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ORIGINAL ARTICLE

Plant economy at a late Neolithic lake dwelling site in Slovenia at the time of the Alpine Iceman

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Abstract We present the results of a plant macroremain study of the late Neolithic lakeshore settlement Stare gmajne (SG) at Ljubljansko barje, Slovenia, with cultural horizons that ended around 3330 and 3110 cal. B.C., as obtained by dendrochronological and radiocarbon dating of the most frequent construction timbers of *Quercus* sp. (oak) and *Fraxinus* sp. (ash). Fourteen systematically taken samples were investigated, using standard methods for studying waterlogged plant remains, which had been developed during lake dwelling research north of the Alps. Most of the remains were preserved in a waterlogged state, and we identified a total of 93 taxa. The most important cultivated plants were *Triticum dicoccum* (emmer), *Hordeum vulgare* (six-rowed naked barley), *T. monococcum* (einkorn), *Linum usitatissimum* (flax) and *Papaver somniferum* (opium poppy). The numerous possibly gathered plants also included *Trapa natans* (water chestnut) and *Vitis vinifera* ssp. *sylvestris* (wild grapevine). *Chenopodium album* (goosefoot) and *Brassica rapa* (turnip) with seeds/fruits rich in oil and starch were probably gathered as well. Comparisons of the Stare gmajne results with contemporary north Alpine sites (NA) showed, among other things, that *Triticum durum/turgidum* (tetraploid naked wheat), frequent at NA, was not found at SG. *Trapa natans* (water chestnut) was rare and *Vitis* (grapevine) was not found at NA. The observed differences in the wild plant spectra may have ecological causes, for example a warmer climate south of the Alps, but differences in cultivar spectra are more likely for cultural-historical reasons.

Keywords Plant macroremains · Late Neolithic · Ljubljansko barje · Slovenia · Waterlogged preservation

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Introduction

Pile dwellings existed in various parts of Europe during the Neolithic period (Menotti 2004), and their number is especially high in the circum-Alpine region (Fig. 1a). Because of their importance, many of them have been nominated for entry in the UNESCO list of world cultural heritage sites, including the Slovenian ones (Suter and Schlichtherle 2009). Archaeological excavations and interdisciplinary investigations, supported by systematic archaeobotanical studies have been conducted on lake dwelling sites in Switzerland, Germany and France since the 1980s (for example Jacomet 2006a, 2009). In contrast, similar studies using comparable methods have been rare in regions south of the Alps, including Slovenia. A compilation of the state of the art in northern Italy was recently published by Rottoli and Castiglioni (2009).

Approximately 40 Neolithic and Bronze Age pile dwelling sites (from ca. 4600–1700 cal. B.C.) have been

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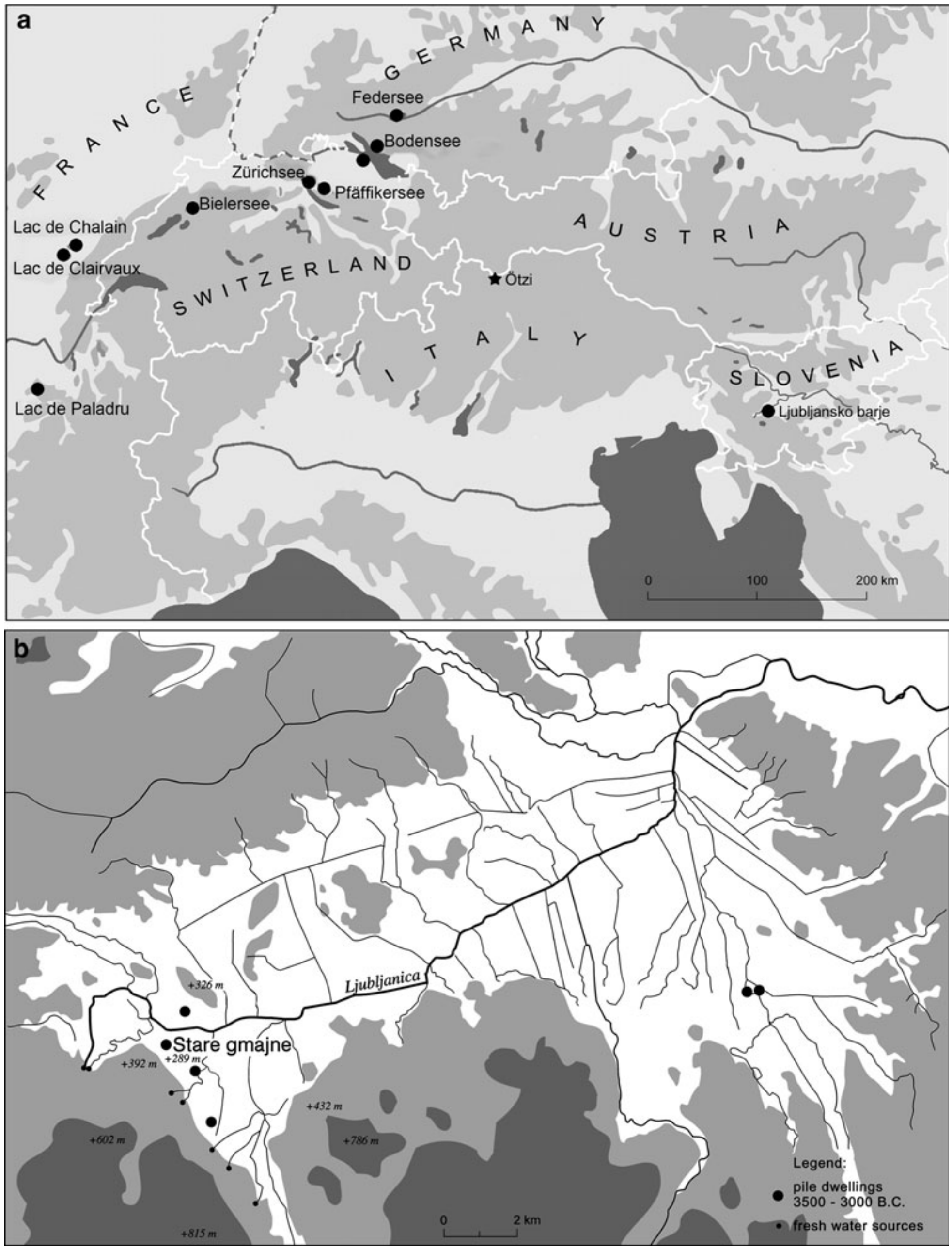


Fig. 1 Maps with positions of **a** Ljubljansko barje, Slovenia and other archaeobotanically investigated European pile dwelling sites (*dots*) around the Alps, dated 3500–3000 cal. B.C. The location at which the Alpine Iceman Ötzi was found (*star*) is also shown; **b** Ljubljansko barje shown as a white area, with the Stare gmajne site and locations of other known contemporary Neolithic pile dwellings dated 3500–3000 cal. B.C. The stratigraphical position of the elevated terrain in m a.s.l. is indicated in *grey*

recorded at Ljubljansko barje, Slovenia (Fig. 1). Some of these have been investigated in the last 130 years (Velušček 2004). Archaeological excavations were often accompanied by archaeobotanical studies (Jeraj et al. 2009), but the recovery techniques used were not in agreement with those used north of the Alps (Hosch and Zibulski 2003; Jacomet et al. 2004). Tolar et al. (2010) showed that too rough washing, inadequate sieve mesh sizes and drying of the fractions after sieving resulted in taxa represented by fragile parts not being recorded, and that taxa with tough lignified diaspores were overrepresented. The same study also suggested a procedure that would ensure representative results, which would be useful for comparisons with other studies. The lack of standardization of archaeobotanical methodologies has been among the main obstacles to reliable comparisons of plant economies of prehistoric settlements both north and south of the Alps.

Furthermore, the archaeological sites in Slovenia have not been exactly dated until recently, in contrast to most of the corresponding sites north of the Alps. Recent introduction of dendrochronology and radiocarbon wiggle-matching have now provided more exact dating than previously of eight pile dwelling settlements at Ljubljansko barje, with end dates from 3547 to 3071 cal. B.C. (Čufar et al. 2010). Culturally, they belong to the late Neolithic (Jacomet 2007), in Slovenian terminology corresponding to the Eneolithic or Copper Age, when copper metallurgy played a crucial role in society (Velušček 2004, 2009). Unfortunately, no archaeobotanical investigations have been carried out there or, if they have been, the recovery techniques were not adequate to obtain reliable data to compare them with sites north of the Alps.

One of the dated pile dwellings is Stare gmajne (Fig. 1b). It was settled in two periods. According to radiocarbon dating the activities at the earlier dwelling ended around 3300 B.C. (3332 cal. B.C.) and at the later one around 3100 B.C. (3109 cal. B.C., Čufar et al. 2009, 2010). Between the two phases, a major settlement gap was recorded at Ljubljansko barje.

The settlement was located at the edge of the floodplain of Ljubljansko barje, which was a lake at the time of occupation. Its immediate vicinity was rich in various habitats. The settlement was likely to have been located on the marshy, temporarily flooded terrain, but the dwellers also had access to the lake. Only about 700 m southwest of the site, the first slopes of the Dinaric Karst started. They are nowadays covered by extensive woods of *Abies alba* (silver fir) and *Fagus sylvatica* (beech), and they were probably also covered by widespread woodland in Neolithic times, as indicated by pollen analyses (Šercelj 1996).

The period from around 3500 to 3000 cal. B.C. was also characterized by intensive occupation in the entire circum-Alpine region (Stöckli 2009). One of the best parallels to the older phase of Stare gmajne is the settlement of Arbon Bleiche 3 at Lake Constance (Bodensee), which was recently investigated as part of a large interdisciplinary project (Jacomet et al. 2004). The settlement at Stare gmajne also corresponds to the time of the Alpine Iceman (Ötzi), who died between 3320 and 3050 cal. B.C. (Kutschera and Müller 2003). Archaeobotanical research conducted on the plant material recovered from the Iceman's body and from the settlements that existed during his lifetime have helped us greatly to learn more about the plant economy at the time of his life (Dickson et al. 2009; Oeggl 2009; Heiss and Oeggl 2009; Jacomet 2009).

The first objective of this study was to identify plant remains from two settlement phases of the Stare gmajne lake dwelling and to evaluate the role of various plant taxa in its economy. The main objective, however, was to compare the obtained results with those from contemporary sites in other parts of the Alpine area. In addition, we discuss some general questions of Neolithic circum-Alpine sites concerning the introduction of cultivars to various parts of Europe.

The investigation area

The excavations at Stare gmajne (ca. 100 × 300 m) were performed in 2002, 2004, 2006 and 2007 in 13 drainage ditches. During the excavations, a total of 932 pieces of wood (mainly piles) were collected. Dendrochronological and radiocarbon wiggle-matching enabled us to date the building activities on the site (Čufar et al. 2009; Čufar et al. 2010). Based on the locations of the piles and other archaeological artefacts, it could be reconstructed that two areas had been occupied, one in the western and one in the eastern part of the investigated area (Fig. 2a). The area in between (ditches 7–11) contained no wood or other artefacts.

The western part (ditches 12, 13, Fig. 2a) had been settled in two periods: there was an earlier settlement of short duration, ca. 20 years, which ended around 3330 cal. B.C. (end date of the youngest tree-ring 3332 ± 10 cal. B.C.), and a later settlement, which ended around 3110 (end date of the youngest tree-ring 3109 ± 14 cal. B.C.). In the later phase, the eastern part of the area (ditches 1–6) was also occupied, in addition to the western part; several building phases were recorded there, indicating that the site was occupied for ca. 50 years. Here, 3109 cal. B.C. is the end date of the latest dated tree ring, but the occupation probably continued for some years after that date.

Materials and methods

In 2007, a trench was dug to collect material for archaeobotanical investigations, in which we detected two cultural layers (Fig. 2a, b). Based on dendrochronological dating (Čufar et al. 2009), we assumed that the lower one corresponded to the earlier and the upper one to the later settlement, in the western part of the area (see Fig. 2c).

For sampling, the trench was divided into 15 quadrants (Q). Three quadrants, Q1, Q9 and Q13, were randomly selected for horizontal sampling (Fig. 2b). Vertical sampling was made along five depth-cuts (depth-cuts 4, 5, 6, 7 and 8) (Fig. 2c). The depth-cuts 8 and 7 were attributed to the earlier settlement, which ended around 3330 cal. B.C. and the depth-cuts 5 and 4 correspond to the later settlement with an end date around 3110 cal. B.C. The depth-cut 6 was located in between and could not be exactly ascribed to either of the settlement phases.

For archaeobotanical investigations, sediment samples of up to 1 l were taken systematically from three quadrants and from the early, intermediate and late cultural layers. Altogether, 14 samples with a total volume of ca. 9 l were analysed (for details, see Table 1 in supplementary material).

Examination of the material

The samples were washed over and sieved as proposed for waterlogged sediments by Hosch and Zibulski (2003). In

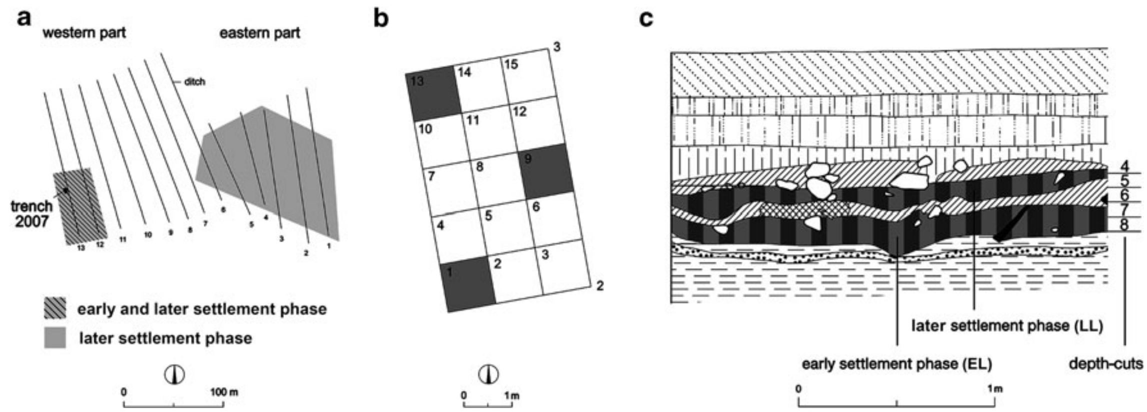


Fig. 2 Stare gmajne. **a** the site (current situation) crossed by 13 drainage ditches (*lines*). The *hatched area* to the west indicates the location of the early settlement, which ended around 3330 B.C. (duration ca. 20 years). The location was resettled after ca. 170 years, when the area to the east, shown in *grey* was also settled; the duration of the later settlement was ca. 50 years and ended after 3110 cal. B.C. The trench excavated in 2007 for archaeobotanical investigations is located in the western part. **b** The trench with quadrants (*horizontal samples*); sampling was carried out in quadrants 1, 9 and 13 (*grey*). **c** The vertical stratigraphy of the trench with cultural layers of two distinct settlement phases: early phase (depth-cuts 7 and 8) and later phase (depth-cuts 4 and 5). Depth-cut 6 indicates an intermediate layer

addition, the clayey and compacted sediment was first frozen and then thawed to make washing easier (Vandorpe and Jacomet 2007). The sediment was washed using sieves with 2 and 0.355 mm mesh sizes at the Institute for Prehistory and Archaeological Science (IPAS), Basel, Switzerland. The collected fractions from the sieves were stored in water and at low temperatures in a refrigerator to prevent desiccation or decay and, consequently, their deformation or destruction.

Prior to analysis, systematic, random sub-sampling of the large (2 mm) and especially the small (0.355 mm) fraction was necessary, because the samples were very rich in macro-remains. According to Van der Veen and Fieller (1982), our aim was to count 384 identifiable plant remains. Since in waterlogged sites the spectra of the taxa vary greatly, this number was aimed for in each of the fractions (Hosch and Jacomet 2001). This allowed us to reconstruct the right proportions of the most important taxa with a probability of 95 ± 5%. For counting, we had to define the types of remains that counted as one piece (see Table 1).

We first examined 90 ml of the large and 25 ml of the small fractions. The subsamples, especially the large fraction, were then enlarged to obtain the reliable minimal number of items. When there were more than 384 plant remains in the examined volume, examination of the subsample was concluded. In some of the large fraction samples, all the material had to be analysed (see Table 1 in supplementary material). The volumes of the examined subsamples are shown in Tables 1 and 2 in supplementary material.

Very small botanical fragments, where less than one quarter of the seed, fruit or grain was found and the plant remains were smaller than 0.3 mm, were not counted. We assessed the abundance of the plant remains in the following categories: not found, single find, small amount, abundant, very abundant. We also noted the presence of animal remains (see Table 1 in supplementary material).

Table 1 Types of plant remains (SFC) that were counted as a single piece

Type of plant remain ("counted unit")	Taxa
Whole seed/fruit and grain	All taxa
Grain fragments with embryo end	Cerealia
Glume base	Hulled *Triticum* sp.
Rachis fragment	*Hordeum vulgare*
Fragments of seed/fruit with the tip	e.g. *Cladium mariscus*
Fragments >1/4 of a seed	Maloideae
Fragments >1/4 of the pericarp	*Quercus* sp., *Fagus sylvatica*, Maloideae
Fragments >3 mm of a seed/fruit	*Viscum album*
The base of the seed/fruit	*Quercus* sp., *Corylus avellana*, *Malus* sp., *Trapa natans*
Capsule fragments >3 mm or capsule fragments with a tip	*Linum usitatissimum*

Table 2 Volumes of the sediment, examined fractions and total number of identified plant remains, seeds, fruits, chaff, capsule and pericarp fragments in the large and small fractions, and their concentrations per litre of sediment for different depth-cuts and layers

Depth-cuts/layers	Sediment vol. (ml)	Volume of organic fractions (ml)	*n* plant remains		Sum	Average (conc./l)
			2 mm	0.355 mm		
4	1,200	95	57	434	491	1,240
5	2,000	325	295	797	1,092	1,903
Later layer (total)	3,200	420	352	1,231	1,583	1,572
6 = intermediate layer	2,200	250	421	1,666	2,087	4,729
7	1,900	410	941	1,984	2,925	9,094
8	1,350	420	607	1,123	1,730	6,027
Early layer (total)	3,250	830	1,548	3,107	4,655	7,560
Total	8,650	1,500	2,299	5,392	7,691	

Depth-cuts 4 and 5 = later layer, end date ca. 3110 cal. B.C.; depth-cut 6 = intermediate; depth-cuts 7 and 8 = earlier layer, end date ca. 3330 cal. B.C., for all three sampled quadrants

A Leica MZ75 stereomicroscope with 6.3–50 magnifications was used for examining and sorting. For identification we used the reference collection of IPAS, Basel, as well as special literature (Berggren 1969, 1981; Anderberg 1994; Cappers et al. 2006; Jacomet 2006b). In order to facilitate interpretation, the identified taxa were divided into groups, first of all based on their actual use and secondly based on their ecology. The nomenclature of plant names follows Zohary and Hopf (2000) for crop plants, Binz and Heitz (1990) for wild plants, supplemented by Martinčič et al. (1999).

Results

Amounts of plant remains and their concentrations

All recognizable plant remains from all quadrants and layers are listed in Table 1 in supplementary material. The entire archaeobotanical record includes 93 plant taxa, mostly identified to species level.

Representative results in accordance with Van der Veen and Fieller (1982) were obtained for the small fractions in all quadrants and in most layers. The large fractions were representative only in the depth cut 8 of quadrant 1 and in the depth cuts 6 and 7 of quadrant 9. Representative numbers could have been achieved if the sample size had been increased to 3 l, as recommended for well preserved waterlogged layers (Hosch and Zibulski 2003; Jacomet and Brombacher 2005).

The concentrations of plant remains are shown in Table 2. They varied with layers and were highest in the lowest (earliest) layer, and averaged 7,560 remains/l. They decreased to the uppermost and latest layer, where they amounted to an average of 1,572 l^{-1} of sediment. The concentrations also varied horizontally. In the later and intermediate layers they proved to be richest in the easternmost quadrant 9. Within the early layer, the concentrations were rather high in all quadrants, although slightly different.

Cultivars

The cereals, *Triticum dicoccum* (emmer) and *Hordeum vulgare* (6-rowed naked barley) showed the highest concentrations, whereas *T. monococcum* (einkorn) was less frequent (Table 3). Cereals were mostly represented by chaff remains such as rachis fragments, glume bases and spikelet forks, but grains were rare (see Table 2 in supplementary material). *Papaver somniferum* (poppy) and *Linum usitatissimum* (flax) had the highest concentrations among the oil and fibre plants. However, high concentrations of *Papaver* could be ascribed to its numerous small seeds and these do not necessarily mean that it was the most important in the diet (see Table 3). The least frequent were remains of pulses, and we found only two whole and one fragment of *Pisum sativum* (pea) in the examined samples (Table 1 in supplementary material).

A detailed list, with the numbers of plant remains, separately for grains, chaff, and other remains, with their state of preservation (carbonized, semi-carbonized, non-carbonized = waterlogged) is given in Table 2 in supplementary material. The cereal grains and peas were mostly preserved in a carbonized state and all other remains mostly or only in waterlogged state.

Gathered plants

Wild plants with edible seeds and fruits

We identified 16 presumably gathered plant taxa (Table 3). The oil/starch rich seeds of *Chenopodium album* (goosefoot) and *Brassica rapa* (turnip) were the most abundant in terms of concentrations. Shell fragments of fruits of

Table 3 Average plant concentrations of the most important edible taxa at Stare gmajne for the early, intermediate and later phase/layer

Plant group		Taxon	Concentration (l^{-1}) Layer Early	Trans.	Late
Cultivars		*Triticum dicoccum* (seed, chaff)	330	106	14
Cultivars		*Triticum di/monococcum* (seed, chaff)	136	56	19
Cultivars		*Triticum monococcum* (seed, chaff)	55	3	14
Cultivars		*Hordeum vulgare* - naked (seed, chaff)	131	92	82
Cultivars		*Papaver somniferum* (seed)	1,304	596	5
Cultivars		*Linum usitatissimum* (seed, capsule)	155	62	7
Cultivars		*Pisum sativum* (seed)	<1	0	0
Gathered plants	Nuts and other oil/starch rich taxa	*Chenopodium album* (seed)	1,869	835	213
Gathered plants	Nuts and other oil/starch rich taxa	*Brassica rapa* (seed)	392	68	17
Gathered plants	Nuts and other oil/starch rich taxa	*Quercus* sp. (pericarp)	189	61	7
Gathered plants	Nuts and other oil/starch rich taxa	*Quercus* sp. (fruit base)	13	6	1
Gathered plants	Nuts and other oil/starch rich taxa	*Corylus avellana* (fruit base)	11	8	0
Gathered plants	Nuts and other oil/starch rich taxa	*Trapa natans* (fruit base)	7	3	0
Gathered plants	Wild fruits	Maloideae (pericarp)	187	129	4
Gathered plants	Wild fruits	Maloideae (seed)	33	16	0
Gathered plants	Wild fruits	*Fragaria vesca* (seed)	158	109	8
Gathered plants	Wild fruits	*Rubus fruticosus* agg. (seed)	141	35	5
Gathered plants	Wild fruits	*Physalis alkekengi* (seed)	22	19	2
Gathered plants	Wild fruits	*Cornus mas* (seed)	3	0	0
Gathered plants	Wild fruits	*Crataegus monogyna* (seed)	2	4	0
Gathered plants	Wild fruits	*Prunus spinosa* (seed)	2	1	0
Gathered plants	Wild fruits	*Vitis vinifera* ssp. *sylvestris* (seed)	2	0	0
Gathered plants	Wild fruits	*Rosa* sp. (seed)	1	0	0

The term "seed" includes all types of diaspores when not specified. The preservation state of most of the remains is waterlogged (details in Table 1 in supplementary material)

Quercus sp. (acorns), *Corylus avellana* (hazelnut) and *Trapa natans* (water chestnut), which are also calorific, were found in considerable numbers as well (Table 3). They were mainly represented in the lower, earlier layers.

Among juicy fruits and berries, Maloideae (wild apples/pears), *Fragaria vesca* (strawberries), *Rubus fruticosus* (blackberries) and *Physalis alkekengi* (bladder cherries) were most abundant. In total, ten taxa were found which can be considered to have been part of the diet (Tables 3 and 1 in supplementary material). In addition, we can assume that other wild plants may also have been used for purposes such as for spices or medicinal plants, although such uses cannot be directly proven (Table 4; Maier 2001). Examples of such possibly useful plants could be *Viscum album* (mistletoe), *Agrimonia eupatoria* (common agrimony), *Anagallis* sp. (scarlet pimpernel), *Hypericum perforatum* (St. Johns wort), *Mentha* sp. (mint), *Solanum nigrum* (black nightshade) and *Thymus* sp. (thyme) (Table 1 in supplementary material). Of the latter group, not only the diaspores but also other plant parts were used.

Wild plants with other useful parts

In addition, we found parts of the fruiting bodies of various fungi and many fragments of mosses (Table 1 in supplementary material). The remains of a sort of fabric were found, too, and one larger piece of well-processed yarn.

Wild plants for construction purposes and fuel: wood

Wood deserves special attention. It was extensively used and was certainly a very important raw material. It was used to build houses, as well as various constructions and objects such as palisades, boats, wheels and carts, various tools and their handles, weapons such as bows, spears, arrows, kitchen utensils and for many other purposes (see Stotzer et al. 1976; Tolar and Zupančič 2009; Velušček et al. 2009a, b). Large amounts of wood were presumably also used for fuel, as in other comparable sites where charcoal remains were investigated (Dufraisse 2006, 2008). At Stare gmajne the wood consisted mainly of the remains of the vertical piles on which the houses were built. The upper parts of the constructions were not preserved and other wooden artefacts were very rare.

Quercus sp. (oak) and *Fraxinus* sp. (ash) were most frequently used for piles. Less often used were *Populus* sp. (poplar), *Salix* sp. (willow), *Alnus glutinosa* (alder), *Fagus sylvatica* (beech), *Acer* sp. (maple), *Corylus avellana* (hazelnut), *Carpinus betulus* (hornbeam) and *Abies alba* (silver fir). The selection and proportion of the woody taxa found in trench 2007 (Fig. 3a) slightly differs from those found in the larger excavated area (Fig. 3b). This is possibly due to the low and less representative number of wood samples in the trench (37 samples) compared to the total collection of samples (932 samples).

Wild plants according to ecological groups

The 71 taxa of wild plants were attributed to 6 larger ecological groups (in line with Behre and Jacomet 1991, see also Brombacher and Jacomet 1997). We considered only those taxa that could be assigned to one of the groups based on firm assumptions.

Water plants, plants of lake shore (reeds) and wetlands

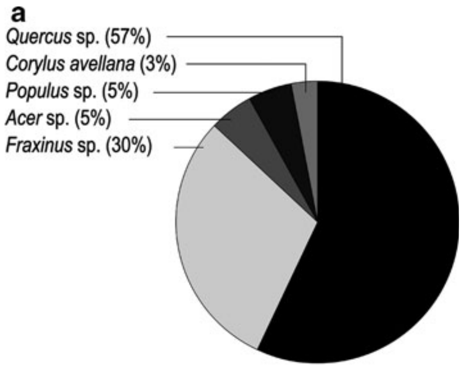
Plants growing in the immediate proximity of the site or even at the site itself are represented by 28 taxa, which is 39% of all wild plant taxa found at the site (Fig. 4). Water plants are represented by eight taxa (11%). The most frequent taxa, Characeae and *Ranunculus aquatilis*, show their highest values in the lower part of the stratigraphy, whereas *Sparganium* sp. becomes much more common in the uppermost part of the cultural layer (Table 4).

Plants of the lake shore, and especially of reed beds, are represented by 20 taxa (28%) and are the most diverse group within the spectrum of Stare gmajne. By far the highest numbers are diaspores of *Oenanthe aquatica*, a

Table 4 Average concentrations of water and lakeshore/wetland plants, of the most important taxa of woodland, clearings and woodland edges and of the most important taxa of segetal and ruderal plants found at Stare gmajne for three phases/layers: early (ca. 3330 cal. B.C.), transitional, late (ca. 3110 cal. B.C.)

Plant group	Layer	Concentration (l^{-1})			Gathered
		Early	Trans.	Late	
Water plants	Characeae	137	67	1	
	Ranunculus aquatilis	53	60	157	
	Potamogeton sp.	16	0	3	
	Sparganium sp.	8	21	38	
	Trapa natans	7	3	0	x
	Nymphaea alba	2	0	0	
	Nuphar luteum	2	0	0	
	+ *Alisma plantago-aquatica* (total: 8 taxa)				
Lakeshore (reeds etc.), other wet places (marshes, pioneers on shores etc.) plants	*Oenanthe aquatica*	480	2,145	381	
	Cladium mariscus	295	9	2	
	Mentha arvensis/aquatica	271	151	614	
	Schoenoplectus lacustris	131	46	20	
	Cyperus fuscus	88	0	1	
	Lythrum sp.	83	8	5	
	Eupatorium cannabinum	45	0	2	
	Lycopus europaeus	9	0	7	
	Typha latifolia	7	0	0	
	Alnus glutinosa	4	0	0	
	Stellaria aquatica	4	0	0	
	Nasturtium officinale	0	5	0	
	Apium cf. *repens*	0	4	2	
	+ *Hippuris vulgaris*, *Ranunculus lingua*, *Rumex hydrolapathum*, *Rumex aquaticus*, *Sagittaria sagittifolia*, *Polygonum hydropiper*, *Molinia* sp. (total: 20 taxa)				
Wood	Maloideae	263	157	4	x
	Quercus sp.	202	67	8	x
	Physalis alkekengi	22	19	2	x
	Viscum sp.	12	2	0	x
	Fagus sylvatica	2	1	0	
	Vitis vinifera ssp. *sylvestris*	2	0	0	x
	+ *Abies alba*, *Moehringia trinervia*, *Pteridium aquilinum*, *Tilia platyphyllos* (total: 10 taxa)				
Clearings and wood edges	*Fragaria vesca*	158	109	8	x
	Rubus fruticosus agg.	141	35	5	x
	Epilobium hirsutum	13	0	7	
	Corylus avellana	11	8	0	x
	Betula pendula/pubescens	8	0	0	
	Cornus mas	3	0	0	x
	Crataegus monogyna	2	4	0	x
	Prunus spinosa	2	1	0	x
	Rubus cf. *idaeus*	2	0	0	x
	Fallopia dumetorum	1	6	0	
	+ *Cornus sanguinea*, *Rosa* sp. (total: 12 taxa)				
Field weeds and ruderals	*Chenopodium album*	1,869	835	213	x
	Brassica rapa	392	68	17	x
	Atriplex sp.	261	160	10	
	Urtica cf. *dioica*	73	56	2	
	Fallopia convolvulus	17	11	1	
	Anagallis foemina/arvensis	11	5	0	
	Arenaria serpyllifolia	8	14	0	
	Silene alba	5	5	1	
	Capsella sp. (cf. genus)	4	0	0	
	Camelina sp.	3	5	0	
	Daucus carota	0	7	0	
	Solanum nigrum	0	5	0	
	+ *Ranunculus repens*, *Sambucus ebulus*, *Galeopsis tetrahit*, *Lamium maculatum* (total: 16 taxa)				

The plants that have been assigned to the group of gathered ones are marked with "X" (cf. Table 3). Rare taxa are mentioned separately. For details, see Table 1 in supplementary material. The proportions of the plant groups are shown in Fig. 4



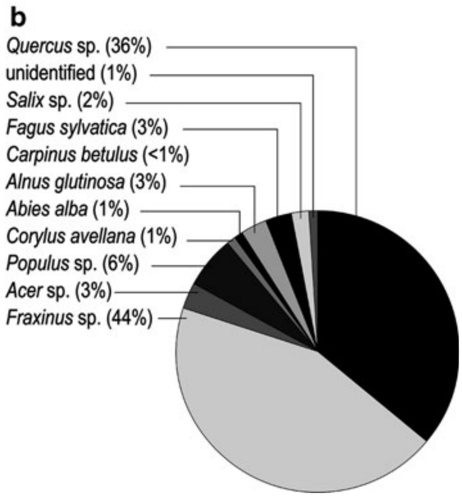


Fig. 3 Wood taxa used for constructions (piles) of Stare gmajne collected in: **a** trench of 2007 (37 samples). **b** in the entire site (ditches and trench, 932 samples)

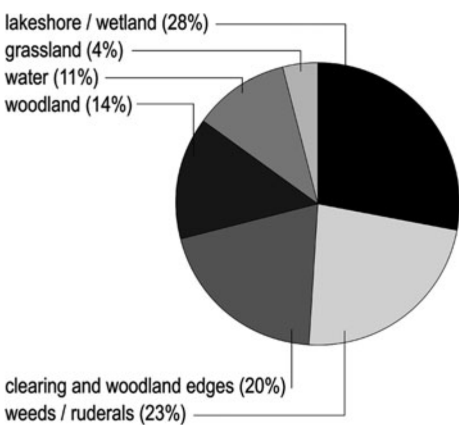


Fig. 4 Proportions of ecological groups, based on 71 taxa. Only wild plants are included

plant which mostly grows in eutrophic, quiet, flat water and tolerates occasional drying (Oberdorfer 2001). A similar environment is also typical of *Mentha arvensis/aquatica* (probably *M. aquatica*), the fruits of which occur in very large amounts. *Cyperus fuscus* is also worth mentioning as a pioneer plant on occasionally drying places, and it is present in by far the highest numbers in the lowest layer. Most of the *Carex* fruits, found regularly but for the most part not unambiguously identifiable to species level, probably belong to the group of lake shore plants (see Table 1 in supplementary material).

Plants of woodlands, clearings and wood edges

A considerable proportion (34%), 24 taxa, come from woodland habitats (Fig. 4). Most of the taxa assigned to clearings and woodland edges could also grow in woodland. Most taxa from these places represent plants that were probably gathered and have already been mentioned in the section "gathered plants". Most of them can be also found in the present-day woodland southwest of Ljubljansko barje, which mostly consists of extensive Dinaric silver fir-beech woods (Šercelj 1996).

Plants of anthropogenic open habitats: field weeds, ruderal plants and plants of grassland

The field weeds and ruderals are well represented, with 16 taxa (23%, Fig. 4). They form the second largest group of wild plants found at Stare gmajne. We put these taxa into a single group because most of them can grow on all of the mentioned habitats. The majority of the taxa are nowadays typical of summer crops or gardens, such as *Chenopodium album*, or ruderal places. Typical winter annuals were not found. The highest concentrations within this group are shown by *Chenopodium album* and *Brassica rapa*, which were probably collected. The concentrations varied with the investigated layers (see Table 4).

The Apiaceae (*Conium/Seseli*) and *Thymus* sp. records could possibly be attributed to grassland. Furthermore, *Agrimonia eupatoria* and *Hypericum perforatum* might also have grown there, although they mainly belong to woodland edge communities. Remains of grassland plants are therefore rare at Stare gmajne (Fig. 4; Table 1 in supplementary material).

Other finds

We also found many coprolites, both whole and fragments, from goat/sheep, cattle and small mammals (Table 1 in supplementary material). They have not yet been analysed in detail. In addition to botanical material, we also found many fish scales, bones and teeth, which mostly belonged to *Esox* (pike) of the Cyprinidae family (Table 1 in supplementary material) (identified by Heide Hüster-Plogmann from IPAS, Basel University). These finds should also be examined in detail in the future.

Discussion

Although the size of the excavated trench and the amounts of the investigated material were rather small, it was possible to obtain some information on the presence versus absence of the most important cultivated and wild taxa, although perhaps not entirely representative. It is therefore possible to compare the results from a lake dwelling site in Slovenia with contemporary waterlogged sites north of the Alps. In the following sections, we mainly discuss cultivated and possibly gathered plants because of their great importance for human food and because they are considered to be properly represented.

Differences in concentrations of plant remains

The concentrations of plant remains in the earlier cultural layer of Stare gmajne indicated that the archaeological layers are very well preserved. The values correspond to those of contemporary sites north of the Alps; at Arbon Bleiche 3, for instance, 7,000 to 9,000 macro-remains per litre of sediment were found (Hosch and Jacomet 2004). In contrast, the later layer in Stare gmajne was less rich, with an average of 1,572 counted macro-remains per litre of sediment material.

The differences in the concentrations could have various reasons. Richer plant spectra in the early and intermediate layers with 7,560 counted macro-remains, for example, might occur due to a different intensity of human activity at the location of the trench in different periods. Dendrochronological investigations indicated that most of the piles were from the earlier phase of the settlement, which ended around 3330 cal. B.C. (Čufar et al. 2009). However, some piles from the later settlement phase were also found, which ended around 3110 cal. B.C. This indicates that the area of the trench was inhabited in both periods, but it might have been in the centre in the early phase and at the edge or even in a separate part of the settlement during the later phase (see Fig. 2a).

Ecological conditions around the site

Littoral zone (marshland and water plants)

The settlement was located close to the lake (Fig. 1b). We assume that many aquatic and littoral plants found in the cultural layers represent the remains of the natural vegetation at and around the site (Tables 4 and 1 in supplementary material).

Plants that probably grew nearby, or even in the settlement are *Schoenoplectus lacustris* (common clubrush) and other wetland (marshy) taxa, such as *Oenanthe aquatica* (fine-leaved water-dropwort), *Cladium mariscus* (great fen-sedge) and *Mentha* sp., probably *M. aquatica* (water mint) (Tables 4 and 1 in supplementary material). Their remains had been deposited at least partially naturally, which supports the assumption that the settlement was located on marshy ground. Aquatic plants probably became entangled in the maze of piles during flooding (Turk and Horvat 2009), which also suggests that the settlement was very close to the lake.

The finds of *Cyperus fuscus* (brown galingale) in the earlier layer are interesting. This plant is very typical of periodically dry lake shores. It has also often been found at sites north of the Alps, just at the transition from natural sediment, mostly lake marl, to the cultural layer (Jacomet 1985). Geoarchaeological (micromorphological) studies of other lake shore settlements have also revealed that a lowering of lake levels was observed before settlement activities began, as at Arbon (Ismail-Meyer and Rentzel 2004). This might also have happened at Stare gmajne (Turk and Horvat 2009).

In the intermediate layer, a massive increase of *Oenanthe aquatica* is evident (Table 4). This could indicate that the conditions at the settlement had changed, maybe due to reduced human activities there; for sedimentological analysis of the settlement surroundings, see Turk and Horvat (2009).

The remains of fish such as *Esox* (pike) and water plants like *Trapa natans* indicate the considerable importance of the lake for the economy. In addition, fishing and hunting of birds that live in wet environments have been proven by analyses at other pile dwellings on Ljubljansko barje (Janžekovič and Malez 2004; Velušček et al. 2004) and evidence was also found at Stare gmajne, but has not been investigated in detail so far (Velušček and co-workers, unpublished).

Many other seeds/fruits of aquatic and marshland plants found in the samples could also have been deposited in the cultural layer due to human activity, for instance by the use of reeds for roofing houses. What proportion of these plants was brought to the layer by human action and which were deposited naturally is hard to say. The remains of two dugout boats that were found at the dwelling from the later settlement phase also show that the people used lake resources (Velušček et al. 2009a, b).

Environment and its use around the site, outside the lake

From the wood spectra, we can assume that there must have been floodplain sites near the settlement where tree taxa such as *Alnus*, *Salix*, *Quercus* (*robur*), *Fraxinus* and *Populus* grew. Outside of the floodplain, on the slopes of the Dinaric mountains, woody taxa such as *Quercus* (*petraea*), *Fagus*, *Acer*, *Carpinus*, *Abies* and *Corylus* could have grown (Figs. 1b, 3).

For the piles, the settlers most probably preferred *Quercus* which has durable heartwood. In addition they used large quantities of *Fraxinus* which was presumably very abundant near the settlement. The largest part of the wood for the piles—at least half of it—must have originated from floodplain sites, and only a minor part—less than 10%—very probably came from the woodland on the slopes of the Dinaric mountains, which start ca. 700 m from the dwelling; human activities probably very much affected them. Based on our data, it is not possible to reconstruct the exact degree of human impact, but it is probable that especially the nearby woodland was used for cutting trees, for pasturing domestic animals, gathering, hunting etc. Strong anthropo-zoogenic influence and an intense use of these areas is indicated by 13 plant taxa characteristic of woodland clearings and margins in present day plant communities (see Table 1 in supplementary material). Seven of them were probably gathered: *Fragaria*, *Rubus*, *Physalis*, *Cornus*, *Prunus spinosa* (sloe), *Corylus* and *Crataegus monogyna* (hawthorn) (Table 4; see also the chapter on gathering). But not only edible fruits and nuts were gathered there, animal fodder and litter with leaves and branches were also brought to the site. Although we do not have exact data for animal husbandry and hunting at Stare gmajne, we can relate it to the results from slightly earlier nearby sites, Hočevarica and Črešnja pri Bistri, where the bones of mammals have been investigated (Toškan and Dirjec 2004; Velušček et al. 2004; Toškan 2008). At these sites, *Ovis aries* (sheep), *Capra hircus* (goat) and *Sus domesticus* (pig) predominated, whereas *Bos taurus* (cattle) were less frequent. Based on analyses of bones, domesticated animals provided an important source of meat for human nutrition. However, hunting was important, too. The most frequent hunted animals were *Cervus elaphus* (red deer), *Capreolus capreolus* (roe deer) and *Sus scrofa* (wild boar).

Based on the ecology of the weeds according to ecological indicator values (Ellenberg 1991), the fields must have been situated on moist to damp soils, possibly with a neutral pH, rich in nitrogen. Such suitable land for cultivation was probably situated on the slightly elevated edges of the floodplain. Flat plateaus on the hilly terrain may also have been used to lay out fields, for example, the elevated plateau at ca. 1 km south of Stare gmajne (Fig. 1b), because they were naturally protected from flooding. Other possibilities for fields were on the nearby islands in the lake, such as the hill Blatna Brezovica (326 m a.s.l.), at a distance of ca. 1.4 km from Stare gmajne, where the remains of another pile dwelling, Blatna Brezovica, settled around 3071 cal. B.C., have been found (Čufar et al. 2010).

It is not possible to ascribe different weeds to different crops. Therefore we cannot be sure about summer and winter crops, although summer crop weeds prevailed in the spectrum and both perennial and annual weeds were recorded. Since we found taxa among the perennials characteristic of disturbed habitats, the soil preparation was probably effective (see Bogaard 2002). For the many problems concerning the interpretation of Neolithic weed spectra, we refer to Hosch and Jacomet (2004) and also Bogaard (2004).

Comparison of the spectra of the economically important plants with those from other circum-Alpine sites

In the entire circum-Alpine area there were many settlements in the second half of the 4th millennium B.C. On the sites at Ljubljansko barje that existed at the same time as Stare gmajne unfortunately no adequate archaeobotanical investigations have been carried out (Tolar et al. 2010). Therefore, we selected 39 late Neolithic waterlogged sites dated between 3496 and 3000 cal. B.C. for which archaeobotanical data exist for comparison with Stare gmajne (Table 4 in supplementary material; Fig. 5). The selected sites are located in France, Germany and Switzerland (Fig. 1a; after Jacomet 2006a, 2009; Herbig 2009a).

Cereals

The three cereals found at Stare gmajne, *Triticum monococcum*, *T. dicoccum* and *Hordeum vulgare*, were also the most important cereals in lake dwellings north of the Alps (Fig. 5). In addition, they also seem to have been the most important cereal taxa south of the Alps in northern Italy (Rottoli and Castiglioni 2009). There is, however, one striking difference between the cereal spectra from Stare gmajne and those from the northern Alpine settlements: *Triticum durum/turgidum* (tetraploid naked wheat), one of the most common cultivars north of the Alps, was not found at Stare gmajne and also seems to have been rare in northern Italian late Neolithic sites. To our knowledge, *T. durum/turgidum* has not yet been found at any of the Slovenian Neolithic lakeshore settlements. This all confirms the hypothesis that *T. durum/turgidum* might have come to central Europe from the southwest and not from the southeast via the Balkans (Maier 1996; Jacomet 2007). In contrast, the great importance of *T. dicoccum* at Stare gmajne confirms the hypothesis that the rising importance of emmer during the late Neolithic in sites north of the Alps could have been influenced by the cultures to the east (Jacomet 2006a).

The archaeobotanical results from Stare gmajne show clear hints that processing of cereals was done in the settlement, because cereal chaff and weed seeds were found in large amounts (Tables 1 and 2 in supplementary material). This is similar to other lakeshore settlements. Carbonised grains were under-represented because we did not excavate any burnt structures.

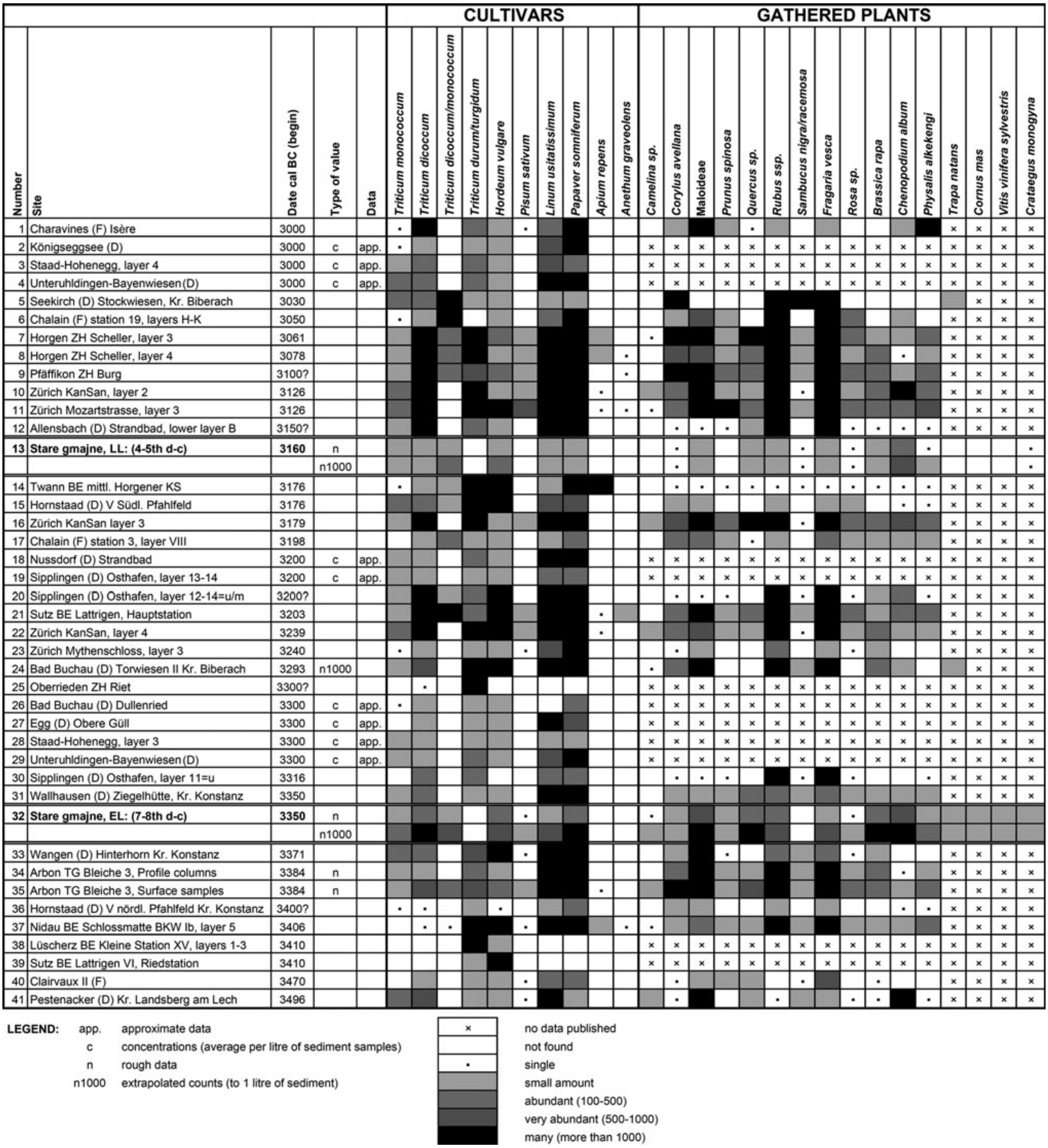


Fig. 5 Presence of crops and gathered plants in selected archaeobotanically investigated sites dated 3500–3000 B.C. in the Alpine region (compare Table 4 in supplementary material). The scheme has been compiled based on published numbers (see Table 3 in supplementary material). The last four columns show gathered plants with a significant presence in the early layer of Stare gmajne; they are mainly absent from other sites

Oil and fibre plants

The oil plants *Linum usitatissimum* and *Papaver somniferum* also provided important nourishment during the late Neolithic (Jacomet 2009; Kohler-Schneider and Cannepele 2009; Pieroni 1999). In addition, they may have been used for other purposes, *Linum* above all for its fibres, and *Papaver* for its medicinal and hallucinogenic properties (Zohary and Hopf 2000; Merlin 2003). The latter, however, cannot be proven by archaeobotanical means.

Papaver was found in considerable amounts in the north Alpine sites from the 2nd half of the 4th millennium cal. B.C. (Fig. 5; Table 3 in supplementary material). We presume that the *P. somniferum* found there is a cultivar, even if differentiation from the seeds of the wild ancestor *P. setigerum* is not clearly possible (Hammer and Fritsch 1977). However, *Papaver* is missing from Chalcolithic sites in northern Italy, but probably for taphonomical reasons (Rottoli and Castiglioni 2009). Our finds at Stare gmajne as well as the somewhat earlier Slovenian finds at Hočevarica, Ljubljansko barje dated ca. 3500 B.C. (Jeraj et al. 2009) now show that *Papaver* was present in the eastern part of the northern Mediterranean region during the late Neolithic. However, it remains unclear from where the *Papaver* arrived, as the origin of domesticated *Papaver* is not yet clear (for a very recent review, see Salavert 2010). We do not have enough data for detailed discussion here, and comparisons with early Neolithic data are not possible since the time gap between the early and late Neolithic is too large.

The remains of *Linum* found at Stare gmajne are also of great interest because these are the first flax finds in a Slovenian Neolithic site. This is mainly due to the improved recovery techniques, which did not allow its detection from former excavations on Ljubljansko barje (Tolar et al. 2010). The large amounts of *Linum* usually found in late Neolithic lakeshore settlements north of the Alps (Jacomet 2006a; Fig. 5) indicate its great importance for several purposes (Hosch and Jacomet 2004, for importance for textiles see Médard 2010). We suppose that it was important during the late Neolithic in Slovenia as well.

Pulses

Pulses are known as important sources of food, above all proteins. However, only *Pisum sativum* appears regularly at most sites north of the Alps (Jacomet 2009; Table 3 in supplementary material). Larger numbers of peas were only preserved there in burnt layers in a carbonised state. There are, however, also regular finds of uncharred pea pods and calyces at various lakeside and moorland sites in Germany as at Hornstaad (Maier 2001) and at Alleshausen-Hartöschle (Maier 2004). At Stare gmajne, we found only three pieces of carbonised *Pisum* seeds, and no waterlogged remains. This is similar to the case of Arbon Bleiche 3, where only three carbonized peas were found in a much larger amount, 340 l, of sieved cultural layer material (Hosch and Jacomet 2004). Since mostly small amounts of *Pisum* have been detected at different lakeside settlements, we can suppose that peas might have been of minor importance. On the other hand it is possible that pea remains were simply not preserved due to unknown taphonomic reasons (Jacomet 2006a, 2009).

Gathering

The list of wild plants probably used for human food, according to ethnographic literature (Ertug-Yaras 1997), is similar to that at other lakeshore settlements where gathered taxa were quantified (Fig. 5). Some hypothetical modelling allows the supposition that at Arbon Bleiche 3, for example, at least a third of the calories were provided by gathered plants. We assume that the great quantity of collected plants found at Stare gmajne indicates that gathering was very important there, too.

In terms of fruits containing starch and oil that could be used as staple foods, the most important gathered taxa at Stare gmajne were *Quercus* (acorns), *Corylus avellana* and *Trapa natans*. The latter are very calorific and can also be ground to flour. Acorns and hazelnuts have also been found in large amounts in other circum-Alpine prehistoric sites (Table 4 in supplementary material, Fig. 5; for the importance of acorns as a staple food see Karg and Haas 1996). *Quercus robur* could have been collected on the floodplain adjacent to the lake, *Q. petraea* from the slopes beyond, and *Corylus* from thinner woodland, woodland edges or clearings outside the swampy lake area.

The water plant *Trapa natans* is of special interest since it is not found everywhere in such large amounts. *Trapa* finds are more restricted to small and especially shallow meso- to eutrophic lakes which become warm in summer. Therefore, water chestnut was for instance common in the Federsee region during the whole Holocene until the Bronze Age (Karg 2006), but it has also often been found in various Neolithic sites of southeast Europe (Borojevič 2009). Federsee and also the lake that existed at Ljubljansko barje were presumably suitably shallow lakes with calm water and quiet bays offering favourable conditions for this plant (Fig. 1b), whereas in the larger, deeper lakes like Lake Constance (Bodensee) this plant could not survive because of the harsh winds and strong lake level fluctuations.

In addition to the gathered staple foods, there is a rather long list of gathered wild fruit taxa from Stare gmajne (Table 3). Most of them also often appear in settlements north of the Alps (Fig. 5). The taxa which are rarer north of the Alps include *Cornus mas* (cornelian cherry) and *Vitis vinifera* ssp. *sylvestris* (wild grape), which were found in the early layer of Stare gmajne. Their occurrence might be due to ecological conditions to the south of the Alps which were possibly more favourable than those north of the Alps. Finds of these taxa from Neolithic sites in northern Italy (Rottoli and Castiglioni 2009) point in the same direction. *V. vinifera*, for example, nowadays grows in Slovenia on warm and dry places in sub-Mediterranean areas or on sunny sand hills and river banks (Tolar et al. 2008). Near Stare gmajne there were such places appropriate for the growth of *Vitis*, especially on the nearby slopes with a southern exposure. In contrast, north of the Alps, *V. vinifera* probably grew only on larger floodplains such as those of the Danube and the Rhine. Remains are therefore not likely to be found in lakeshore settlements there. There is an isolated find of wild grape from Meersburg-Ramsbach on Lake Constance (Horgen culture, ca. 2900 cal. B.C.; Herbig 2009b).

Cornus mas is also fairly rare in natural stands north of the Alps. Finds of its fruits are usually rare or absent, or they are considered to have been imported. For *C. mas* fruit finds from the western Lake Constance region it is supposed that they were imported (Hoffstadt and Maier 1999; Maier 2001), and that there might have been some secondary but not indigenous stands at Lake Constance (Hosch and Jacomet 2004).

Chenopodium album and *Brassica rapa* commonly occur in fields as weeds. They can also show high densities on temporary fallows (Jacomet, personal communication). Both plants have seeds rich in starch, oil and proteins. Since they regularly appear and are often abundant in Neolithic cultural layers (Fig. 5), we assume that the settlers probably collected them for food (see Schlichterle 1981; Brombacher 1997).

It is also worth mentioning the regular appearance of *Viscum album*. Neolithic people could have used it in various ways. In Hornstaad (G) Hörnle IA, mistletoe remains were detected in human coprolites, which suggest that it was consumed. It was probably used for medicinal purposes (Maier 2001). On the other hand, remains of mistletoe regularly occur in the coprolites of ruminants (Kühn and Hadorn 2004).

In addition to the often mentioned gathered plants, we found parts of the fruiting bodies of various fungi that could not be exactly identified. Jacomet et al. (1989) reported that fungi, along with some other vegetable and salad plants, may have played an important role in the diet of Neolithic people. The abundance of their remains does not directly indicate how important they were, because they are rarely preserved. In a previous excavation at Stare gmajne the whole fruiting body of *Daedalea quercina* (maze-gill fungus) was found, which usually grows on dead wood, mainly oak and causes brown rot. Though inedible, its fruit bodies could have been used, for instance, as a natural comb (Rolfe 1974).

We also found many fragments of mosses which were presumably brought to the settlement for insulation material in the buildings (Table 1 in supplementary material; Hosch and Jacomet 2004). The remains of a sort of fabric were found, too. Its identification with the help of a scanning electron microscope showed that it was made of lignified material, probably bast (Reichert 2007). Finally, one larger piece of well-processed yarn was found during one of the previous excavations at the site in 2006. It originated from the latest settlement phase and was made of the spun fibre of an unknown Poaceae species (Pajagič Bragar et al. 2009).

Conclusions

The late Neolithic pile dwelling of Stare gmajne on Ljubljansko barje, Slovenia has only recently been exactly dated by dendrochronology. It was inhabited in two periods, during an early phase about 3350 to 3330 B.C. and during a later one lasting about 50 years and ending after 3110 cal. B.C. Based on this, the site can be considered to be partly contemporary with the Alpine Iceman (Ötzi).

Our investigations revealed that there are many similarities in useful plant spectra between Slovenian and northern Alpine lake dwelling sites. There are, however, also some differences. Among the crop plants, we noted the absence of *Triticum durum/turgidum* at Stare gmajne. Furthermore, we found *Papaver somniferum* in greater amounts. It was previously found only on one Slovenian site. Furthermore, the improved recovery techniques made it possible to recover the remains of *Linum usitatissimum* for the first time at a Slovenian Neolithic site. This all sheds a new light on the early history of these crop plants in Europe.

In addition to numerous similarities, we also observed some differences within the group of gathered plants. In the early layer of Stare gmajne *Vitis vinifera* ssp. *sylvestris*, *Cornus mas* and *Trapa natans* were found. They had previously already been found at other Slovenian pile dwelling sites but they are rare or absent north of the Alps. This may be due to ecological differences.

The people of Stare gmajne influenced the vegetation in the vicinity of the settlement by agricultural cultivation and gathering, as well as by pasturing and fodder collecting activities, as in other circum-Alpine lakeside settlements (Jacomet et al. 2004).

In future excavations on exactly dated sites, more material should be collected and investigated in a representative way, using appropriate recovery techniques. Only additional results can improve the picture of the nutrition, activities and organisation of the settlers, as well as of the ecological conditions at and around the pile dwellings in Slovenia. In addition, comparisons with pollen analyses and other interdisciplinary investigations should be made in order to interpret the climatic and ecological conditions and disturbances in the period of the 4th and also 3rd millennium B.C.

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References

Anderberg AL (1994) Atlas of seeds and small fruits of Northwest-European plant species with morphological descriptions. Part 4: Resedaceae–Umbelliferae. Risbergs Tryckeri AB, Uddevalla

Baudais D, Grudler A, Lundström-Baudais K (1997) Les paléosemences de niveau VIII et leur répartition spatiale. In: Pétrequin P (ed) Les sites littoraux néolithiques des Clairvaux-les-Lacs et de Chalain (Jura) III: Chalain Station 3, 3200–2900 av. J.-C., vol 2. Editions de la Maison des Sciences de l'Homme, Paris, pp 723–732

Behre KE, Jacomet S (1991) The ecological interpretation of archaeobotanical data. In: Van Zeist WA, Wasylikowa K, Behre KE (eds) Progress in Old World palaeoethnobotany. Balkema, Rotterdam, pp 81–108

Berggren G (1969) Atlas of seeds and small fruits of northwest-European plant species (Sweden, Norway, Denmark, East Fennoscandia and Iceland) with morphological descriptions. Part 2 Cyperaceae. Swedish Natural Science Research Council, Stockholm

Berggren G (1981) Atlas of seeds and small fruits of northwest-European plant species (Sweden, Norway, Denmark, East Fennoscandia and Iceland) with morphological descriptions. Part 3 Salicaceae–Cruciferae. Swedish Natural Science Research Council, Stockholm

Binz A, Heitz C (1990) Schul- und Exkursionsflore für die Schweiz, mit Berücksichtigung angrenzender Gebiete. Schwabe, Basel

Bittmann F (2001) Die jungneolithische Feuchtbodensiedlung Pestenacker, Lkr. Landsberg/Lech—Auswirkungen auf die Landschaft aus botanischer Sicht. Regensbg Beitr zur Prähist Archäol 7:93–107

Bocquet A, Caillat R, Lundstrom-Baudais K (1986) Alimentation et techniques de cuisson dans le village néolithique de Charavines—Isere. In: Demoule JP, Guilaine J (eds) Le Néolithique de la France. Hommage à G. Bailloud. Colloque International sur l'Alimentation de l'Homme Préhistorique. Picard, Paris, pp 319–329

Bogaard A (2002) Questioning the relevance of shifting cultivation to Neolithic farming in the loess belt of Europe: evidence from the Hambach Forest experiment. Veget Hist Archaeobot 11:155–168

Bogaard A (2004) Neolithic farming in central Europe. An archaeobotanical study of crop husbandry practices. Routledge, London

Borojevič K (2009) Water chestnuts (*Trapa natans* L.) as controversial plants: botanical, ethno-historical and archaeological evidence In: Fairbairn A, Weiss E (eds) From foragers to farmers. Papers in honour of Gordon C. Hillman. Oxbow, Oxford, pp 86–97

Brombacher C (1997) Archaeobotanical investigations of Late Neolithic lakeshore settlements (Lake Biel, Switzerland). Veget Hist Archaeobot 6:167–186

Brombacher C (2000) Archäobotanische Untersuchungen. In: Hafner A, Suter P (eds) -3400. Die Entwicklung der Bauerngesellschaften im 4. Jahrtausend v. Chr. am Bielersee aufgrund der Rettungsgrabungen von Nidau und Sutz-Lattrigen. Haupt, Bern, pp 155–168

Brombacher C, Hadorn P (2004) Untersuchungen der Pollen und Makroreste aus den Profilsäulen. In: Jacomet S, Leuzinger U, Schibler J (eds) Die Jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Umwelt und Wirtschaft (Archäologie im Thurgau 12). Amt für Archäologie, Frauenfeld, pp 55–65

Brombacher C, Jacomet S (1997) Ackerbau, Sammelwirtschaft und Umwelt: Ergebnisse archäobotanischer Untersuchungen. In: Schibler J, Hüster-Plogmann H, Jacomet S, Brombacher C, Gross-Klee E, Rast-Eicher A (eds) Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürichsee. Ergebnisse der Ausgrabungen Mozartstrasse, Kanalisationssanierungen Seefeld, AKAD/Pressehaus und Mythenschloss in Zürich. Direktion der öffentlichen Bauten des Kantons Zürich, Zürich, pp 220–279

Cappers R, Bekker RM, Jans JEA (2006) Digitale zadenatlas van Nederland [Digital seed atlas of the Netherlands]. Barkhuis Publishing, Groningen

Čufar K, Velušček A, Tolar T, Kromer B (2009) Dendrochronological research at the pile-dwelling settlements Stare gmajne and Blatna Brezovica. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, the Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 177–196

Čufar K, Kromer B, Tolar T, Velušček A (2010) Dating of 4th millennium B.C. pile-dwellings on Ljubljansko barje, Slovenia. J Archaeol Sci 37:2031–2039

Dickson JH, Hofbauer W, Porley R, Schmidl A, Kofler W (2009) Six mosses from the Tyrolean Iceman's alimentary tract and their significance for his ethnobotany and the events of his last days. Veget Hist Archaeobot 18:13–22

Dufraisse A (2006) Firewood economy during the 4th millennium B.C. at Lake Clairvaux, Jura, France. Environ Archaeol 11:87–100

Dufraisse A (2008) Firewood management and woodland exploitation during the late Neolithic at Lac de Chalain (Jura, France). Veget Hist Archaeobot 17:199–210

Ellenberg H (1991) Zeigerwerte der Gefässpflanzen Mitteleuropas, 3rd edn. Scripta Geobotanica 9. Goltze, Göttingen

Ertug-Yaras F (1997) An ethnoarchaeological study of subsistence and plant gathering in central Anatolia. Doctoral thesis, Washington University, UMI Dissertation Services, St. Louis

Favre P (2001) Analyse pflanzlicher Grossreste aus den spätneolithischen Ufersiedlungen von Horgen-Scheller Kanton Zürich, Schweiz. Ein Beitrag zu Umwelt- und Wirtschaftsgeschichte des 31. Jh. v. Chr. im nördlichen Alpenvorland. Doctoral thesis, University of Basel

Favre P (2002) Archäobotanik. In: Achour-Uster C, Eberli U, Ebersbach R, Favre P (eds) Die Seeufersiedlungen in Horgen. Die neolithischen und bronzezeitlichen Fundstellen Dampfschiffsteg und Scheller. Fotorotar, Zürich, pp 150–180

Furger AR (1980) Botanische Untersuchungen. In: Die Siedlungsreste der Horgener Kultur. In: Bern SL (ed) Die neolithischen Ufersiedlungen von Twann. Staatlicher Lehrmittelverlag, Bern, pp 125–131

Hafner A, Suter PJ (1997) Entwurf eines neuen Chronologie-Schemas zum Neolithikum des schweizerischen Mittellandes. Archaol Korresp 27:549–565

Hammer K, Fritsch R (1977) Zur Frage nach der Ursprungsart des Kulturmohns (*Papaver somniferum* L.). Kulturpflanze 25:113–124

Heiss AG, Oeggl K (2009) The plant macro-remains from the Iceman site (Tisenjoch, Italian–Austrian border, eastern Alps): new results on the glacier mummy's environment. Veget Hist Archaeobot 18:23–35

Herbig C (2002) Archäobotanische Untersuchungen in der spätneolithischen Moorsiedlung Torwiesen II im Federseemoor (Stadt Buchau, Kreis Biberach). Universität Frankfurt, Magisterarbeit

Herbig C (2006) Archaeobotanical investigations in a settlement of the Horgener culture (3300 B.C.) "Torwiesen II" at Lake Federsee, southern Germany. Environ Archaeol 11:131–142

Herbig C (2009a) Recent archaeobotanical investigations into the range and abundance of Neolithic crop plants in settlements around Lake

Constance and in Upper Swabia (south-west Germany) in relation to cultural influences. J Archaeol Sci 36:1277–1285

Herbig C (2009b) Archäobotanische Untersuchungen in neolithischen Feuchtbodensiedlungen am westlichen Bodensee und in Oberschwaben. Frankfurter Arch Schrift 10. Habelt, Bonn

Hoffstadt J, Maier U (1999) Handelsbeziehungen während des Jungneolithikums im westlichen Bodenseeraum am Beispiel der Fundplätze Mooshof und Hornstaad Hörnle I.A. Archaol Korresp 29:21–34

Hosch S (2003) Ackerbau und Sammelwirtschaft in der Neolithischen Seeufersiedlung Arbon Bleiche 3 (3384–3370 v. Chr.) Kanton Thurgau, Schweiz. Unpublished doctoral thesis, Institute for Prehistory and Archaeological Science, Basel University

Hosch S, Jacomet S (2001) New aspects of archaeobotanical research in central European Neolithic lake dwelling sites. Environ Archaeol 6:59–71

Hosch S, Jacomet S (2004) Ackerbau und Sammelwirtschaft. Ergebnisse der Untersuchung von Samen und Früchten. In: Jacomet S, Schibler J, Leuzinger U (eds) Die neolithische Seeufersiedlung Arbon Bleiche 3: Wirtschaft und Umwelt. Amt für Archäologie des Kantons Thurgau, Frauenfeld, pp 112–157

Hosch S, Zibulski P (2003) The influence of inconsistent wet-sieving procedures on the macroremains concentration in waterlogged sediments. J Archaeol Sci 30:849–857

Ismail-Meyer K, Rentzel P (2004) Mikromorphologische Untersuchung der Schichtabfolge. In: Jacomet S, Leuzinger U, Schibler J (eds) Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Umwelt und Wirtschaft. Huber, Frauenfeld, pp 66–80

Jacomet S (1985) Botanische Makroreste aus den Sedimenten des neolithischen Siedlungsplatzes AKAD-Seehofstrasse am untersten Zürichsee. Die Reste der Uferpflanzen und ihre Aussagemöglichkeiten zu Vegetationsgeschichte, Schichtentstehung und Seespiegelschwankungen. Juris, Zürich

Jacomet S (1990) Veränderungen von Wirtschaft und Umwelt während des Spätneolithikumus im westlichen Bodenseegebiet. Ergebnisse samenanalytischer Untersuchungen an einem Profilblock aus der Horgener Schichtabfolge von Sipplingen-Osthafen (Tauchsondierung Ruoff 1980). In: Landesdenkmalamt Baden-Wüttemberg, Archäologische Denkmalpflege (eds) Berichte zu den Ufer- und Moorsiedlungen Südwestdeutschlands. Siedlungsarchäologie im Alpenvorland 2, Theiss, Stuttgart, pp 295–324

Jacomet S (2004) Archäobotanische Grobuntersuchung verkohlter Getreideklumpen. In: Hügin U, Michel-Tobler C (eds) Oberrieden ZH-Riet—eine frühhorgenzeitliche Siedlung. Jahrbuch Schweiz Ges für Ur- Frühgesch 87:21–23

Jacomet S (2006a) Plant economy of the northern Alpine lake dwelling area—3500–2400 cal. B.C. In: Karg S, Baumeister R, Schlichtherle H, Robinson DE (eds) Economic and environmental changes during the 4th and 3rd Millenia B.C. Proceedings of the 25th symposium of the AEA Sept. 2004 in Bad Buchau, Germany. Environ Archaeol 11:65–85

Jacomet S (2006b) Bestimmung von Getreidefunden aus archäologischen Ausgrabungen (Identification of cereal remains from archaeological sites). IPAS, Basel University, Basel. http://ipna.unibas.ch/archbot/pdf/Cereal_Id_Manual_engl.pdf

Jacomet S (2007) Neolithic plant economies in the northern alpine foreland from 5500–3500 B.C. cal. In: Colledge S, Conolly J (eds) The origins and spread of domestic plants in southwest Asia and Europe. Left Coast Press, Walnut Creek, pp 221–258

Jacomet S (2009) Plant economies and village life in Neolithic lake dwellings at the time of the Alpine Iceman. Veget Hist Archaeobot 18:47–59

Jacomet S, Brombacher C (2005) Reconstructing intra-site patterns in Neolithic lakeshore settlements: the state of archaeobotanical research and future prospects. In: Della Casa P, Trachsel M (eds) WES'04—wetland economies and societies. Proceedings of the international conference in Zürich, 10–13 March 2004. Chronos, Zürich, pp 69–94

Jacomet S, Brombacher C, Dick M (1989) Archäobotanik am Zürichsee. Ackerbau, Sammelwirtschaft und Umwelt von neolithischen und bronzezeitlichen Seeufersiedlungen im Raum Zürich. Ergebnisse von Untersuchungen pflanzlicher Makroreste der Jahre 1979–1988. Orell Füssli Verlag, Zürich

Jacomet S, Leuzinger U, Schibler J (eds) (2004) Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3: Umwelt und Wirtschaft. Archäologie im Thurgau 12, Frauenfeld

Janžekovič F, Malez V (2004) Birds (Aves) at the Eneolithic pile dwelling at Hočevarica. In: Velušček A (ed) Hočevarica. An Eneolithic pile dwelling in the Ljubljansko barje. Opera Instituti Archaeologici Sloveniae 8. Založba ZRC, Ljubljana, pp 155–168

Jeraj M, Velušček A, Jacomet S (2009) The diet of Eneolithic (Copper Age, Fourth millennium cal B.C.) pile dwellers and the early formation of the cultural landscape south of the Alps: a case study from Slovenia. Veget Hist Archaeobot 18:75–89

Karg S (1990) Pflanzliche Grossreste der jungsteinzeitlichen Ufersiedlungen von Allensbach-Strandbad. Wildpflanzen und Anbaufrüchte als stratigraphische, ökologische und wirtschaftliche Informationsquellen. In: Landesdenkmalamt Baden-Wüttemberg (ed) Siedlungsarchäologie im Alpenvorland 2. Theiss, Stuttgart, pp 113–166

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

Karg S, Haas JN (1996) Indizien für den Gebrauch von mitteleuropäischen Eicheln als prähistorische Nahrungsressource. In: Campen I, Hahn J, Uerpmann M (eds) Festschrift für Hans Jürgen Müller-Beck. Mo Vince Verlag, Tübingen, pp 429–435

Kohler-Schneider M, Cannepele A (2009) Late Neolithic agriculture in eastern Austria—archaeobotanical results from sites of the Baden and Jevišovice cultures (3600–2800 B.C.). Veget Hist Archaeobot 18:61–74

Kühn M, Hadorn P (2004) Pflanzliche Makro- und Mikroreste aus Dung von Wiederkäuern. In: Jacomet S, Leuzinger U, Schibler J (eds) Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Umwelt und Wirtschaft. Amt für Archäologie des Kantons Thurgau, Frauenfeld, pp 327–350

Kutschera W, Müller W (2003) "Isotope language" of the Alpine Iceman investigated with AMS and MS. Nucl Instrum Methods Phys Res B 204:705–719

Lundström-Baudais K (1989) Les macrorestes végétaux du niveau V de la Motte-aux-Magnins. In: Pétrequin P (ed) Le Néolithique Moyen (Les sites littoraux néolithiques de Clairvaux-les-Lacs (Jura), 2). Éditions de la Maison des Sciences de I'Homme, Paris, pp 417–439

Maier U (1996) Morphological studies of free-threshing wheat ears from a Neolithic site in southwest Germany, and the history of naked wheats. Veget Hist Archaeobot 5:39–55

Maier U (2001) Archäobotanische Untersuchungen in der neolithischen Ufersiedlung Hornstaad-Hörnle IA am Bodensee. In: Maier U, Vogt R (eds) Botanische und pedologische Untersuchungen zur Ufersiedlung Hornstaad-Hörnle IA. Siedlungsarchäologie im Alpenvorland 6. Theiss, Stuttgart, pp 9–384

Maier U (2004) Archäobotanische Untersuchungen in jung- und endneolithischen Moorsiedlungen am Federsee (mit einem Beitrag von Richard Vogt). In: Köninger J, Schlichtherle H (eds) Ökonomischer und ökologischer Wandel am vorgeschichtlichen Federsee. Archäologische und naturwissenschaftliche Untersuchungen. Landesdenkmalamt Baden-Württemberg, Gaienhofen-Hemmenhofen, pp 71–159

Martinčič A, Wraber T, Jogan N, Ravnik V, Podobnik A, Turk B, Vreš B (1999) Mala flora Slovenije, Ključ za določanje praprotnic in semenk. Tehniška založba Slovenije, Ljubljana

Médard F (2010) L'art du tissage au Néolithique: IVe-IIIe millénaires avant J-C en Suisse. Collection CRA Monographies. CNRS Editions, Paris

Menotti F (2004) Living on the lake in prehistoric Europe, 150 years of lake-dwelling research. Routledge, London

Merlin MD (2003) Archaeological evidence for the tradition of psychoactive plant use in the old world. Econ Bot 57:295–323

Neef R (1990) Botanische Untersuchungen im jungneolithischen Pestenacker. Ber Röm Ger Komm 71:381–389

Oberdorfer E (2001) Pflanzensoziologische Exkursionsflora für Deutschland und angrenzende Gebiete. Ulmer, Stuttgart

Oeggl K (2009) The significance of the Tyrolean Iceman for the archaeobotany of Central Europe. Veget Hist Archaeobot 18:1–11

Pajagič Bragar G, Velušček A, Tolar T, Strlič M, Bukošek V, Kolar J, Ravbar I (2009) Analysis and conservation of the Ljubljansko barje yarn. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, the Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 309–318

Piening U (1981) Die verkohlten Kulturpflanzenreste aus den Proben der Cortaillod- und Horgener Kultur. In: Ammann B, Bollinger T, Jacomet S, Liese-Kleiber H, Piening U (eds) Botanische Untersuchungen. Die neolithischen Ufersiedlungen von Twann, 14. Staatlicher Lehrmittelverlag, Bern, pp 69–88

Pieroni A (1999) Gathered wild food plants in the upper valley of the Serchio river (Garfagnana), Central Italy. Econ Bot 53:327–341

Reichert A (2007) Zwischen Rinde und Holz: Bast—textiles Material der Steinzeit. In: Fansa M (ed) Holz-Kultur. Von der Urzeit bis in die Zukunft, Oldenburg, pp 203–230

Riehl S (1993) Botanische Grossreste aus einer neolithischen Profilabfolge. Die Horgenzeitliche Seeufersiedlung Wangen/Bodensee. Magisterarbeit, Tübingen

Rolfe F (1974) The romance of the fungus world: an account of fungus life in its numerous guis, both real and legendary. Dover, New York, p 158

Rösch M (1990a) Botanische Untersuchungen in spätneolithischen Ufersiedlungen von Wallhausen und Dingelsdorf am Überlinger See (Kr. Konstanz). In: Siedlungsarchäologie im Alpenvorland II (Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 37). Theiss/Archäologische Denkmalpflege, Stuttgart, pp 227–266

Rösch M (1990b) Botanische Untersuchungen an Pfahlverzügen der endneolithischen Ufersiedlung Hornstaad-Hörnle V am Bodensee. In: Landesdenkmalamt Baden-Wüttemberg, Archäologische Denkmalpflege (eds) Siedlungsarchäologie im Alpenvorland II. Theiss, Stuttgart, pp 325–351

Rottoli M, Castiglioni E (2009) Prehistory of plant growing and collecting in northern Italy, based on seed remains from early Neolithic to the Chalcolithic (c. 5600–2100 cal B.C.). Veget Hist Archaeobot 18:91–103

Salavert A (2010) Apport de l'archéobotanique à la compréhension des sociétés néolithiques. Analyses anthracologiques et carpologiques de neuf sites rubanés de Moyenne-Belgique (5200–5000 av. J.-C.). Doctoral thesis, Université de Paris I, Panthéon-Sorbonne

Schaal C (2000) Etude carpologique d'un Village Neolithique: la Station 19 de Chalain (Jura) au 30ème Siècle av. J.-C. DEA. Université de Franche Comte, Besançon

Schlichterle H (1981) Cruciferen als Nutzpflanzen in neolithischen Ufersiedlungen Südwestdeutschlands und der Schweiz. Z Archäol 15:113–124

Šercelj A (1996) The origins and development of forests in Slovenia. Dela, 35. Slovenska Akademija Znanosti in Umetnosti, Ljubljana, p 142

Stöckli W (2009) Chronologie und Regionalität des jüngeren Neolithikums (4300–2400 v. Chr.) im Schweizer Mittelland, in Süddeutschland und in Ostfrankreich. Antiqua 45, Basel

Stotzer M, Schweingruber FH, Šebek M (1976) Prähistorisches Holzhandwerk. Mitt Schweiz Ges für Ur- Frühgesch 7:13–23

Suter P, Schlichtherle H (2009) Pfahlbauten–Palafittes–Palafitte–Pile Dwellings–Kolišča. UNESCO Welterbe Kandidatur "Prähistorische Pfahlbauten rund um die Alpen". Biel/Bienne

Tolar T, Zupančič M (2009) Newly discovered wooden finds from Stare gmajne near Verd. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, The Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 235–243

Tolar T, Jakše J, Korošec-Koruza Z (2008) The oldest macroremains of *Vitis* from Slovenia. Veget Hist Archaeobot 17:93–102

Tolar T, Jacomet S, Velušček A, Čufar K (2010) Recovery techniques for waterlogged archaeological sediments: a comparison of different treatment methods for samples from Neolithic lake shore settlements. Veget Hist Archaeobot 19:53–67

Toškan B (2008) Živalstvo v koliščarski dobi. In: Pavšič J (ed) Ljubljansko barje. Društvo Slovenska Matica, Ljubljana, pp 153–158

Toškan B, Dirjec J (2004) Hočevarica—an analysis of macrofauna remains. In: Velušček A (ed) Hočevarica. An Eneolithic pile dwelling in the Ljubljansko barje. Opera Instituti Archaeologici Sloveniae 8. Založba ZRC, Ljubljana, pp 76–132

Turk J, Horvat A (2009) Sedimentological method for determination of palaeoenvironmental conditions at the Ljubljansko barje. Case study: Stare gmajne. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, The Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 35–48

Van der Veen M, Fieller N (1982) Sampling seeds. J Archaeol Sci 9:287–298

Vandorpe P, Jacomet S (2007) Comparing different pre-treatment methods for strongly compacted organic sediments prior to wet-sieving: a case study on Roman waterlogged deposits. Environ Archaeol 12:207–214

Velušček A (2004) Past and present lake-dwelling studies in Slovenia, Ljubljansko barje (the Ljubljana Marsh). In: Menotti F (ed) Living on the lake in prehistoric Europe, 150 years of lake-dwelling research. Routledge, London, pp 69–82

Velušček A (2009) Stare gmajne pile-dwelling settlement and its era. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, The Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 11–34

Velušček A, Čufar K, Culiberg M, Toškan B, Dirjec J, Malez V, Janžekovič F, Govedič M (2004) Črešnja pri Bistri, a newly discovered pile-dwelling settlement in the Ljubljansko barje. Arheol Vestn 55:39–54

Velušček A, Veranič D, Čufar K (2009a) Logboats from the pile-dwelling settlement Stare gmajne at the Ljubljansko barje. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, The Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 223–234

Velušček A, Čufar K, Zupančič M (2009b) Prehistoric wooden wheel with an axle from the pile-dwelling Stare gmajne at the Ljubljansko barje. In: Velušček A (ed) Stare gmajne pile-dwelling settlement and its era, The Ljubljansko barje in the 2nd half of the 4th millennium B.C. Opera Instituti Archaeologici Sloveniae 16. Založba ZRC, Ljubljana, pp 197–222

Zohary D, Hopf M (2000) Domestication of plants in the Old World, 3rd edn. Oxford University Press, Oxford