggest that Vedrovice also served as the focal point of a far-flung contact network that facilitated the exchange of goods and information. The evidence for these connections is apparent from the material culture, such as the Spondylus ornaments, flints from southern Poland, Hungarian radiolarite, or schist/amphibolite from northern Bohemia. They even go on to reconstruct the life biographies of selected individuals from the Vedrovice community in order to reconstruct the personal diversity and variability of the Vedrovice community and to emphasise that we can, within the bioarchaeological approach, reconstruct the life histories of people who died long ago (Zvelebil, Pettitt 2008).

4. Certain concluding remarks

The current research into the Neolithisation process in Central Europe can be summarised as follows:

1. Although much attention has been paid to the agricultural transition, archaeological attitudes towards the transition to farming have been influenced by a variety of reasons such as the political and academic climate (Zvelebil 1995a; Pluciennik 1998). Therefore, prehistorians placed a great emphasis on the Neolithic, whereas the study of Mesolithic hunter-gatherers has remained one of the neglected issues in European prehistory. This has been particularly true in the case of Czech archaeology (Beneš 2004).
2. It is believed that the first farmers of Central Europe originated in the Transdanubia, and spread rapidly across a broad area extending from the western Ukraine to the Rhine River in Germany (Lukes, Zvelebil, eds. 2004; Gronenborn 2007). These first farmers appeared in Central Europe around 5500 BC (Pavlů 2005). Recently, it has become clear that the spread of agriculture involved a variety of mechanisms and cannot be merely explained by a simple model of migration or acculturation (Zvelebil 2004; Robb, Miracle 2007). According to the integrationist model, local Mesolithic groups played an important role in this process and, at present, the majority of researchers concerned with Early Neolithic archaeology prefer this intermediate scenario (Gronenborn 2007).
3. The integrationist model finds strong support in a number of disciplines. Genetic studies of classical markers, mtDNA, and the Y-chromosome have indicated the major contribution of Mesolithic foragers to the gene pool of modern Europeans. The contribution of Near Eastern lineages to the European gene pool has been indicated at around a quarter or less (Richards 2003). Similarly, ancient DNA supports gene admixture on a regional scale (Haak *et al*. 2005).
4. In addition, strontium isotope analyses of LBK skeletons from Germany have revealed a high incidence of non-locals, which may indicate that people from hunting-gathering groups had joined agriculturalist communities (Price *et al*. 2001).
5. The admixture view has also been supported by recent lithic studies, which suggest continuity in stone tool production and the distribution of stone raw materials from the Mesolithic to the Early LBK (Gronenborn 2007; Mateiciucová 2008).
6. The integrationist view of the Neolithic transition in Central Europe is supported by a demographic model, which has indicated that LBK fertility was not high enough to allow farmers to spread over Central Europe without an admixture with the local Mesolithic population (Galeta, Brůžek 2009).
7. Imported LBK finds within the late Mesolithic context of Central Europe may demonstrate contacts between Mesolithic foragers and LBK farmers, which also supports the integrationist view of the agricultural transition (Zvelebil 2004; Gronenborn 2007).
8. With regard to LBK homogeneity, traditionally considered as evidence of the rapid colonisation of Central Europe by farming groups, currently, a number of scholars regard this uniformity as an actively chosen phenomenon for social reasons (Robb, Miracle 2007). Since current research has reached the conclusion that the LBK culture has numerous origins (an admixture of intrusive Near Eastern farmers and indigenous Mesolithic populations) (Zvelebil 2004*,* 199), the LBK culture had to be symbolically standard and uniform. In other words, people from various communities joined the LBK and accepted a new way of life and new identity. This strategy, consequently, enabled rapid and successful spread of the LBK to all of Central Europe (Zvelebil 2009). On a continental scale, the sharp shift in subsistence practice with the onset of the Neolithic

might also have been bound up with the assumption of a new cultural identification ("being Neolithic") (Thomas 2003).

Acknowledgements

I would like to thank Jaromír Beneš for supporting me, for fruitful discussions and valuable remarks upon an earlier version of this paper, which forms part of my Bachelor thesis. I also thank the reviewers for their helpful comments. The work was supported by a grant from the Faculty of Science, University of South Bohemia (MSMT 6007665801 & GAJU 138/2010/P).

References

AMMERMAN, A. J., BIAGI, P. (Eds.) 2003: *The widening harvest. The Neolithic transition in Europe: looking back, looking forward.* Archaeological Institute of America, Boston.
AMMERMAN, A. J., CAVALLI-SFORZA, L. L. 1973: A population model for the diffusion of early farming in Europe. In Renfrew, C. (ed.): *The explanation of culture change.* Duckworth, London, 343–357.
AMMERMAN, A. J., CAVALLI-SFORZA, L. L. 1984: *The Neolithic transition and the genetics of populations in Europe.* Princeton University Press, Princeton.
AMMERMAN, A., PINHASI, R., BÁNFFY, E. 2006: Comment on "Ancient DNA from the First European Farmers in 7500-Year Old Neolithic Sites", *Science* 312, 1875.
BARBUJANI, G., BERTORELLE, G. 2001: Genetics and the population history of Europe, *Proceedings of the National Academy of Sciences of the United States of America* 98, 22–25.
BARBUJANI, G.BERTORELLE, G., CHIKHI, L. 1998: Evidence for Paleolithic and Neolithic gene flow in Europe, *American Journal of Human Genetics* 62, 488–491.
BARBUJANI, G., DUPANLOUP, I. 2002: DNA variation in Europe: estimating the demographic impact of Neolithic dispersals. In Bellwood, P., Renfrew, C. (Eds.): *Examining the farming/language dispersal hypothesis.* McDonald Institute Monographs, Cambridge, 421–433.
BARKER, G. 1985: *Prehistoric farming in Europe.* Cambridge University Press, Cambridge.
BEHRE, K.-E. 2007: Evidence for Mesolithic agriculture in and around Central Europe? *Vegetation History and Archaeobotany* 16, 203–219.
BELLWOOD, P. 2001: Early agriculturalists populations diasporas? Farmers, languages, and genes, *Annual Review of Anthropology* 30, 181–207.
BENEŠ, J. 2004: Palaeoecology of the LBK: the earliest agriculturalists and the landscape of Bohemia. In: Lukes, A, Zvelebil, M. (Eds.): *LBK Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304, Archaeopress, Oxford, 143–150.
BENTLEY, R. A. 2006: Strontium isotopes from the Earth to the archaeological skeleton: a review, *Journal of Archaeological Method and Theory* 13, 135–187.
BENTLEY, R. A. 2007: Mobility, specialisation and community diversity in the Linearbandkeramik: isotopic evidence from the skeletons. In Whittle, A. W. R, Cummings, V. (Eds.): *Going over: the Mesolithic-Neolithic transition in north-west Europe.* Proceedings of the British Academy 144, Oxford University Press, London, 117–140.
BENTLEY, R. A., CHIKHI, L., PRICE, T. D. 2003a: The Neolithic transition in Europe: comparing broad scale genetic and local scale isotopic evidence, *Antiquity* 77, 63–66.
BENTLEY, R. A., KRAUSE, R., PRICE, T. D., KAUFMANN, B. 2003b: Human mobility at the early Neolithic settlement of Vaihingen, Germany: evidence from strontium isotope analysis, *Archaeometry* 45, 471–486.
BENTLEY, R. A., PRICE, T. D., LÜNING, J., GRONENBORN, D., WAHL, J., FULLAGAR, P. D. 2002: Human migration in early Neolithic Europe: strontium isotope analysis of early Neolithic skeletons, *Current Anthropology* 43, 799–804.
BICKLE, P., HOFMANN, D. 2007: Moving on: the contribution of isotope studies to the early Neolithic of Central Europe, *Antiquity* 81, 1029–1041.
BINFORD, L. R. 1968: Post-Pleistocene adaptations. In: Binford, S. R., Binford, S. R. (Eds.): *New perspectives in archaeology.* Aldine, Chicago 313–341.
BOCHERENS, H., POLET, C., TOUSSAINT, M. 2007: Palaeodiet of Mesolithic and Neolithic populations of Meuse Basin (Belgium): evidence from stable isotopes, *Journal of Archaeological Science* 34, 10–27.
BOGUCKI, P. 2001: Recent research on early farming in Central Europe. In M. Budja (Ed.): *8th Neolithic Studies. Documenta Praehistorica* XXVIII, 85–97.
BOGUCKI, P. 2003: Neolithic dispersals in riverine interior Central Europe. In: Ammerman, A., Biagi, P. (Eds.): *The widening harvest. The Neolithic transition in Europe: looking back, looking forward.* Archaeological Institute of America, Boston, 249–272.
BRAMANTI, B. 2008: Ancient DNA. Genetic analysis of aDNA from sixteen skeletons of the Vedrovice collection, *Anthropologie* XLVI, 153–160.
BRAMANTI, B., THOMAS, M. G., HAAK, W., UNTERLAENDER, M., JORES, P., TAMBETS, K., ANTANAITIS-JACOBS, I., HAIDLE, M. N., JANKAUSKAS, R., KIND, C.-J., LUETH, F., TERBERGER, T., HILLER, J., MATSUMURA, S., FORSTER, P., BURGER, J. 2009: Genetic discontinuity between local hunter-gatherers and Central Europe's first farmers, *Science* 326, 137–140.
BRŮŽEK, J. 2003: Antropologické aspekty neolitizace střední Evropy. In: Sládek, V., Galeta, P., Blažek, V. (Eds.): *Evoluce člověka a antropologie recentních populace.* Katedra sociální a kulturní antropologie, Fakulta humanitních studií Západočeské univerzity v Plzni, Plzeň, 39–53.
BURGER, J., GRONENBORN, D., FORSTER, P., MATSUMURA, S., BRAMANTI, B., HAAK, W. 2006: Response to comment on "Ancient DNA from the first European farmers in 7500-year-old Neolithic sites", *Science* 312, 1875b.
CAUVIN, J. 2003: *The birth of gods and the origins of agriculture.* Cambridge University Press, Cambridge.
CAVALLI-SFORZA, L. L., MENOZZI, P., PIAZZA, A. 1994: *The history and geography of human genes.* Princeton University Press, Princeton.
CAVALLI-SFORZA, L. L., MINCH, E. 1997: Paleolithic and Neolithic lineages in the European mitochondrial gene pool, *American Journal of Human Genetics* 61: 247–251.
CHIKHI, I. 2002: Admixture and demic diffusion model in Europe. In Bellwood, P., Renfrew, C. (Eds.): *Examining the farming/language dispersal hypothesis.* McDonald Institute Monographs, Cambridge, 435–447.
CHIKHI, L., NICHOLS, R. A., BARBUJANI, G., BEAUMONT, M. A. 2002: Y genetic data support the Neolithic demic diffusion model, *Proceedings of the National Academy of Sciences of the United States of America* 99, 11008–11013.
CHILDE, V. G. 1925: *The dawn of European civilisation.* Kegan Paul, London.
CHILDE, V. G. 1936: *Man makes himself.* Watts and Co, London.
CLARK, J. G. D. 1965: Radiocarbon dating and the expansion of farming culture from the Near East over Europe, *Proceedings of the Prehistoric Society* 31, 57–73.
CLARK, J. G. D. 1966: The invasion hypothesis in British archaeology, *Antiquity* 40, 172–189.
DENNEL, R. 1983: *European economic prehistory: a new approach.* Academic Press, London.
ERNY-RODMANN, C., GROSS-KLEE, E., HAAS, J. N., JACOMET, S., ZOLLER, H. 1997: Früher "human impact" und Ackerbau im Übergangasbereich Spätmesolithikum-Frühneolitikum im schweizerischen Mittelland, *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 80, 27–56.
FISCHER, A., OLSEN, J., RICHARDS, M., HEINEMEIER, J., SVEINBJÖRNSDÓTTIR, Á. E., BENNIKE, P. 2007: Coast-inland mobility and diet in the Danish Mesolithic and Neolithic: evidence from stable isotope values of humans and dogs, *Journal of Archaeological Science* 34, 2125–2150.

GALETA, P., BRŮŽEK, J. 2009: Demographic model of the Neolithic transition in Central Europe, *Documenta Praehistorica* XXXVI, 139–150.
GEHLEN, B., SCHÖN, W. 2003: Das "Spätmesolithikum" und das initiale Neolithikum in Griechenland – Implikationen für die Neolithisierung der alpinen und circumalpinen Gebiete, *Archäologische Informationen* 26, 255–273.
GRONENBORN, D. 1994: Überlegungen zur Ausbreitung der bäuerlichen Wirtschaft in Mitteleuropa – Versuch einer kulturhistorischen Interpretation ältestbandkeramischer Silexinventare, *Praehistorische Zeitschrift* 69, 135–151.
GRONENBORN, D. 1997: *Silexartefakte der ältestbandkeramischen Kultur. Mit einem Beitrag von Jean-Paul Caspar.* Universitätsforschungen zur prähistorischen Archäologie 37. Habelt, Bonn.
GRONENBORN, D. 1999: A variation on a basic theme: the transition to farming in southern Central Europe, *Journal of World Prehistory* 13, 123–210.
GRONENBORN, D. 2007: Beyond the models: "Neolithisation" in Central Europe. In: Whittle, A., Cummings, V. (Eds.): *Going over: the Mesolithic-Neolithic transition in north-west Europe.* Proceedings of the British Academy 144, Oxford University Press, London, 73–98.
HAAK, W., BALANOVSKY, O., SANCHEZ, J. J., KOSHEL, S., ZAPOROZHCHENKO, V., ADLER, C. J., DER SARKISSIAN, C. S. I., BRANDT, G., SCHWARZ, C., NICKLISCH, N., DRESELY, V., FRITSCH, B., BALANOVSKA, E., VILLEMS, R., MELLER, H., ALT, K. W., COOPER, A. 2010: Ancient DNA from European early Neolithic farmers reveals their Near Eastern affinities, *PLoS Biology* 8, 1–16.
HAAK, W., FORSTER, P., BRAMANTI, B., MATSUMURA, S., BRANDT, G., TÄNZER, M., VILLEMS, R., RENFREW, C., GRONENBORN, D., ALT, K. W., BURGER, J. 2005: Ancient DNA from the first European farmers in 7500-year-old Neolithic sites, *Science* 310, 1016–1018.
HODDER, I. 1990: *The domestication of Europe.* Blackwell, Oxford.
INNES, J. B., BLACKFORD, J. J., DAVEY, P. J. 2003: *Dating the introduction of cereal cultivation to the British Isles. Early palaeoecological evidence from the Isle of Man*, Journal of Quaternary Science 18/7, 603–613.
KATZENBERG, M. A. 2008: Stable isotope analysis: a tool for studying past diet, demography, and life history. In Katzenberg, M. A., Saunders S. R. (Eds.): *Biological anthropology of the human skeleton.* Wiley-Liss, New York, 413–441.
KIND, C. J. 1998: Komplexe Wildbeuter und frühe Ackerbauern: Bemerkungen zur Ausbreitung der Linearbandkeramik im südlichen Mitteleuropa, *Germania* 76, 1–24.
KING, R., UNDERHILL, P. A. 2002: Congruent distribution of Neolithic painted pottery and ceramic figurines with Y-chromosome lineages, *Antiquity* 76, 707–714.
KOVAČIKOVÁ, L., BRŮŽEK, J. 2008: Stabilní izotopy a bioarcheologie – výživa a sledování migrací v populacích minulosti, *Živa* 1, 42–45.
KRAČMAROVÁ, A., BRUCHOVÁ, H., ČERNÝ, V., BRDIČKA, R. 2006: Podíl „*paleolitických" versus „neolitických"* haploskupin Y chromozomu u české populace, *Archeologické rozhledy* LVIII, 237–249.
KVĚTINA, P. 2007: První kontakt. Neolitizace jako nejstarší známé setkání extra-outsiderů, *Vesmír* 86, 635–641.
LELL, J. T., WALLACE, D. C. 2000: The peopling of Europe from the maternal and paternal perspectives, *American Journal of Human Genetics* 67, 1376–1381.
LUBELL, D., JACKES, M., SCHWARCZ, H., KNYF, M., MEIKLEJOHN, C. 1994: The Mesolithic Neolithic transition in Portugal: isotopic and dental evidence of diet, *Journal of Archaeological Science* 21, 201–216.
LUKES, A., ZVELEBIL, M. (Eds.) 2004: LBK *Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304. Archaeopress, Oxford.
LUKES, A., ZVELEBIL, M., PETTITT, P. 2008: Biological and cultural identity of the first farmers: introduction to the Vedrovice bioarchaeological project, *Anthropologie* XLVI, 117–124.
MATEICIUCOVÁ, I. 2003: Mesolitische Traditionen und der Ursprung der Linearbandkeramik, *Archäologische Informationen* 26, 299–320.
MATEICIUCOVÁ, I. 2004: Mesolithic traditions and the origins of the Linear Pottery Culture (LBK). In: Lukes, A., Zvelebil, M. (Eds.): *LBK Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304. Archaeopress, Oxford, 91–108.
MATEICIUCOVÁ, I. 2008. *Talking stones: the chipped stone industry in Lower Austria and Moravia and the beginnings of the Neolithic in Central Europe (LBK), 5700–4900 BC.* Dissertationes Archaeologicae Brunenses/Pragensesque 4. Masarykova univerzita, Brno-Praha.
MAYS, S. 1998: *The archaeology of human bones.* Routledge, London.
MILNER, N., CRAIG, O. E., BAILEY, G. N., PEDERSEN, K., ANDERSEN, S. H. 2004: Something fishy in the Neolithic? A re-evaluation of stable isotope analysis of Mesolithic and Neolithic coastal populations, *Antiquity* 78, 9–22.
NEHLICH, O., BORIĆ, D., STEFANOVIĆ, S., RICHARDS, M. P. 2010: Sulphur isotope evidence for freshwater fish consumption: a case study from the Danube Gorges, SE Europe, *Journal of Archaeological Science* 37, 1131–1139.
NEUSTUPNÝ, E. 1983: *Demografie pravěkých pohřebišť.* Archeologický ústav ČSAV, Praha.
NEUSTUPNÝ, E. 2004: Remarks on the origin of the Linear Pottery Culture. In: Lukes, A., Zvelebil, M. (Eds.): *LBK Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304. Archaeopress, Oxford 3–5.
NOWAK, M. 2009: Hunter-gatherers and early ceramics in Poland. In Jordan, P., Zvelebil, M. (Eds.): *Ceramics before farming. The dispersal of pottery among prehistoric Eurasian hunter-gatherers.* University College London, London 449–475.
ONDRUŠ, V. 2002: Dvě pohřebiště lidu s neolitickou lineární keramikou ve Vedrovicích. In: Podborský, V. (Ed.): *Dvě pohřebiště neolitického lidu s lineární keramikou ve Vedrovicích na Moravě.* Masarykova univerzita, Brno, 9–122.
PAVLŮ, I. 2005: Neolitizace střední Evropy, *Archeologické rozhledy* LVII, 293–302.
PAVÚK, J. 1994: Zur relativen Chronologie der älteren Linearkeramik, *Jósa András Múzeum Évkönyve* 36, 135–149.
PAVÚK, J. 2004: Early Linear Pottery Culture in Slovakia and the Neolithisation of Central Europe. In: Lukes, A, Zvelebil, M. (Eds.): *LBK Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304. Archaeopress, Oxford, 71–82.
PETRASCH, J. 2001: "Seid fruchtbar und mehret euch und füllet die Erde und machet sie euch untertan": Überlegungen zur demographischen Situation der bandkeramischen Landnahme, *Archäologisches Korrespondenblatt* 31, 13–25.
PLUCIENNIK, M. 1998: Deconstructing the "the Neolithic" in the Mesolithic-Neolithic transition. In Edmonds, M, Richards, C. (Eds.): *Understanding the Neolithic of north-western Europe.* Cruithne Press, Glasgow, 61–83.
PODBORSKÝ, V. ED. 2002: *Dvě pohřebiště neolitického lidu s lineární keramikou ve Vedrovicích na Moravě.* Masarykova univerzita, Brno.
POSKA, A., SAARSE, L. 2006: New evidence of possible crop introduction to north-eastern Europe during the Stone Age. Cerealia pollen finds in connection with the Akali Neolithic settlement, East Estonia, *Vegetation History and Archaeobotany* 15, 169–179.
PRICE, T. D. 2000: Europe's first farmers: an introduction. In: Price, T. D. (Ed.): *Europe's first farmers.* Cambridge University Press, Cambridge, 1–18.
PRICE, T. D., BENTLEY, R. A., LÜNING, J., GRONENBORN, D., WAHL, J. 2001: Prehistoric human migration in the Linearbandkeramik of Central Europe, *Antiquity* 75, 593–603.
RENFREW, C. 1987: *Archaeology and language: the puzzle of Indo-European origins.* Jonathan Cape, London.
RICHARDS, M. 2003: The Neolithic invasion of Europe, *Annual Review of Anthropology* 32, 135–162.
RICHARDS, M., CÔRTE-REAL, H., FORSTER, P., MACAULAY, V., WILKINSON-HERBOTS, H., DEMAINE, A., PAPIHA, S., HEDGES, R., BANDELT, H., SYKES, B. 1996: Paleolithic and Neolithic lineages in the European mitochondrial gene pool, *American Journal of Human Genetics* 59, 185–203.
RICHARDS, M. P., HEDGES, R. E. M. 1999: A Neolithic revolution? New evidence of diet in the British Neolithic, *Antiquity* 73, 891–897.
RICHARDS, M. B., MACAULAY, V. A., BANDELT, H. J., SYKES, B. C. 1998: Phylogeography of mitochondrial DNA in western Europe, *Annals of Human Genetics* 62, 341–260.
RICHARDS, M., MACAULAY, V., HICKEY, E., VEGA, E., SYKES, B., GUIDA, V., RENGO, C., SELLITTO, D., CRUCIANI, F., KIVISILD, T., VILLEMS, R., THOMAS, M., RYCHKOV, S., RYCHKOV, O., RYCHKOV, Y., GÖLGE, M., DIMITROV, D., HILL, E., BRADLEY, D., ROMANO, V., CALÌ, F., VONA, G., DEMAINE,

A., PAPIHA, S., TRIANTAPHYLLIDIS, C., STEFANESCU, G., HATINA, J., BELLEDI, M., DI RIENZO, A., NOVELLETTO, A., OPPENHEIM, A., NØRBY, S., AL-ZAHERI, N., SANTACHIARA-BENERECETTI, S., SCOZZARI, A., TORRONI, A., BANDELT, H.-J. 2000: Tracing European founder lineages in the Near Eastern mitochondrial gene pool, *American Journal of Human Genetics* 67, 1251–1276.

RICHARDS, M. P., MONTGOMERY, J., NEHLICH, O., GRIMES, V. 2008: Isotopic analysis of humans and animals from Vedrovice, *Anthropologie* XLVI, 185–194.

RICHARDS, M. P., SCHULTING, R. J., HEDGES, R. E. M. 2003: Sharp shift in diet at onset of Neolithic, *Nature* 425, 366.

RICHARDS, M. P., SCHULTING, R. J. 2006: Against the grain? A response to Milner *et al*. (2004), *Antiquity* 80, 444–458.

ROBB, J., MIRACLE, P. 2007: Beyond "migration" versus "acculturation": new models for the spread of agriculture. In Whittle, A, Cummings, V. (Eds.): *Going over: the Mesolithic-Neolithic transition in north-west Europe.* Proceedings of the British Academy 144. Oxford University Press, London, 99–115.

ROWLEY-CONWY, P. 1983: Sedentary hunters: the Erteböle example, In Bailey, G. (Ed.): *Hunter-gatherer economy in prehistory: a European perspective.* Cambridge University Press, Cambridge, 111–126.

RUNNELS, C. N., VAN ANDEL, T. H. 1995: The earliest farmers in Europe, *Antiquity* 69, 481–500.

SCHULTING, R. J., RICHARDS, M. P. 2002: The wet, the wild and the domesticated: the Mesolithic-Neolithic transition on the West Coast of Scotland, *Journal of European Archaeology* 5, 147–189.

SEALY, J. 2001: Body tissue chemistry and palaeodiet. In Brothwell, D. R., Pollard, A. M. (Eds.): *Handbook of archaeological sciences.* John Wiley and Sons, Chichester, 269–279.

SEMINO, O., PASSARINO, G., BREGA, A., FELLOUS, M., SANTACHIARA-BENERECETTI, S. 1996: A view of the neolithic demic diffusion in Europe through Y chromosome-specific markers, *American Journal of Human Genetics* 59, 964–968.

SEMINO, O., PASSARINO, G., OEFNER, P. J., LIN, A. A., ARBUZOVA, A., BECKMAN, L. E., DE BENEDICTIS, G., FRANCALACCI, P., KOUVATSI, A., LIMBORSKA, S., MARCIKI, M., MIKA, A., MIKA, B., PRIMORAC, D., SANTACHIARRA-BENERECETTI, A. S., CAVALLI-SFORZA, L. L., UNDERHILL, D. 2000: The genetic legacy of Paleolithic Homo sapiens sapiens in extant Europeans: a Y chromosome perspective, *Science* 290, 1155–1159.

SIMONI, L., CALAFELL, F., PETTENER, C., BERTRANPETIT, J., BARBUJANI, B. 2000: Geographic patterns of mtDNA diversity in Europe, *American Journal of Human Genetics* 66, 262–278.

SOARES, P., ACHILLI, A., SEMINO, O., DAVIES, W., MACAULAY, V., BANDELT, H.-J., TORRONI, A., RICHARDS, M. B. 2010: The archaeogenetics of Europe, *Current Biology* 20, R174–R183.

TAUBER, H. 1981: ^{13}C evidence for dietary habits of prehistoric man in Denmark, *Nature* 292, 332–333.

THOMAS, J. 1996: The cultural context of the first use of domesticates in continental Central and Northwest Europe. In Harris, D. R. (Ed.): *The origins and spread of agriculture and pastoralism in Eurasia.* University College Press, London, 310–322.

THOMAS, J. 2003: Thoughts on the "repacked" Neolithic revolution, *Antiquity* 77, 67–74.

THOMAS, J. 2006: Gene-flows and social processes: the potential of genetics and archaeology, *Documenta Praehistorica* XXXIII, 52–59.

THOMAS, J. 2007: Mesolithic-Neolithic transitions in Britain. From essence to inhabitation, *Proceedings of the British Academy* 144, 423–439.

TILLMANN, A. 1993: Kontinuität oder Diskontinuität? Zur Frage einer bandkeramischen Landnahme im südlichen Mitteleuropa, *Archäologische Informationen* 16, 157–187.

TINNER, W., NIELSEN, E. H., LOTTER, A. F. 2007: Mesolithic agriculture in Switzerland? A critical review of the evidence, *Quaternary Science Reviews* 26, 1416–1431.

TORRONI, A., BANDELT, H.-J., D'URBANO, L., LAHERMO, P., MORAL, P., SELLITTO, D., RENGO, C., FORSTER, P., SAVONTAUS, M.-L., BONNÉ-TAMIR, B., SCOZZARI, R. 1998: mtDNA analysis reveals a major late Paleolithic population expansion from southwestern to northeastern Europe, *American Journal of Human Genetics* 62, 1137–1152.

TRINGHAM, R. 1971: *Hunters, fishers, and farmers of eastern Europe, 6000–3000 B.C.* Hutchinson University Library, London.

TRINGHAM, R. 2000: Southeastern Europe in the transition to agriculture in Europe: bridge, buffer, or mosaic. In: Price, T. D. (Ed.): *Europe's first farmers.* Cambridge University Press, Cambridge, 19–56.

UNDERHILL, P. A., PASSARINO, G., LIN, A. A., SHEN, P., LAHR, M. M., FOLEY, R. A., OEFNER, P. J., CAVALLI-SFORZA, L. L. 2001: The phylogeography of Y chromosome binary haplotypes and the origins of modern human populations, *Annals of Human Genetics* 65, 43–62.

UNDERHILL, P. A., SHEN, P. D., LIN, A. A., JIN, G., PASSARINO, G., YANG, W. H., KAUFFMAN, E, BONNÉ-TAMIR, B., BERTRANPETIT, J., FRANCALACCI, P., IBRAHIM, M., JENKINS, T., KIDD, J. R., MEHDI, S. Q., SEIELSTAD, M. T., WELLS, R. S., PIAZZA, A., DAVIS, R. W., FELDMAN, M. W., CAVALLI-SFORZA, L. L., OEFNER, P. J. 2000: Y chromosome sequence variation and the history of human populations, *Nature genetics* 26, 358–361.

VENCL, S. 1960: *Kamenné nástroje prvních zemědělců ve střední Evropě.* Sborník NM Praha A, hist. 14, Praha.

VENCL, S. 1982: K otázce zániku sběračsko-loveckých kultur. Problematika vztahů mesolitu vůči neolitu a postmesolitických kořistníků vůči mladším pravěkým kulturám, *Archeologické rozhledy* XXXIV, 648–693.

VENCL, S. 1986: The role of hunting-gathering populations in the transition to farming: a Central-European perspective, In: Zvelebil, M. (Ed.): *Hunters in transition.* Cambridge University Press, Cambridge 43–51.

VENCL, S. 2007: Mezolit. In Vencl, S., Fridrich, J. (Eds.): *Archeologie pravěkých Čech 2. paleolit a mezolit.* Archeologický ústav AV ČR Praha, Praha, 124–164.

WHITTLE, A. 1996: *Europe in the Neolithic: the creation of new worlds.* Cambridge University Press, Cambridge.

ZVELEBIL, M. 1981: *From forager to farmer in the Boreal zone: reconstructing economic patterns through catchment analysis in prehistoric Finland.* BAR International Series 115. Archaeopress, Oxford.

ZVELEBIL, M. 1986*a*: Mesolithic prelude and Neolithic revolution. In: Zvelebil, M. (Ed.): *Hunters in transition.* Cambridge University Press, Cambridge, 5–15.

ZVELEBIL, M. 1986*b*: Mesolithic societies and the transition to farming: problems of time, scale and organisation. In: Zvelebil, M. (Ed.): *Hunters in transition.* Cambridge University Press, Cambridge, 167–188.

ZVELEBIL, M. 1989: On the transition to farming in Europe, or what was spreading with the Neolithic: a reply to Ammerman (1989), *Antiquity* 63, 379–383.

ZVELEBIL, M. 1995*a*: Farmers our ancestors and the identity of Europe. In Graves-Brown, P., Jones, S., Gamble, C. (Eds.): *Cultural identity and archaeology: the construction of European communities.* Routledge, London, 145–166.

ZVELEBIL, M. 1995*b*: Indo-Europeans origins and the agricultural origins in Europe. In: Kuna, M., Venclová, N. (Eds.): *Whither archaeology?* Archeologický ústav AV ČR, Praha, Praha, 173–203.

ZVELEBIL, M. 1998: Genetic and cultural diversity of Europe: a comment on Cavalli-Sforza, *Journal of Anthropological Research* 54, 411–417.

ZVELEBIL, M. 2001: The agricultural transition and the origins of Neolithic society in Europe. In Budja, M. (Ed.): *8th Neolithic Studies. Documenta Praehistorica* XXVIII, 1–26.

ZVELEBIL, M. 2002: Demography and dispersal of early farming populations at the Mesolithic-Neolithic transition: linguistic and genetic implications. In: Bellwood, P., Renfrew, C. (Eds.): *Examining the farming/language dispersal hypothesis.* McDonald Institute Monographs, Cambridge, 379–394.

ZVELEBIL, M. 2004: The many origins of the LBK. In: Lukes, A., Zvelebil, M. (Eds.): *LBK Dialogues: studies in the formation of the Linear Pottery Culture.* BAR International Series 1304. Archaeopress, Oxford, 183–205.

ZVELEBIL, M. 2009: *Čestný doktorát.* Západočeská univerzita v Plzni, Plzeň.

ZVELEBIL, M. (Ed.) 1986: *Hunters in transition.* Cambridge University Press, Cambridge.

ZVELEBIL, M., DOLUKHANOV, P. 1991: The transition to farming in Eastern and Northern Europe, *Journal of World Prehistory* 5, 233–278.

ZVELEBIL, M., PETTIT, P. 2006: Contribution of Palaeolithic and Neolithic Y-chromosome lineages to the modern Czech population, *Archeologické rozhledy* LVIII, 250–260.

ZVELEBIL, M., PETTITT, P. 2008: Human condition, life, and death at an early Neolithic settlement: bioarchaeological analyses of the Vedrovice cemetery and their biosocial implications for the spread of agriculture in Central Europe, *Anthropologie* XLVI, 195–218.

ZVELEBIL, M., ROWLEY-CONWY, P. 1984: Transition to farming in northern Europe: a hunter-gatherer perspective, *Norwegian Archaeological Review* 17, 104–128.

ZVELEBIL, M., ROWLEY-CONWY, P. 1986: Foragers and farmers in Atlantic Europe. In: Zvelebil, M. (Ed.): *Hunters in transition.* Cambridge University Press, Cambridge, 67–93