SZENT ISTVÁN UNIVERSITY

THE ANALYSIS OF THE ROMAN AGE ARHAEOBOTANICAL FINDS OF KESZTHELY-FENÉKPUSZTA, WITH A SPECIAL EMPHASIS ON THE FORMER ENVIRONMENT

Theses of PhD dissertation

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Past studies, and aims of the work

The fortress of Keszthely-Fenékpuszta, which originates from the late Roman ages, plays an important role in the researches on Pannonian times. Its explorations have started as early as more than 125 years ago. The archaeobotanical studies started in 1904. Later, during the 1970`s, these types of explorations have become more important and continued with the same dynamism. New plant remains have been found in 1993, while digging was finished in 2013. I have been participating in the project as an archaeobotanist since 2009. Based on the former hypothesis of Sági and Füzes (1967) about the inhabitants of the fortress after the decline of the Roman Empire, the debate is still ongoing, whether it was still inhabited by the same people or after the Avars age a whole new population moved into the fort. Strongholds which are situated out of the Limes, in the back-country,are called inNÉR fortresses. Besides Keszthely-Fenékpuszta, structures like this are to be found at, Környe (Vincentia), Ságvár (Quadriburgium), Alsóheténypuszta (Iova) and Tác (Gorsium) in the territory of Pannonia (Tóth 2009, http1). Their main function could be either civilian use, ormilitary use. Latest researches favour the second option as the strongholds by the Limes had been built to supply the crawling military. During my dissertation I intend to help to decide such debates as well.

Beforehand we can state that the late Roman age fortress of Keszthely-Fenékpuszta is unique from archaeobotanical aspect. Such a long lasting botanical excavation never happened before in Hungary. The rich botanical relics can give us a new aspect for the analysis of the environment reconstruction and may be useful in broadening our agricultural knowledge in numerous fields, as well as for the archaeologists.

I hadset the following aims before starting the research:

- To study and entirely elaborate the soil samples collected during the 2009 excavation , and the samples that were found in the same year at the Balatoni Museum untouched, originating from 1971, 1973,1974;and match the date with the ones from 1904-05, 1970-72 and 1993, that were studied earlier by Miklós Füzes and Ferenc Gyulai.To analyse and evaluate the botanical species by using the eco-archaeo-botanical methods as well as new solutions
- To make a conclusion about the late Roman age land use, plant growing, and knowledge
- By investigating the remnant food supply and plant species I wished to contribute to the knowledge of understanding the late Roman age feeding habits
- By the ecological rating and through finding new species I wished to make a conclusion about the contemporary vegetation, and make a virtual environmental reconstruction.
- I also wished to help answering the origin of the grain and different species(import or local growing, see Füzes 1978).

The most important point of my dissertation was to integrate the great deal of findings from different digging periods, as well as the soil samples that have been never processed and forgotten for long time ; and accurately evaluate all of them to have a closer image of the connection between man and plant.

The significance and difficulties of the study in numbers:

- A culture from 1600 years ago
- Archaeological excavation for 3 centuries
- Botanical substance of 6 diggings
- Several quintals of soil sample
- 568.755 pieces of botanical remnants
- 180 taxa

Last but not least my job was to follow my ancestors and exemplars to continue their research and contribute to the research on perhaps the biggest and most important archaeobotanical findings of Hungary. I also wish to represent the importance, the usability, and the possibilities for complex evaluation of the micro- and macro-archaeobotany.

Materials and methods

Methods applied for processing the plant remnants

I have flotated out the soil samples that were taken from the field and the museum with a standing flotation machine based on the methods of Kenward (1980) and Gyulai (2001). This was followed by sorting the food and plant remains that could have been identified manually, with a PZO type binocular stereo microscope with 20x magnification. The identification books of Schermann (1966), Radics (1998) Cappers et al. (2006) and Brecher (1960) were used for species determination as well as a comparative collection (with the help of my supervisor, Dr. Ferenc Gyulai). Species' Hungarian and scientific names follow the nomenclature of Zohary (2012) and Király (2009). During the examination of the grape seeds I used the work of Rivera et al. (2007), Mangafa and Kotsakis (1996), Jacquat and Martinoli (1999), Gyulai et al. (2009), and Facsar (1970, 1972, 2000).

During research of the food remains I used the work of Gyulai(2007). By overhauling the morphological and structure of the supposedly cereal made dough, I wished to map the common dough type used by the former inhabitants. We have explored altogether 6 charred food remains (with the help of Dr. Ákos Pető) to search them through for phytoliths. Our aim was to determine the purity of the flour which has been used for making the food remains – i.e., the purity of raw material for the flour. The epidermis of the husk (palea) and the glume (gluma) of the cereals form characteristic and easily separatable phytolite morphotypes (elongate dendritic LC). If the grain is not properly cleared, parts ofhusk and glume may be mixed into it, and through the grinding phytolits release which will appear in the product. We used the works of Miller Rosen (1992) and Pearsall (2000) to examine and explore the phytolits. Among the several excavations, we found charcoal suitable for examination in the ones of 1970-72, 1973, 1974, and 2009. Determination and identification were prepared on the freshly fractured surface with a binocular microscope (Olympus SZX7 and DP25 digital camera with the help of Dénes Saláta). To specify the timber we used the works of Babos (1994), Grosser (2003), and Schoch et al. (2004), and the electromicroscope photo collection of the Hungarian National Museum National Heritage Center.

Methods applied for the ecological evaluation of the botanical material

It is very hard to identify plant communities in the field of archaeobotany; moreover, it is usually impossible, since even character species of a community may be absent in the samples. Therefore, I rated every species one by one according to their ecological indicator values. I aimed to integrate the floristic elements of Horváth et al. (1995), the ecological groups of Jacomet et al. (1989) and the ecological indicators of Borhidi (Horváth et al. 1995) (TB, WB, RB, NB) based on Ellenberg (1974), the habitat mapping methods used by the Á-NÉR (GeNÉRal National Habitat Classification System, Bölöni et al. 2011) and the GHC (GeNÉRal Habitat Categories, Bunce et al. 2008) into the archaeobotanical work to explore the characteristics of the one-time vegetation and its habitat, to reconstruct the former probable habitat. As some plant species have more than one ecological group value categories (even 4 in extreme cases), this refers to a wide range of the species, and more than one habitat. For statistical analysis (what habitat type is likely based on the findings of these species) I weighted them, forming the following groups:

Some example by the help of species:

Corncockle (*Agrostemma githago* L.) ecogroup: 9.3., point: 1p autumn cereal weeds category

White goosefoot (*Chenopodium album* L.) ecogroup: 9.2./9.3./10.2., point: 0,33p spring cereal/row crop weeds, 0,33p autumn cereal weeds and 0,33p the average grow region ruderal plants. At the end of the species list, the points have to match with the number of species.

The description of the Á-NÉR and its potential in the archaeobotanical research

The Á-NÉR categories have not been used for the environmental reconstruction so far, therefore, the inclusion of this method into archaobotanical analyses is new. The National GeNÉRal Habitat Classification System (Á-NÉR) has originally been prepared for the National Biodiversity Monitoring Program (NBmR). It is easy to be used and is the most widely used habitat mapping system (Nagy 2013)

I used this system in my archaeobotanical research by the following ways:

- I searched for those species that are specific for the fort in the list of characteristic species of each Á-NÉR habitat type
- I listed the possible habitat codes for the species that I found
- I skipped the habitat types which did not exist during the Roman Empire (e.g. black locust stands, poplar hybrid stands, black pine stands etc.)
- I weighted the probability of one-time presence of the species the same way as presented at the ecological groups.

Description of the GHC and the possibility of its use in archaeobotanical research

Like in the case of the Á-NÉR, the GHC system has not been used in Hungarian archaeobotanical environmental reconstructions so far. This system should be considered as an option for monitoring the biological diversity. The subdivision of the classification is the habitat, and its main difference from the Á-NÉR system is that in case of existing vegetation, its basis is the Raunkiaer's life form of each species (ie. geophyte, hemikryptophyte etc), but in areas where vegetation is absent it uses the land use type and the physical characteristics. This system can be used on the field easily and fast. In the Ph.D. dissertation of Anita Nagy (2013) the above-mentioned Á-NÉR sub-categories are combined with those of the GHC , which creates the possibility that, based on the national Á-NÉR system, an environmental reconstruction can be prepared with habitat types that are understandable even at a European level . According to the above described method, the plant remains designate Á-NÉR categories, which we can assign to the GHC categories following the mentioned work of Nagy. Several GHC subgroups can be combined with one Á-NÉR subgroup, therefore, we have to use the same weighting method that was launched in the case of the Á-NÉR system, in order to describe the probability of one-time habitat types.

Results

Cereal species

Considering the entire late Roman unearthed artifacts from Fenékpuszta, 99.19% of the plant remains was grain, dominated by barley. Therefore, in order to facilitate the listing, I name all the barley taxa as one species, *Hordeum vulgare*.

The distribution of cereal species in the remains is the following: cereal fragment (350.958 pcs), barley (146.045 pcs), bread wheat (29.702 pcs), rye (17,889 pcs), oat (10,508 pcs), einkorn (2,596 units), emmer (1849 pcs), millet (994 pcs), spelt (625 pieces), dwarf wheat (125 pieces). The remaining residues were identified only at genus level (eg. *Triticum* spikelet forks or grains).

<u>Barley(Hordeum vulgare)</u>

In the case of the barley findings the material basically consists of two-rowed and multi-rowed subspecies, but both subspecies bare version (var. *nudum*) can be found. Unfortunately, the condition of the remnants did not allow to define exact species, or subspecies, or variants, therefore, the following distribution can be set for the barleys (in descending order based on the amount of residues found): naked barley (81.086 pcs), multi-rowed naked barley (42.796 pcs), two-rowed naked barley (15.486 pcs), multi-rowed barley (3482 pcs), barley (3172 pcs), two-rowed barley (23 pcs).

By examining several findings from Roman and late Roman sites, we can state that barley played an important role alongside the wheat also during the Roman era (Cooremans 2008, Britton and Huntley 2010); however, Gyulai (2010) presents from the Budapest region Roman site that the importance and use of barley had decreased in the Carpathian basin for the Roman period. In our case, the dominance of naked barley support the previously recorded writings, that the barley does not necessarily can be considered as fodder, but the inhabitants feeding was also an aspect since it was easier to produce (either large amounts) food (porridge, bread, dough etc), which is although difficult to digest, but filling at the meantime.

<u>*Bread wheat (Triticum aestivum* ssp. *vulgare)*</u>

The importance of this species has constantly grewn during the historical periods over the older archaic hulled wheat species (einkorn, emmer), since its cleaning is simpler after the harvest . Through the threshing the husk leaves and the ear spool stayed whole the beard and the bare eyes fall off, afterwards these parts were easy to separate by sieving or winding. In addition of easing its processing, another important factor in the expansion of the bread wheat was its the significantly higher yield against the hulled wheat species. The two properties made it possible to produce more food in a simpler way. Since the late Roman period, archaic wheat grown has fallen also in Hungary, and there is more finding of bread wheat remain through the time progresses as wheat chaff (Gyulai 2001). Among the bread wheat caryopses there were also rachis fragments within the Fenékpuszta findings.

The differences of the caryopses morphology suggest that there was some sort of selection effect on the bread wheat, or local growing specificities (ecotype or variety) was present, since the following types occurred between the findings:
normal, shouldered, elongate, rounded, „compactoid”.

Rye (Secale cereale)

Rye has got less demand than the wheat species, and is more resistant to the climatic effects. Possibly it was the main grain in the late Roman period in parallel with barley and bread wheat (Gyulai 2001). The rye was represented in the findings by three different residues: glume fragments (1), small elongated grain (559 pieces) and normal grain (17,329 units), therefore, morphological differences were found also in case of rye, such as for the bread wheat . The small- and large-grain rye were also mentioned by Gyulai (2001). I note here that the rye straw as a by-product is / has been used for the creation of thatch and thatch tiling (Gilyán 2005). Roman buildings of this kind of use were made of stones and wood structure was not typical, but in case of smaller pit houses(see object no. 3020 from 1973 excavation), this roof may have been used as well.

Oat (Avena sativa)

In connection with the oat, archaeobotanists (Miklós Füzes and Ferenc Gyulai) who studied this site found that this species gives evidence for cavalry army in Fenékpuszta. This, however, seems to be contradicted by the fecal test of British-Roman sites (civil and military) outhouse materials (Britton and Huntley 2009), which also showed that the inhabitants consumed oats, most likely in the form of porridge (where the grains been used cracked). The authors draw attention to the fact that the presence of oats at militant Roman sites does not automatically mean a cavalry station, or horse keepers presence. So the naked oats at Fenékpuszta can be classified as a potential food crop with the barley, wheat and rye.

Einkorn and Emmer

These two archaic wheat species mainly characterized the historical periods prior to the Roman era. Their presence may prove an even older culture's survival and presence. Einkorn and Emmer primarily differs from bread wheat discussed above, the spindle does not give glume fragments (by-products) and the naked grain (final) during threshing, but the whole ear falling apart to a so called spikelet (coccoid type). This requires additional cleaning process, thus involves more energy invest producing food from these species. The aforementioned hulled wheat species (and also the spelt), despite their higher resistance to diseases and less demand to ecological backgrounds, had lower yield than the naked wheats. The Roman age production of grain structure has shifted towards the latter species (e.g. bread wheat, dwarf wheat) (Gyulai 2001).

Their joint presence in Fenékpuszta is proven, since the bread wheat and dwarf wheat finds counts in total of 29827 pieces of residue, while the total amount of einkorn and emmer exceed only 4445 pieces. The presence of the former two species at archaeological sites (such Fenékpuszta) can not only reveal the caryopses, but called spikelet forks, which are actually the parts of the glumes in the spikelets funds that remain after threshing and the cleaning of the chaff. It also indirectly indicates whether cereal was locally grown or not.

<u>Millet (Panicum miliaceum)</u>

Millet basically was a typical grain for fast moving, horse riding nomadic steppe people (Scythians, Sarmatians, Huns, Avars, Hungarians) (Gyulai 2001). The main advantages of this spring-sown cereal is its short growing period, so for the second sowing on the summer willing to ripe and its little demand for soil preparation and tillage. Thanks to these features, nomadic people favored its production. In the Roman era, similarly to the hulled wheat, its importance decreased, but nevertheless found between many domestic and foreign Roman hotspots. Gyulai (2001) also suggests that the vast majority of Roman millet artifacts in Hungary come from military objects (guard towers, forts). This raises the possibility that the millet was not only useful for migrating people, but to supply a large number of infantry and cavalry troops as well. This is no better proof that there are whole millet grains in the texture of some food remains in the findings.

<u>*Spelt (Triticum aestivum ssp. spelta)*</u>

This archaic hulled wheat is also present in the find material. The situation was similar in the case of Fenékpuszta as we mentioned previously at the einkorn and the emmer, so it got less importance, but for example in Helvetiae it formed the majority of the wheat. The production and the amount of archaeological material are related to the climate, because spelt prefers cool and wet weather (Gyulai 2010). As for the other two bearded wheat species mentioned above, the spelled wheat not only can be justified in an archaeological material by the seed. One may also find spikelet forks and glume remains (chaff). In Fenékpuszta, the residual by-product after threshing (in this case, spikelet fork and glume fragments) compared to the full, spelt wheat-related artifacts is 8.88%.

<u>*Dwarf wheat (Triticum aestivum* ssp. *compactum)*</u>

The dwarf wheat is already ”*aestivum*”-type naked wheat. Its caryopsis are very different from those of bread wheat, as they sharply depressed together. Among the species in Fenékpuszta grain artifacts they are the smallest proportion. Gyulai (2001) writes that in the late Roman period at Fenékpuszta the old, hulled wheats role clearly been taken by the bread wheat and the dwarf wheat review of several excavation material only see this been justified in the case of sowing wheat.

Legumes, oil and fibre plants

A total of six leguminous and two oil plant species have been found from the late Roman period. Small- and large-seeded lentils (330 and 6), garden pea (1 piece), field pea (1 piece), the bitter vetch (2 pcs), small-seeded horse beans (2 pcs), black mustard (1 piece) and poppy (1 piece) were found. The diverse racial composition and a large number of garden plants is a legacy of a high level gardening culture. It is interesting to note that a small grain of bitter vetch and the lens is typical of pre-Roman archaeological eras species cropping systems, farming and nutrition means that these moments can be found at the late Roman section as well. The cookbook of Apicius (1996, Paper V) discusses the use of leguminous species in detail. The lentils and peas are listed as a raw material used in the preparation of a barley porridge type, with some excellent supporting role of barley. In addition to the porridge of legumes, the so called dense soups chickpeas, peas, lentils, beans etc), and other cooked / baked vegetable dishes (e.g. pea casserole, peas overturned) were also favored foods among the Romans. The presence of species that are suitable for oil recovery do not confirm the oil production, but its possibility cannot be rejected. However, both species can be used in the kitchen as spice (Apicius 1996). This group of plants constitutes only 0.06% of the plant material that can be determined. This is a very low number, but it carries more information than it would be suspected from the low proportion.

Vegetables and Herbs

Four species belong to this category: carrot (1 piece), savory (2 pieces), black mustard and poppy that were also mentioned above. According to the cookbook of Apicius (1996), savory and mustard were the most commonly used raw materials in the Roman kitchen. Although mustard is *Sinapis alba* in the contemporary recipes, both species can be used equally well for preparing mustard. The vegetables and spices cover also a very low proportion in the found material (only 0.00053%).

Fruits

The cultivated fruit species found in the site can be divided in two groups. One is the import Mediterranean fruits: olive (7 pcs) and fig (1 piece) presumably, the other is the fruits presumably from local cultivation: walnut (7 pcs) and peach (3pcs). The import fig most likely arrived as dried fruit candy to Hungary, because the freshly picked figs would have got rotten during this distance. The olives were probably preserved in vinegar and arrived in barrels (Füzes 1978) to the Pannonia province. Apicius (1996) mentions both species in several places (e.g., dried figs fattened pigs and geese, spicy cabbage with olives, chopped olives stuffed birds etc). According Livarda (2011), forts along the limes played a major role in the spread of peach in Pannonia. The presence of the walnut (*Juglans* sp.) was also shown in pollen studies of the area at the time of the Romans (Sümegi 2009), and researches also show that walnut pollens (as well as grape pollens) accumulate in this period (Nagyné Bodor 1988). An interesting artifact at Fenékpuszta is the coffee (*Coffea arabica*), which also refers to the trading relations. The charred coffee beans are found by Miklós Füzes, and handed over for investigations to Dr. Dezső Surányi, but unfortunately these findings have not been maintained for future generations (based on interview with Dr. Dezső Surányi). The case is similar with the domestic holly (*Sorbus domestica*), which can only found in the paper of Füzes (1978).

Grape

Despite the fact that Pannonia had an extensive viticulture, only 38 grape seeds were found among the 568.755 pieces of plant origin remnants of Fenékpuszta . This can be explained by two causes. There have been no samples taken from buildings which process grapes during the soil samplings. Or grapes around the fort as delicacy, were negligible, and may have been present only in the form of wine. However, the cane and stalk foundings of Miklós Füzes (Füzes and Sági 1968) clarify that viticulture took place around the fort. After morphological comparisons to the seeds of 30 kind of / sort presented by Gyulai (2009), the seeds are similar to the following cultivars:

1., 2., 3., 4., 5. seeds: Csabagyöngye, 6. seed: „kék bakator". Computer-based morphological tests were also performed on these seeds with the help of Zoltán Mravcsik. According to the indexes the cultivar can be any the following ones: Apró fehér, Fehér izsáki, Furmint, Kövidinka, Piros tramini, Ezerjó, Fehér lisztes, Juhfark, Kékfrankos, Ortliebi, Sárgamuskotály. Among these, the seeds of cultivars produced for a long time were measured by Fovea Pro 4.0 programme (Zoltán Mravcsik own seed collection) (Russ 2005). Based on the morphological characteristics (Area, Roundness, Lenght, Breadth, Formfactor, Aspect ratio, Perimeter, Convexity, stb.) the seeds of the archaeological foundings cannot be identified clearly. The data series values were also compared with other ancient breeds (Gohér, Kecskecsöcsű, Szürkebarát, Bakator, Mézesfehér, Kéknyelű, Csókaszőlő, Zöldszilváni), but still did not find any similar among them. Therefore we state that the late Roman era grapes at Keszthely-Fenékpuszta fortress are not matching to any of the old Hungarian grape varieties, so it is possible that it originates from a Mediterranean import.

Crop- and ruderal weeds

Both crop- and ruderal weeds (altogether 71 different taxa) may help identify the former crop production, and certain cultural habits. The use of a variety of ecological indicators (based on the needs of each species) we determine what kind of site conditions once ruled the arable land also are highly influenced and disturbed areas by the people and (due to grazing / pasture) animals.

Ecological groups

Based on the list of index numbers, ecological categories of the former vegetation types can be concluded: the autumn-sown cereal weeds, spring-sown cereal or row weeds, composed of average regional ruderal vegetation, dry regional ruderal growing areas, wet regional ruderal vegetation, average regional meadow / pasture.

As much as possible, I created two groups (the existence of which is most likely):

1: Weed, also known as common weed species communities (autumn and spring-sown cereal weeds, row crops or weeds) - 43 species classified here.

2: ruderal weeds - 28 species classified here.

With the help of the first group of species we can guess the characteristics of the contemporary arable lands; while the second group lets us see the most common surrounding areas of inhabited sites. The mean values of the ecological indicators do not differ significantly for the two groups above, as the differences are within 0.5. In the light of ecological indicators both arable and ruderal areas can be characterized by the following habitat features: Weed species represent the "sub-montane broad-leaved forest belt" climate. The arable lands as growing sites were characterized most likely with semi-dry water supply, neutral pH, and medium nutrient content. Species different from the average ecological characteristics refer mainly to the mosaic-like situation of the production sites. *Lolium remotum* and *Myagrum perfoliatum* are adventive weeds, meaning that they are not native to Hungary and are present only since the Roman times (Pinke and Pál 2005). This refers to the fact that the grain (or seed) partly came from the Mediterranean provinces, but based on the ecological characteristics of weeds that live in cereal grains, most of the cereals were grown in the Pannonian fields.

The species of natural vegetation

I have detected 70 different taxa and 1069 pcs of traces from the former naturally derived flora. As for the weeds, species related to the natural vegetation can be evaluated with the help of their relative ecological indicators. So it can be detected what natural vegetation types and which habitat features were specific to the area around the fort.

Ecogroups

While in case of the weeds we clearly see cultural weed species or ruderal species dominated communities, several vegetation and habitat types emerge on the basis of the species that belong to natural vegetation:

1. Meadow / pasture with average conditions, 2. Arid and wet meadow / pasture, 3. Autumn-crop weeds, 4. Spring-crop weeds, 5. Ruderal plants, 6. Riverbank / lakeside vegetation , 7. Marshes, 8. Gallery forests, 9. Shady forests, 10. Shrubs, 11. Forestsides, 12. Submerse aquatic plants.

The results of the used Á-NÉR and GHC methods

The potential vegetation cover of the site based on the Á-NÉR

From the findings of Fenékpuszta I could classify 102 species according to the Á-NÉR book. As one species may occur within more than one habitat types, we can assume a total of 89 different habitat types, but the probability of their existence might be vastly different if we use the methodology described in the related section.

According to the Á-NÉR categories the following habitat types are likely:

1. Agricultural habitats, 2. Other habitats (villages, farms roads etc.), 3. Colline and mountain hay meadows (indicating natural grasslands around the fort) , 4. Reed beds and marshes, 5. Other woody habitats, 6. Rich fens, eu- and mesotrophic meadows and tall herb communities, 7. Dry deciduous woodlands, 8. Bush vegetation and woodland margins, 7. Other non-woody habitats, 8. Riverine and swamp woodlands, 9. Dry open grasslands, 10. Dry and semi-dry closed grasslands, 11. Euhydrophyte habitats, 12. Rivers and streams.

If we compare these results with the results of the ecogroups, we seethat there is a large consistency between the data obtained and habitat types. These results confirm that the integration of the Á-NÉR categories to the archaeobotanical analysis with a proper manner can bring similar good results like the previously used Ecogroup method.

The potential vegetation cover of the site according to the GHC

Anita Nagy has compared and connected two habitat mapping methods, the Hungarian Á-NÉR and the pan-European GHC in her recently defended Ph.D. dissertation. This also created the opportunity for the communication of the work in archaeobotanical research internationally, to obtain the results that have been generated with the Á-NÉR. Therefore, if we know that which Á-NÉR habitat types were supposed in the site, then we can still refine using the GHC assigned categories. The species of these habitat types refer to the followings:

1. Cultivated herbaceous crop, 2. Therophytes, 3. Leafy hemicryptophytes, Caespitose hemicryptophytes, 4. Urban Artificial, 5. Geophytes, 6. Herbaceous chamaephytes, 7. Urban Non-vegetated, 8. Tall phanerophytes, 9. Helophytes (marshlands), 10. Mid phanerophytes, 11. Forest phanerophytes, 12. Urban Vegetables, 13. Cultivated woody crops, 14. Emergent hydrophytes, 15. Submerged hydrophytes, 16. Aquatic, 17. Stones.

The test results of the charcoal examinations

The charcoal residues observed on the basis of the fresh fracture surface pattern belong to the English oak (*Quercus robur* L.) (with the assistance of Dénes Saláta). This is a dominant species of the oak – ash – elm forests, with much higher water demand than the sessile oak (*Quercus petraea* (Matt.) Liebl.). This habitat type had been widespread around the Lake Balaton and along the River Zala, but currently it is only found in smaller spots (Marosi and Somogyi 1990, Bartha 1998, Dövényi 2010). Columns and beams can be created of it. Tannins can be obtained from its bark. (Égető 1987, Jereb and Kondor 1996). Füzes (1978) mentions another oak species from the records of the fort. On the basis of a lot downy oak (*Quercus pubescens* Willd.) acorn fragment assumes that the acorn seeds were grinded and they made coffee of it, similar to the customary use of the holm oak (*Quercus ilex* L.) in the Mediterranean region.

Food remains

I could distinguish several different cereal-based foods within the founds of crop residues during food fragment morphological tests: leavened bread, unrose flat bread, refined flour "cake" coarse flour made from groats porridge, fat or meat made porridge, whole millet grains and Italian millet cooked porridge, pea porridge. The amount of food unearthed during the excavations remains negligible compared to the macro-botanical material, but it is still an important and direct evidence of the eating and cooking habits of the inhabitants in the inner fortress. The samples were proven to be sterile when examining total and partial phytolith. However, the negative result of the phytolith analysis is informative. The lack of phytoliths in the food remains bases the assumption that the Roman advanced agriculture is evident not only based on the cultivation and the high agronomic level, or a diverse crop-staff for maximizing the culinary delights, but also the cleaning roasting and preparation of the grain, as the grain seeds do, but the cleaning waste (chaff) do not contain phytoliths.

Conclusions and recommendations

Agricultural practices, and the features of arable habitats

Several cereal species and several subspecies were grown, many of which also been used in the food production. The vast majority of autumn-sown cereal species were used, among them the dominant barley very likely functioned as food (as well). The presence of the archaic wheat and millet suggest the existence of pre-Roman farming practices, and it's continuing by native vassal people. The great diversity of cereal weeds, insignificant amount of remnants refers to good crop production, mature harvest and effective cleaning processes. The latter one is confirmed by results of the studies on phytolith residues in food, as neither beard nor husk phytoliths were recorded, referring to good quality flour used for to preparing pasta. Leguminous plants such as peas, bitter vetch, lentils etc, have served as a basic food for them. Differences in appearance were observed for both the sowing wheat and grapes remnants, which suggest some degree of breeding. The 73 weed taxa (predominantly arable weeds) concerned a very species-rich arable weed association. Nowadays this may only happen in extensive cultivation or entirely organic farming. Fenékpuszta according to the cropping practices broadly fits (together with their unique characteristics) into the late Roman Pannonia excavation sites.

Import, foreign trade relations

The fig probably, and the olive and coffee certainly underpin that there was a commercial connection between Fenékpuszta and the Mediterranean provinces. According to Füzes (1978), the absolute proof of the import in case of cereals is the residue of Mite Cress (*Myagrum perfoliatum*) kernel, since this plant was introduced in Hungary in the Roman times (Pinke and Pál 2005), but also into other areas occupied by the Romans (Zech-Matterne 2010). The grain is not reassuring the data, since the presence of the Mite Cress in the botanical material does not mean that the whole crop that was found originated from import. It is possible, however, that a portion of grain (or seed) really originated from other Mediterranean provinces to Pannonia. The found threshing waste such as villas, chaff funds, spindle fragments, however, suggest local production.

The dietetic habits of the fortress inhabitants.

The above-described locally grown, import and collected diverse species suggests a varied diet. The cereals, breads and porridge have been known in several forms: flat bread, fermented bread, porridge, millet porridge, porridge of millet and foxtail millet, peas and millet porridge, cakes. Fat was also used during food production, as some residuals are glossy, which is a sign that the the fatty acids crystallize and precipitate as a consequence of heat (Gyulai 2007). None of the spice residues found in the northwest European sites mentioned by Livarda (2011) (e.g. cinnamon - *Cinnamonum verum* J. Pres., saffron - *Crocus sativus* L., curcuma - *Curcuma longa* L., ginger - *Zingiber officinale* Rosc., pepper - *Piper nigrum* L.) was found in the excavations at the fort of Fenékpuszta. The millet consumption mentioned by Füzes in 1978 was only assumed, but my work clearly proved it with the analysis of more porridge dish fraction. And the leguminous species served as raw material for porridge, dense soups, salads, etc. Olives and coffee were imported to Fenékpuszta, but the hazelnut and oak acorn presumably originated from local collection . The grinded seeds of acorn could serve as coffee as well, but also could apply for making fillings, according to Apicius (1996). The origin of the nut is still in question, but it is certain that they ate it as a main ingredient for digestive soups, or puffs (Apicius 1996). The evidence of the fleshy fruit consumption are the peaches, table grapes and the church rowan mentioned by Füzes (1978). Overall, we meet a diverse habit of eating at the fort of Fenékpuszta through the late Roman period which carried the habits of the Mediterranean characteristics.

The image of the natural vegetation cover

The results show that at least 10 different natural vegetation types can be distinguished based on the species. The results indicate that the species of natural vegetation form the following pictureon vegetation of the contemporary environment of the late Roman age at Fenékpuszta:
1. submerse plants, 2. reed beds, sedges and other lakeshore plants, 3. marshlands, 4. fresh and wet grasslands, 5. moderately wet meadows/pastures, 6. dry grasslands (mainly possible at the eastern side of the fortress, and the southern part of the peninsula), 7. forest edges and shrubs, 8. forests (oak – hornbeam forests on drier, higher areas) and gallery forests (on deeper areas and close to the shores, both willow – poplar and oak – ash – elm stands), 9. arable fields, 10. ruderal areas (roads, and the cemetery next to the southern fortress gate).

New and novel scientific results

1. I consider the monographic summary on the archaeobotanical finds of Keszthely-Fenékpuszta a novel scientific contribution to Hungarian archaeobotany. In my view, this will complement the already existing archaeological monographs written on the long history and excavation history of this particularly important archaeological site.
2. Previous archaeobotanical results have been complemented with further ethnobotanical, landscape historical and plant ecological data and observations.
3. The known taxa of the archaeobotanical material of Keszthely-Fenékpuszta reached 170 instead of the previously known 53. The database built on the extend archaeobotanical record forms the base of a more precise environmental reconstruction. This latter has been graphically visualised.
4. Morphometric measurements were conducted on grape pips, which yielded novel information on the viticulture of Roman Age Pannonia and Keszthely-Fenékpuszta.
5. Different lines of archaeobotanical evidence and methods were applied on the archaeobotanical material. Data gained from carpological, phytolith and anthracological analysis were integrated and interpreted.
6. The Á-NÉR and GHC ecological systems, routinely used in recent plant ecology and mapping,have been applied to an extensive archaeobotanical material for the first time. Based on my results it has been proved that these ecological systems have a big potential in archaeobotany.

Proposals

Recently, in 2011 Orsolya Heinrich-Tamáska and Bálint Havasi organised a workshop at ‘Balatoni’ Museum, which aimed at preparing ideas and plans for the establishment of an archaeological park at the inner fortress of Keszthely–Fenékpuszta. The following organisations participated at this workshop: Keszthely Municipalit Council, ‘Balatoni’ Museum of Keszthely, Helikon Castle Museum of Keszthely, Board of Directorates of County Zala (Zalaegerszeg), Office for Cultural Heritage, Laboratory for Applied Research (Hungarian National Museum, National Heritage Protection Centre), Archaeological Institution of the Hungarian Academy of Sciences, Office of Zala County Tourism, ‘Balaton-felvidéki’ National Park, Local Office of Land Registry, Road Maintenance Office. In case the ideas and preliminary plans discussed on the above mentioned workshop will be brought to live, I will suggest the followings:

Cultivation of historic cereal species on small plots (with information boards on the cultivated species). ‘Cultivation’ of historic weed assemblages within the cereal plots. Possible contributors and partners for this demonstration panel could be: Georgikon Faculty of Keszthely, Plant Diversity Centre and Research Centre for Agrobiodiversity (Tápiószele), ‘Matrica’ Museum and Archaeological Park (Százhalombatta).

In the harvest period a small-scale presentation could be performed with the replicas of archaeological iron tools(e.g. sickles, scythe etc.). In case the granary is reconstructed, the harvested cereal stocks could be stored in separate compartments. All of these could be demonstrated with information boards that lead the visitor and provides information on the difficulties of storing cereals assemblages in Roman times. The preparation phase would follow storing phase. In this cereal cleaning, the removal of weed seeds and fruits form the cereal assemblage could be demonstrated (e.g. sieving, winnowing, manual separation etc.). The demonstration of the dehusking procedure of hulled cereals, like einkorn and emmer could also be demonstrated. The preparation and baking of contemporary food types (with regard to the receipts of Apicius) could bring the whole process closer to the visitors. For this, flour produced of the cereals harvested at the archaeological park could be used.

The morphometric analysis of grape pips presented in this dissertation are only the first steps towards the better understanding of Roman Age viti- and viniculture. I wanted to present the possibilities of different archaeobotanical tools. In case the entire, non-charred grape pip assemblage of Keszthely–Fenékpuszta becomes accessible for archaeobotanical research, I suggest the proper morphometric analysis of it within the frames of an individual PhD dissertation.

Samples collected during the 2011 excavation campaign could form a suitable basis for further archaeobotanical examination on BSc level. These additional analyses will all help to complement and deepen our understanding of the archaeobotany of Keszthely-Fenékpuszta.

Relevant publications

Peer-reviewed journal articles:

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