

The botanical macroremains from the prehistoric settlement Kalnik-Igrišće (NW Croatia) in the context of current knowledge about cultivation and plant consumption in Croatia and neighboring countries during the Bronze Age

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Abstract

This paper presents the results of the first extensive archaeobotanical research into a Bronze Age site in Croatia. The aim of the study was to reveal what plants were consumed (grown) at Kalnik-Igrišće (NW Croatia) in the Bronze Age and to realize if the plant diet of the local population differed from that of the inhabitants in neighboring countries.

The results show that all plant macrofossils found at Kalnik-Igrišće can be classified into one of four functional groups: cereals, cultivated legumes, useful trees and weeds. As much as 98% of the findings are of cereals and legumes. The most abundant species found are *Panicum miliaceum* (millet), *Hordeum vulgare* (barley), *Vicia faba* (faba bean), *Triticum aestivum* ssp. *aestivum* (bread wheat), *Triticum turgidum* ssp. *dicoccon* (emmer wheat) and *Lens culinaris* (lentils). The findings from Kalnik-Igrišće do not differ from the findings of neighboring countries, indicating that there were similar diets and agricultural/plant-collecting activities throughout the whole of the studied area (Bosnia and Herzegovina, Slovenia, Serbia, Italy, Austria and Hungary).

Keywords: Kalnik-Igrišće; NW Croatia; Bronze Age; carbonized plant macrofossils; human nutrition

Introduction

Investigations into human nutrition in the Bronze Age in Croatia are very rare; the only data related to it are from Nova Bukovica [1] and Monkodonja near Rovinj [2]. Nova Bukovica-Sjenjak is a site located in the Croatian inland and only two kinds of botanical macrofossils have been recorded; seeds of the faba bean (*Vicia faba*) and fragments of the acorn (*Quercus* sp.) [1]. The Monkodonja site is a historical village, surrounded by strong dry stone walls, situated five kilometers from Rovinj [3]. At Monkodonja, archaeologists recorded four plant species: the grapevine (*Vitis vinifera*), oat (*Avena* sp.), faba bean (*Vicia faba*) and grass pea (*Lathyrus sativus*) [2].

On the other hand, studies of Bronze Age sites in the surrounding countries are more numerous: Bosnia and Herzegovina (2 sites), Serbia (3), Slovenia (5), Austria (11) and Italy (28). Insight into Late Bronze Age plant remains from Hungary was acquired from Gyulai [4], in which the author summed up all archaeobotanical researches in that

area to date. In order to provide easier access to all the data, a comparison of the findings from neighboring countries with the results from Kalnik-Igrišće is presented in tabular form in [Appendix S1](#).

The context of the findings (Kalnik-Igrišće site)

Samples analyzed in the study come from the site Kalnik-Igrišće, located on the southern slopes of Mount Kalnik (north Croatia; [Fig. 1](#)), at about 500 m a.s.l. Archaeological research into the multilayer site Kalnik-Igrišće began in the year of 2006 and was completed in 2012. The archaeological excavation covered in total an area of 60 square meters located on a terrace.

Under layers with the traces of habitation from the Middle Ages, Roman period and the Late Iron Age we discovered well preserved remains of a Bronze Age house. This was a layer (SU 14) of a burned house with large quantity of charcoal, carbonized cereals and broken pottery. Several layers under layer 14 were formed as a result of the collapse of the house and erosion. The research included the western and northern edges of the structure. Construction elements of the house have been preserved in the form of postholes and a partially preserved stone structure, along the western edge of the house.

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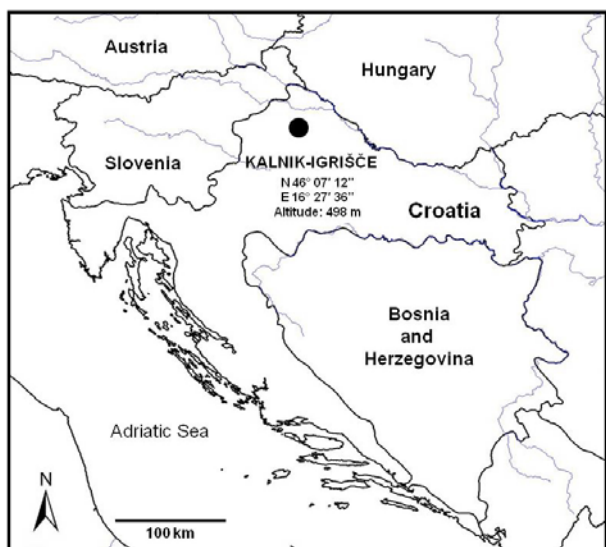


Fig. 1 The location of Kalnik-Igrišće site.

The house was destroyed in a fire, which was evident from the findings of carbonized grains and pottery fragments damaged by high temperatures. Although the dwelling is not yet completely explored, it is assumed that this part of the house was used for food storage. The evidence for this is the large number of vessels for storage and preparation of food as well as items of plant food that have been found [5,6].

Radiocarbon analysis (conducted in the Beta Analytic Radiocarbon Dating Laboratory) of the wheat grains found at Kalnik-Igrišće with 95% confidence placed the sample in the period between 840 and 790 BC (Late Bronze Age), which is also confirmed by the analysis of pottery found on the site. The pottery belongs to the Ha B phase of the late Urnfield culture. Based on their stylistic traits, the potsherds fit best in the assemblage of the Ruše cultural group in Slovenia. In the Late Bronze Age a mostly unique culture was present on the wide region of Danube, the southeastern Alps and the northern edge of the Balkans. At that time a unique archaeological culture, manifested primarily in the burial of cremated decedents in large flat urn fields, was created. Bronze metallurgy reached its highest achievements in prehistoric Europe, while trading and cultural connections were established with distant areas [6].

The aim of our research was to investigate what plants were consumed (grown) at Kalnik-Igrišće (NW Croatia) in the Bronze Age and to see if the plant diet of the local population was similar to that of the inhabitants in neighboring countries.

Material and methods

During an archaeological excavation campaign in 2008, 55 samples were collected and without flotation put in plastic bags and delivered to the Faculty of Science, Department of Biology (Botany) in Zagreb for archaeobotanical analysis. First, the volume of each sample was measured and then

all the plant remains were isolated from the soil. The soil from our samples was loose enough to be dry sieved, so we did not use water recovery techniques. For dry sieving we used sieves with mesh diameters of 2.5 mm and 0.315 mm and obtained three fractions. The fraction with the smallest particles had no botanical remains in the first 15 randomly picked samples, so no more checking was done of this fraction. Some samples rich with macrofossils (Tab. 1) were reduced by grid-method [7,8] to one third of their overall volume in order to save research time and energy.

After isolation, determination of plant macrofossils was done. For determination of plant species (genus/families) we used seed atlases [9–11], textbooks [12,13] and some scientific and qualification papers with useful illustrations and explanations [14–18]. For the taxa determination the carpological collection (under establishment) of the Botany Division was found very helpful. The nomenclature of plant species was done according to Cappers and Neef [19]. All the determined macrofossils and their frequencies are listed in Tab. 1.

With the help of the computer program Motic Images Plus 2.0 and the camera placed on the microscope, the average dimensions (height, length and width or radius) were measured for cereals and cultivated legume species (with more than 5 findings), which were found at both Kalnik-Igrišće and the comparison site Stillfried an der March [20]. For comparison site was chosen Stillfried an der March, because from that site we had data on dimensions of carbonized remains, of the same plant species like the ones from Kalnik-Igrišće.

All the plant species found were classified into one of four categories (cereals, cultivated legumes, useful trees and weeds) and their occurrence and abundance were analyzed.

After review of the scientific archaeobotanical literature about the Bronze Age sites from Croatia and neighboring countries (Slovenia, Hungary, Austria, Italy, Bosnia and Herzegovina, and Serbia), comparison was made between the literature and the Kalnik-Igrišće site, and conclusions were drawn about the plant diet of the Bronze Age human population living in the area.

Results

A total of 55 samples were subjected to archaeobotanical research. The volume of the investigated samples was 136.5 l. We isolated and identified 69 116 plant remains, of which only 13 (0.02%) were not carbonized (*Viburnum lantana*); however, they represent contamination from the present time. When we calculated (for the samples in which only 1/3 of the sample was analyzed) the assumed total amount of plant remains, we got a total number of 139 581 macrofossils present at the site (Tab. 1). Tab. 1 shows that in the analysis of 69 116 macrofossils, we identified 18 species (67 146 remains), 5 genera (597 remains), 2 families (34 remains) and 14 (246 remains) insecurely determined species or genera (so called “cf.” taxa). Three seeds remained undetermined. The number of macrofossils undetermined was small because poorly preserved or morphologically atypical remains were assigned to broad categories such as

Tab. 1 The list of all taxa found at the late Bronze Age site Kalnik-Igrišče, with accompanying data about type of a macrofossil, category of taxa, number of isolated and assumed number of macrofossil on the site.

Taxa	Type of macrofossils	Number of isolated macrofossils	Assumed number of macrofossils
Cereals			
<i>Avena</i> sp.	grain	68	248
cf. <i>Avena</i> sp.	grain	5	13
Cerealia	grain	279	407
<i>Hordeum vulgare</i> L.	grain	12 735	27 283
cf. <i>Hordeum vulgare</i> L.	grain	61	61
<i>Panicum miliaceum</i> L.	grain	22 570	45 452
<i>Secale cereale</i> L.	grain	5	15
cf. <i>Secale cereale</i> L.	grain	2	2
<i>Setaria italica</i> (L.) P. Beauv.	grain	433	833
cf. <i>Setaria italica</i> L.	grain	29	57
<i>Triticum aestivum</i> ssp. <i>aestivum</i> L.	grain	6230	12 338
<i>Triticum</i> cf. <i>aestivum</i> ssp. <i>aestivum</i> L.	rachis fragment	1	3
<i>Triticum aestivum</i> ssp. <i>spelta</i> (L.) Thell.	grain	3900	8412
<i>Triticum aestivum</i> ssp. <i>spelta</i> (L.) Thell.	glume base	31	75
<i>Triticum</i> cf. <i>aestivum</i> ssp. <i>spelta</i> (L.) Thell.	glume base	39	115
<i>Triticum monococcum</i> ssp. <i>monococcum</i> L.	grain	399	787
<i>Triticum monococcum</i> ssp. <i>monococcum</i> L.	glume base	38	106
<i>Triticum turgidum</i> ssp. <i>dicoccon</i> (Schrank) Thell.	grain	5735	11 383
<i>Triticum turgidum</i> ssp. <i>dicoccon</i> (Schrank) Thell.	glume base	66	166
<i>Triticum</i> cf. <i>turgidum</i> ssp. <i>dicoccon</i> (Schrank) Thell.	glume base	24	62
<i>Triticum</i> sp.	grain	462	1066
<i>Triticum turgidum</i> ssp. <i>dicoccon</i> (Schrank) Thell./	grain	811	1293
<i>Triticum aestivum</i> ssp. <i>spelta</i> (L.) Thell.			
Cultivated legumes			
<i>Lens culinaris</i> Medik.	seed	4918	11 056
cf. <i>Pisum sativum</i> L.	grain	11	25
<i>Vicia faba</i> L.	seed	9053	16 489
Useful trees			
<i>Cornus mas</i> L.	stone	1	3
<i>Malus sylvestris</i> Mill.	fruit fragment	31	31
<i>Malus sylvestris</i> Mill.	fruit	207	215
<i>Malus sylvestris</i> Mill.	seed	4	9
<i>Quercus</i> sp.	cotyledon (half)	31	61
<i>Quercus</i> sp.	cotyledon fragment	15	19
Weeds			
<i>Bromus arvensis</i> L.	grain	2	2
<i>Bromus secalinus</i> L.	grain	17	37
<i>Bromus</i> cf. <i>secalinus</i> L.	grain	4	10
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	grain	728	1102
cf. <i>Echinochloa crus-galli</i> (L.) P. Beauv.	grain	64	124
<i>Galium aparine</i> L.	seed	19	45
<i>Galium</i> cf. <i>aparine</i> L.	seed	4	12
<i>Galium spurium</i> L.	seed	10	26
<i>Galium</i> cf. <i>spurium</i> L.	seed	2	6
Unknown			
<i>Bromus</i> sp.	grain	14	38
cf. <i>Bromus</i> sp.	grain	1	1
Chenopodiaceae	seed	1	3
<i>Galium</i> sp.	seed	7	21
Poaceae	grain	33	51
<i>Viburnum lantana</i> L.	seed	13	13
Indet.	seed	3	5
Σ		69 116	139 581

Cerealia (cereals). The Cerealia group consists of cultivated large-grained cereals (*Triticum/Hordeum/Secale/Avena*), which could not be determined to the genus or (sub)species level, because they were in a poor state of preservation. Tab. 1 also includes the category *Triticum turgidum* ssp. *dicoccon* (syn. *Triticum dicoccon*, emmer wheat) / *Triticum aestivum* ssp. *spelta* (syn. *Triticum spelta*, spelt), to which we allocated wheat grains that have morphological features of both taxa, but do not completely match any of them. The identification of *Triticum* subspecies was not always easy, because there were many grains without completely clear morphological characteristics of any subspecies. But with the help of literature and the comparative carpological collection, we managed to sort most grains into one of the four subspecies, whose characteristic representatives we show in Fig. 2.

The most frequently found species (>3900 remains) were *Panicum miliaceum* (millet), *Hordeum vulgare* (barley), *Vicia faba* (faba bean), *Triticum aestivum* ssp. *aestivum* (syn. *Triticum aestivum*, bread wheat), *T. turgidum* ssp. *dicoccon* (syn.

Triticum dicoccon, emmer wheat), *Lens culinaris* (lentils) and *Triticum aestivum* ssp. *spelta* (spelt; Fig. 3, Tab. 1).

Based on the literature data on the use of certain plant species and customs related to them in the past and the present, we have divided macrofossils found into four categories (cereals, cultivated legumes, useful trees and weeds) which helped us to draw conclusions about the dietary and agricultural habits of the local human population. The numbers of species in each category and the total number of found macrofossils for each category is shown in the graphs (Fig. 4, Fig. 5).

The list of species identified clearly shows that most remains found at this site were intentionally brought to the house for the purpose of being consumed. The number of macrofossils that were accidentally collected together with cultivated plants or otherwise entered the house (for example brought in by the wind, after the house was demolished and became more open to external accidental contamination), is much smaller.

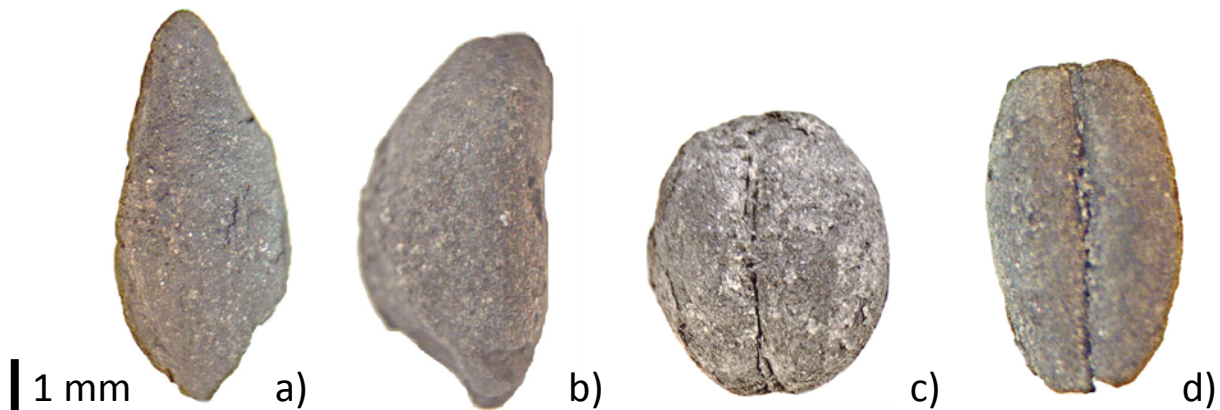


Fig. 2 The morphological differences between *Triticum* subspecies: *T. monococcum* ssp. *monococcum* (a; lateral view), *T. turgidum* ssp. *dicoccon* (b; lateral view), *T. aestivum* ssp. *aestivum* (c; ventral view) and *T. aestivum* ssp. *spelta* (d; ventral view).

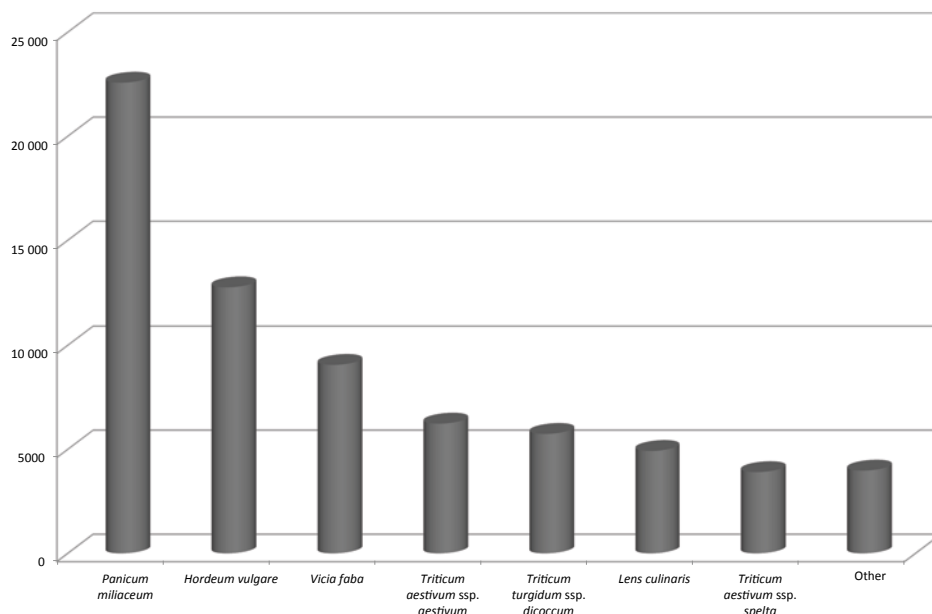


Fig. 3 The amount of the most numerous plant taxa macrofossils found on the Kalnik-Igrišče site.

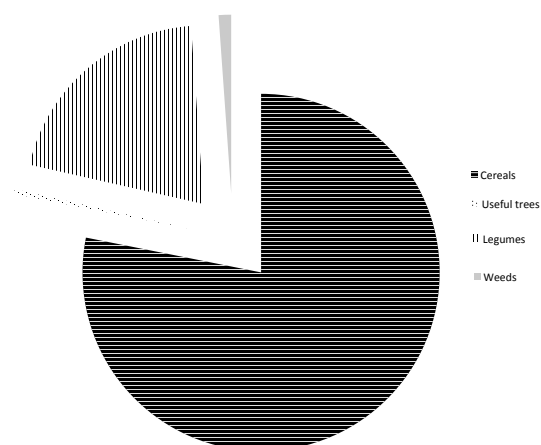


Fig. 4 The percentage of each category, according to the total number of macrofossils from category.



Fig. 5 The percentage of each category, according to the total number of found (sub)species/genera from category.

Discussion

Plant macrofossils from the Kalnik-Igrišće site

Since all the plant macrofossils were collected from the house floor, the result was expected: that 98% of the findings were of cereals and legumes. The rest of findings (2%) consisted of useful tree species, growing in the nearby woods, and weeds, growing as crop admixture.

Legumes are less frequent than cereals, but that does not necessarily mean they had less importance for the human population. Legumes and cereals have always been grown together and were both used in the diet. Legumes were an important source of protein, and cereals are primarily a rich source of carbohydrates. We noticed that at Kalnik-Igrišće there are fewer legumes than cereals, for which there can be many reasons. One of them could be the difference in food preparation; the legumes were most probably soaked before cooking and the cereals roasted, which could make cereals harder and more resistant to disintegration. The remains of lentils are in comparison to cereal remains very fragile [21], so it is possible that a large part of the lentil remains was destroyed before the archaeobotanical investigation(s). It is also possible that at the moment when the house in Kalnik-Igrišće was burnt, there happened to be more cereals in it, because the legumes were already consumed or maybe even generally less frequently used as food.

It is interesting to note that no oil plants remain (e.g., flax, gold of pleasure, common poppy, etc.) were found on the Kalnik-Igrišće site. Otherwise these are the species that regularly occur in Europe in the (late) Bronze Age [22].

Weed species are represented by a small number of species and in small amounts. Barnyard grass (*Echinochloa crus-galli*) forms the main part of these findings. This plant is still cultivated in Asia, so it is possible that it may even have been cultivated at Kalnik-Igrišće (or tolerated as crop admixture). Plants of this whole group most likely grew as weeds among cultivated plants and were accidentally brought to the house together with cereals.

The remains of apples (*Malus sylvestris*), cornelian cherries (*Cornus mas*) fruit and acorns of oak (*Quercus* sp.) indicate the fruit collecting activity of the human population.

It is assumed that those remains originate from the vicinity of the site, where they grew as native species. As well as for human nutrition, the species listed could also have been used as a supplement food for animals.

Unfortunately, this research cannot confirm that the local population grew the found plant taxa, because the collected remains from the settlement can primarily prove that the inhabitants consumed and owned that food. For a reliable reconstruction of the paleoenvironment it would be advisable to do pollen analysis (or at least wood charcoal analysis). The pollen analysis could show the human impact on the area around the site. Any cereal pollen found would indicate that the cereals were not only consumed, but also cultivated in the area. Pollen analysis could also show if the woods were replaced with grasslands, which could indicate possible livestock farming. However, close to the village Kalnik-Igrišće there are no appropriate places for collecting pollen samples (fens, lake mud, etc.).

A comparison of findings from the Kalnik-Igrišće site with findings from other sites in Croatia and neighboring countries

Appendix S1 shows the data on the relative representation of the species found at Kalnik-Igrišće and at other Bronze Age sites in Croatia and neighboring countries (Slovenia, Bosnia and Herzegovina, Austria, Hungary, Italy and Serbia).

Until this research, only two Bronze Age sites (Monkodonja and Nova Bukovica) were archaeobotanically investigated in Croatia, therefore it was not a surprise that all the species from Kalnik-Igrišće, except *Avena* sp., *Quercus* sp. and *Vicia faba*, were recorded for the first time in Croatia in the Bronze Age.

The comparison of findings from Kalnik-Igrišće with findings from neighboring countries indicates that in continental Croatia plant species used for food (and probably also cultivated there) were also present in the neighboring countries. From the Tab. 1 is evident that millet and barley, the most numerous cereals from the studied site, were also recorded in most of the sites compared and in large quantities in Serbia, Italy, Austria and Hungary. The mentioned cereals can primarily be used for making porridge and/or bread.

Regarding wheat, the situation in Kalnik-Igrišće is similar to that found in surrounding countries. The species that appear are the same, but the abundance and distribution vary from country to country and from locality to locality. It is interesting to note that in Austria *Triticum aestivum* ssp. *spelta* and *T. aestivum* ssp. *aestivum* were never recorded with a higher relative quantity than “a lot of” (“xx”), while on Kalnik-Igrišće site (as well as in Serbia and Italy) were represented with the mark “xxx” (“very much”). In Hungary spelt (*T. aestivum* ssp. *spelta*) was recorded as “very much”, representing 1000–10 000 findings, while *T. aestivum* ssp. *aestivum* has only between 10 and 100 findings.

As well as at Kalnik-Igrišće, *Setaria italica*, with 100–1000 findings, also occurs in Austria. In Serbia there is one site with 10–100 findings, while in other countries it is either missing or recorded with the mark “r” (less than 10 findings).

Since it is not possible to distinguish the grains of the cultivated form of oat (*Avena sativa*) from the wild weed forms such as *A. sterilis* and *A. fatua*, oats from archaeological layers were usually determined as *Avena* sp. Only if good preserved parts of florets (esp. lemma and parts of rachilla) are present, it may be possible to distinguish *Avena* species. It is therefore difficult to determine when its cultivation really began. The oat (at Kalnik-Igrišće 68 remains were recorded) is also found in several sites in Austria and Italy, but in Hungary there are no confirmed findings for the Bronze Age. Very probably, the oat started its evolution under domestication not as a crop but by the evolution of the weedy types that infested cultivated wheat and barley. Definite indications of domestication appear first in Europe (the Czech Republic and Slovakia) in the 2nd and 1st millennia BC [23].

Secale cereale (rye) at the Kalnik-Igrišće site was rare. In the whole territory of Hungary, between 10 and 100 findings were reportedly found. The records of rye from the late Neolithic and the Bronze Age are, compared to barley and wheat, very occasional and the assumption is that at first rye was just tolerated as a weed in crops and its separate cultivation did not begin before the Iron Age [23].

The faba bean (*Vicia faba*) is the legume that was found in all the surrounding countries and it was labeled with the mark xxx (1000–10 000) at Kalnik-Igrišće, as it is in a similar Italian site; Ganglegg/Schluderns [24]. It is interesting to note that in Hungary *Vicia faba* was recorded only rarely (less than 10 findings). Lentils (*Lens culinaris*) were also recorded in all the researched countries; Serbia has the site (Feudvar) with the most listed lentil macrofossils. Peas (*Pisum sativum*) is a typical cultivated plant of the Bronze Age in our region, but at the Kalnik-Igrišće site we recorded only 11 questionable findings, so we cannot claim with certainty that it was bred (or consumed).

The remains of the apple fruit (*Malus sylvestris*), cornelian cherry (*Cornus mas*) and acorns of oak (*Quercus* sp.) at Kalnik-Igrišće suggest the collecting activity of the population. These three species have been a part of traditional nutrition in rural Croatia [25,26].

It is assumed that these remains originate from the vicinity of the site, where they grew as native species. The species listed were used not only in human nutrition but also as a supplement food for animals. These species have

been reported in Italy, Hungary and Serbia (Appendix S1). It is interesting to note that, although many localities from Austria were taken for comparison, there were no findings of remains of these useful trees. On the other hand, in Italy the frequency of the cornelian cherry is very high (12 sites).

Weeds at Kalnik-Igrišće site were rare due to the fact that they were found in the house, where the food was obviously already prepared for consumption. Regardless of that, it may be noted that the weed species found at Kalnik-Igrišće were frequently mentioned also in research from Serbia, Italy, Hungary and Austria. In particular there are numerous records of *Bromus arvensis* and *Galium spurium* in Feudvar (Serbia), and findings of *Bromus secalinus* in Kulm (Austria). Some weed species, like *Bromus secalinus*, were found at some sites in carbonized stew form, which leads us to conclusion that it was tolerated in crops and consumed by the human population of that time [27]. In some countries, like for example Poland, *B. secalinus* was consumed as an admixture with cultivated cereal until the early 20th century [28].

Appendix S1 lists all Bronze Age sites with literature available to us. However only a few sites entirely, or in a large part, fit the context from which the samples were taken at the Kalnik-Igrišće site (some samples were collected from the cremation altar, out of the pit, mine etc.). Therefore we would like to single out the Austrian site Kulm bei der Trofaiach [27], which according to its position (hill settlement at an altitude of 886 m a.s.l.) and the location from where the samples were taken (a wooden house destroyed by fire), is the site most similar to Kalnik-Igrišće. A detailed comparison between those two sites was made.

At both sites four subspecies of wheat were recorded; however, the ratio of individual species was significantly different (Fig. 6). A comparison with other Austrian sites gives us grounds to conclude that einkorn wheat in the Bronze Age was not very widespread in these areas and that it was only a small part of the cereal diet of the local population.

For both sites, *Panicum miliaceum* and *Hordeum vulgare* are one of the four most numerous species. At the Kalnik-Igrišće site they are the most numerous macrofossils, while at the Kulm site, *T. turgidum* ssp. *dicoccon* and *Bromus secalinus* are more frequent. Due to the very large number of weed species *Bromus secalinus*, Stika [27] suggests that this species in those days was tolerated in crops and even deliberately sown together with wheat for later consumption.

At both sites three species of edible legumes were recorded: *Vicia faba*, *Lens culinaris* and *Pisum sativum*. *Vicia faba* was in both cases the most numerous and confirmed its status as the main legume of that period in these areas. The percentage of lentil was higher in Kalnik-Igrišće (7.1%) than in Kulm (0.09%), while the number of pea findings was in both cases almost negligible (11 cf. / 1 finding).

As far as weed species are concerned, *Galium aparine* and *Echinochloa crus-galli* have been recorded at both sites. Other weed species do not match, but they are not numerous and do not affect much the global composition of species found at the sites.

Remains of useful tree species were not found at Kulm, while at Kalnik-Igrišće the number of apple findings (*Malus sylvestris*) was significant (242 residues).

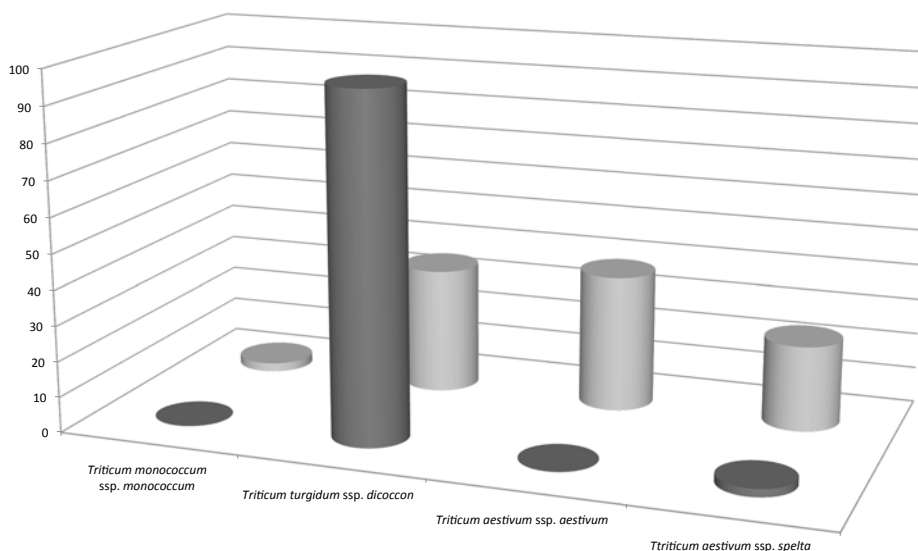


Fig. 6 Percentage of each wheat subspecies on the site Kalnik-Igrišče (light bars) and Kulm bei der Trofaiach (dark bars).

Spruce (*Picea abies*) occurred relatively frequently (71 leaf fragment remains) at the Kulm site. This woody species is likely to be present near Kulm, while on Mount Kalnik it did not appear (in large numbers).

Other plant taxa found at both sites are rare and just some of them (like *Cornus mas*, *Avena* sp. and *Secale cereale*) can have indicator values for the eating habits of the local population. A comparison of the measured dimensions of carbonized seeds/fruits for the species *Triticum aestivum* ssp. *aestivum*, *T. turgidum* ssp. *dicoccon*, *T. monococcum* ssp. *monococcum* (syn. *Triticum monococcum*, einkorn wheat), *T. aestivum* ssp. *spelta*, *Panicum miliaceum*, *Setaria italica*, *Vicia faba* and *Lens culinaris* from the Kalnik-Igrišče site with the dimensions of carbonized seeds/fruits of the same species from the Late Bronze Age site Stillfried an der March [20] is shown in Tab. 2. From this table it is evident that the average sizes of all seeds/fruits of all species from Kalnik-Igrišče are slightly higher than the average sizes of the same species from the site Stillfried an der March. The only exception is the *V. faba* seed, in which the difference in size is greater than 2 mm. This small difference in dimensions may indicate long or short-term favorable conditions on the Kalnik-Igrišče site for cultivating the listed cereals and pulses, or perhaps that the inhabitants of Kalnik-Igrišče were successful farmers. But it is also possible that some size differences appeared due to different methods of measurement.

Conclusion

An analysis of 69 116 plant macrofossils from the Late Bronze Age site Kalnik-Igrišče showed that 98% of the findings belong to cultivated species (cereals and legumes), and the remaining 2% of the remains are useful tree species, the fruits of which were gathered for food by residents, and weeds, which were accidentally brought to the investigated house.

The average dimensions of plant remains from Kalnik-Igrišče, compared with the dimensions of macrofossils from a similar Bronze Age site Stillfried an der March [20], are all slightly larger (up to max. 2 mm in length – *Vicia faba* seed).

The most important plant food at Kalnik-Igrišče were cereals, with *Panicum miliaceum* and *Hordeum vulgare* appearing in the largest numbers. Four subspecies of wheat were found (*Triticum turgidum* ssp. *dicoccon*, *T. monococcum* ssp. *monococcum*, *T. aestivum* ssp. *spelta* and *T. aestivum* ssp. *aestivum*), while the species *T. monococcum* ssp. *monococcum* had the lowest and *T. aestivum* ssp. *aestivum* the highest importance. Among the legumes, the species *Vicia faba* and *Lens culinaris* were certainly consumed (cultivated) and possibly *Pisum sativum* as well. The fruits of useful trees found, *Malus sylvestris*, *Cornus mas* and *Quercus* sp. suggest that the local population was engaged in the collecting activity, which helped them supplement their diet and possibly that of their livestock.

In the studied area (Croatia, Bosnia and Herzegovina, Slovenia, Austria, Hungary, Italy and Serbia) in the Bronze Age, the most commonly used cereals were *Hordeum vulgare*, *Triticum turgidum* ssp. *dicoccon*, *T. aestivum* ssp. *aestivum*, *Panicum miliaceum* and to a lesser extent *Triticum monococcum* ssp. *monococcum*. The legumes (*Vicia faba*, *Lens culinaris* and *Pisum sativum*) appear at the sites in smaller numbers than cereals, but they always accompany them and have a significant impact on the population's diet. For species *Secale cereale* and *Avena* sp. there is no reliable proof that they were deliberately bred at that time and it is assumed that they grew as weeds among the cultivated cereals. There is no reliable evidence of the cultivation of the species *Setaria italica*, either. Similar weed species appear throughout the area, while it is assumed that the species *Bromus secalinus* was tolerated in crops and also consumed, due to the large number of findings at the Austrian site of Kulm.

Tab. 2 Comparison of the dimensions of carbonized seeds/fruits found on the Kalnik-Igrišće site, with carbonized seeds/fruits of the same species from the site Stillfried an der March.

	Kalnik-Igrišće			Stillfried an der March		
	L (mm)	W (mm)	H (mm)	L (mm)	W (mm)	H (mm)
<i>Triticum aestivum</i> ssp. <i>aestivum</i>	4.68 (3.93–5.43)	3.72 (3.01–4.46)	3.13 (2.52–3.98)	4.46 (4.1–5.0)	3.36 (3.0–3.8)	2.69 (2.4–3.0)
<i>T. turgidum</i> ssp. <i>dicoccon</i>	6.18 (5.15–7.41)	3.30 (2.74–4.23)	3.07 (2.42–3.73)	5.2 (4.5–6.0)	2.5 (2.0–2.8)	2.3 (2.1–2.6)
<i>T. monococcum</i> ssp. <i>monococcum</i>	5.99 (5.25–7.36)	2.84 (2.27–3.75)	3.06 (2.61–3.76)	5.2 (4.6–5.7)	2.1 (1.7–2.7)	2.5 (2.3–2.8)
<i>T. aestivum</i> ssp. <i>spelta</i>	6.10 (4.32–8.77)	3.34 (2.70–4.07)	2.60 (2.07–3.29)	5.24 (3.9–6.0)	-	2.23 (1.8–2.6)
<i>Panicum miliaceum</i>	2.19 (1.76–2.64)	2.12 (1.69–2.57)	1.82 (1.28–2.32)	1.86 (1.7–2.0)	1.53 (1.4–1.7)	-
<i>Setaria italica</i>	1.57 (1.36–1.80)	1.44 (1.21–1.69)	1.08 (0.84–1.35)	1.41 (1.21–1.6)	1.20 (1.1–1.3)	-
<i>Pisum sativum</i>	5.31 (4.94–5.97)	5.15 (4.81–5.50)	4.98 (4.58–5.21)		2r (mm)	
					3.44 (3.2–3.6)	
<i>Vicia faba</i>	7.47 (5.79–9.66)	5.89 (4.38–7.36)	5.96 (4.85–7.61)	5.5	4.7	
	2r (mm)		2r (mm)			
<i>Lens culinaris</i>		3.36 (2.39–4.13)			2.91 (2.6–4.0)	

2r – diameter.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: writing the manuscript, conducting the archaeobotanical research: SM; giving the scientific view into the archaeobotanical context of the samples: SM, RŠ; chief of the archaeological excavations at Kalnik: SK; organizing the collecting and analysing of the archaeological data, giving the scientific view into the archaeological context of the samples: SK, AK; research designing, mentorship of archaeobotanical research: RŠ.

Competing interests

No competing interests have been declared.

Supplementary material

The following supplementary material for this article is available online at <http://pbsociety.org.pl/journals/index.php/asbp/rt/suppFiles/asbp.2015.015/0>:

1. Appendix S1: the list and relative abundance of plant species found on the site Kalnik-Igrišće and comparison with findings from the surrounding bronze age sites from Croatia, Slovenia, Bosnia and Herzegovina, Serbia, Italy, Austria and Hungary.

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