The water chestnut (*Trapa natans* L.) as a food resource during the 4th to 1st millennia BC at Lake Federsee, Bad Buchau (southern Germany)

Sabine Karg

During archaeological excavations at several wetland sites around Lake Federsee, remains of water chestnut were detected. The finds are dated to between the 4th and 1st millennia BC. Until recently the starch-containing nuts of water chestnut were used for human nutrition in Europe. The nuts can easily be harvested in autumn. Pollen and plant macrofossil remains from several sites are proof of a wide distribution during the Holocene, probably influenced by humans. Nowadays this annual water plant is extinct in many parts of Europe. The growing conditions of water chestnut are strongly restricted with regard to water quality, depth and temperature, and therefore finds of this plant have the potential to allow reconstruction of former ecological conditions.

Keywords: wetland archaeology, southern Germany, Neolithic period, Bronze Age, subsistence economy

Introduction

Large-scale excavations during the 1980s at wetland sites around the Lake Federsee were accompanied by environmental studies (Fig. 1). Dendrochronology played an important role in establishing the absolute dating of the thousands of piles from houses, palisade systems and wooden pathways (Billamboz 2003). The 'Siedlung Forschner' situated on the south-western edge of Lake Federsee (no. 5 on Fig. 1) was excavated between 1983 and 1989. The tree-ring data show two felling phases for the timber used in the settlement: an initial phase from 1767–1730 BC, and a second phase between 1511 and 1481 BC (Fig. 2). Quantitative studies of the different tree species used for the wooden constructions of the Bronze Age settlement revealed the exploitation of different ecosystems for the timber supply at Siedlung Forschner (Billamboz 2003). Large-scale coring and pollen analysis of the sediments helped to reconstruct the former extent of the lake (Liese-Kleiber 1993). Animal and fish remains found during the archaeological excavations were studied by Kokabi (1990). Plant remains were present in an uncharred and (only very rarely) a charred condition, but the study of the finds was very problematic. Many of the uncharred seeds germinated during the laboratory work within a few days and, as the stratigraphy of the Siedlung Forschner was very complex (Keefer 2001), the author concentrated exclusively on the study of charred remains from dated clay concentrations originally belonging to house constructions from the second occupation phase of the site.

Material and methods

During all archaeological excavations at the Lake Federsee since the 1980s, soil samples were systematically taken and analysed in the laboratory. Maier (1988) has described the analytical methods employed. During the excavations at Siedlung Forschner, clay concentrations were sampled. In the laboratory, the clay was soaked in water with added hydrogen peroxide for around 12 hours. Then each sample was washed through sieves with mesh-sizes down to 0·25 mm. The organic remains were screened under a microscope with 10–60 x magnifications and the plant finds identified with the help of a modern reference collection and selected literature. The sieve residues were found to contain several hundred burnt

Sabine Karg, The National Museum of Denmark, Environmental Archaeology, Ny Vestergade 11, DK-1471 Copenhagen K, Denmark; e-mail: Sabine.Karg@natmus.dk
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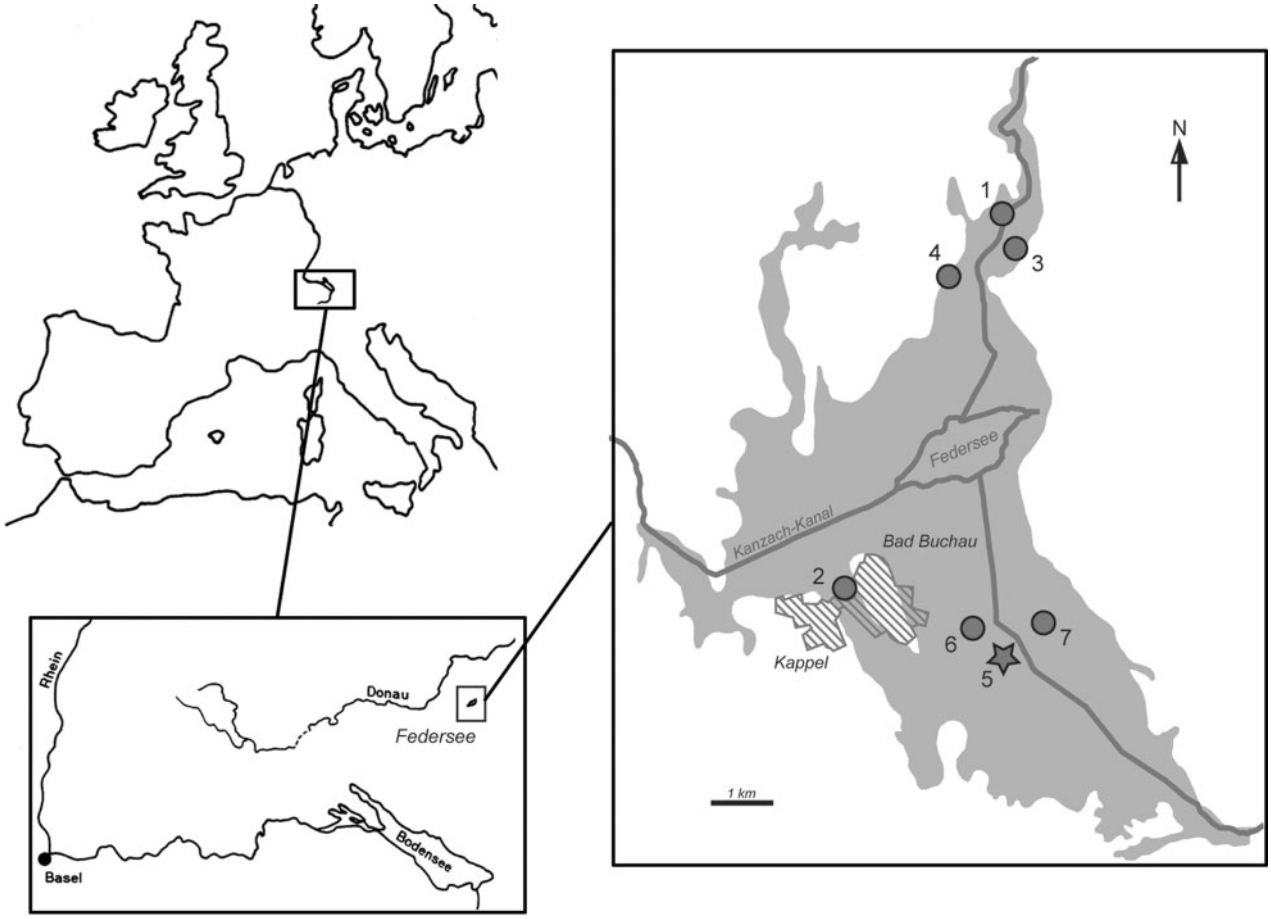

Figure 1 Location of Lake Federsee in southern Germany, with the archaeological sites named in Table 1. Designed by Almut Kalkowski

water chestnut fragments, as well as chaff and grains from various crop species (Table 1), together with ceramic fragments and a rare piece of an amber bead. The archaeobotanical finds of interest for the present study were charred fragments of the thorny fruits and seeds of water chestnut (*Trapa natans* L.) (Fig. 3). Remains from this water plant were also found in uncharred condition, where the nuts are interpreted as having been deposited in natural sediments at the bottom of the former lake and along the original shorelines. This study focuses solely on finds that definitely derive from cultural layers or deposits from prehistoric settlements (Table 2).

Table 1 Charred plant macrofossil remains from the clay concentrations of the Siedlung Forschner. Total number of remains = 619, found in 170 kg of clay sediment (92 samples)

Cultivated Plants	Latin name	English name	Plant part	Absolute number	Relative abundance (%)
Cereals	*Triticum spelta* L.	Spelt	seeds	21	3
			spikelet fragments	98	16
	Triticum dicoccum Schübl	Emmer	seeds	7	1
			spikelet fragments	24	4
	Triticum cf. monococcum L.	Einkorn	seed	1	<1
	Triticum aestivum L. / *durum* Desf.	Naked Wheat	seed	1	<1
			spikelet fragment	1	<1
	Hordeum vulgare L.	Barley	seeds	34	6
			spikelet fragment	1	<1
Legumes	*Pisum sativum* L.	Pea	seed	1	<1
Wild plants	*Trapa natans* L.	Water Chestnut	fragments of exocarp	426	69
			fragments of endocarp	2	<1
	Corylus avellana L.	Hazelnut	fragment of exocarp	1	<1
	Sambucus sp.	Elder	seed	1	<1

Figure 2 The excavation plan showing the piles and houses of the Siedlung Forschner. Designed by André Billamboz and Joachim Köninger

Results and discussion

Dating and interpretation of the water chestnut finds from Siedlung Forschner

At the Siedlung Forschner no intact refuse or cultural layers from the former settlements were found. All layers had been re-deposited by transgressions of the lake. Nevertheless, within and beside the ground plans of some houses (Fig. 2), clay spreads from the former hearths could be identified. The archaeobotanical samples were taken from these clay features. A radiocarbon date was obtained for charcoal from one clay concentration (from profile 32). The two-sigma ranges for the calibrated date are 1492–1476 BC, 1460–1370 BC and 1351–1316 BC (HC 11747), according to Reimer *et al.* (2004). This date makes it most likely that the water chestnuts are contemporaneous with the second occupation phase of the settlement.

The charred finds from Siedlung Forschner, shown in Figure 3, were found embedded in clay lenses within or beside the former house ground plans. These clay deposits are generally interpreted as degraded remains of former hearths (Schlichtherle and Strobel 1992). It therefore seems reasonable to

Table 2 Charred water chestnut finds from archaeological sites around the Lake Federsee (after Ursula Maier, unpublished)

No. on Fig. 1	Site name	Dating	Stratigraphical unit	Frequency	Analysed by
1	Alleshausen-Ödenahlen	3700 BC	cultural layer	++	Maier
2	Bad Buchau-Torwiesen II	3250 BC	cultural layer	+++	Maier
3	Seekirch-Stockwiesen	3000 BC	cultural layer	+	Maier
4	Alleshausen-Grundwiesen	2900–2700 BC	cultural layer	++	Maier
5	Siedlung Forschner	1511–1481 BC	clay concentrations	++	Karg
6	Wasserburg-Buchau	1000–850 BC	cultural layer (not *in situ*)	++++	Maier
6	Wasserburg-Buchau	*c.* 1000 BC	cultural layer	+++	Maier
6	Wasserburg-Buchau	*c.* 850 BC	cultural layer	+	Maier
7	Oggelshausen-Bruckgraben	600 BC	cultural layer (not *in situ*)	++++	Maier

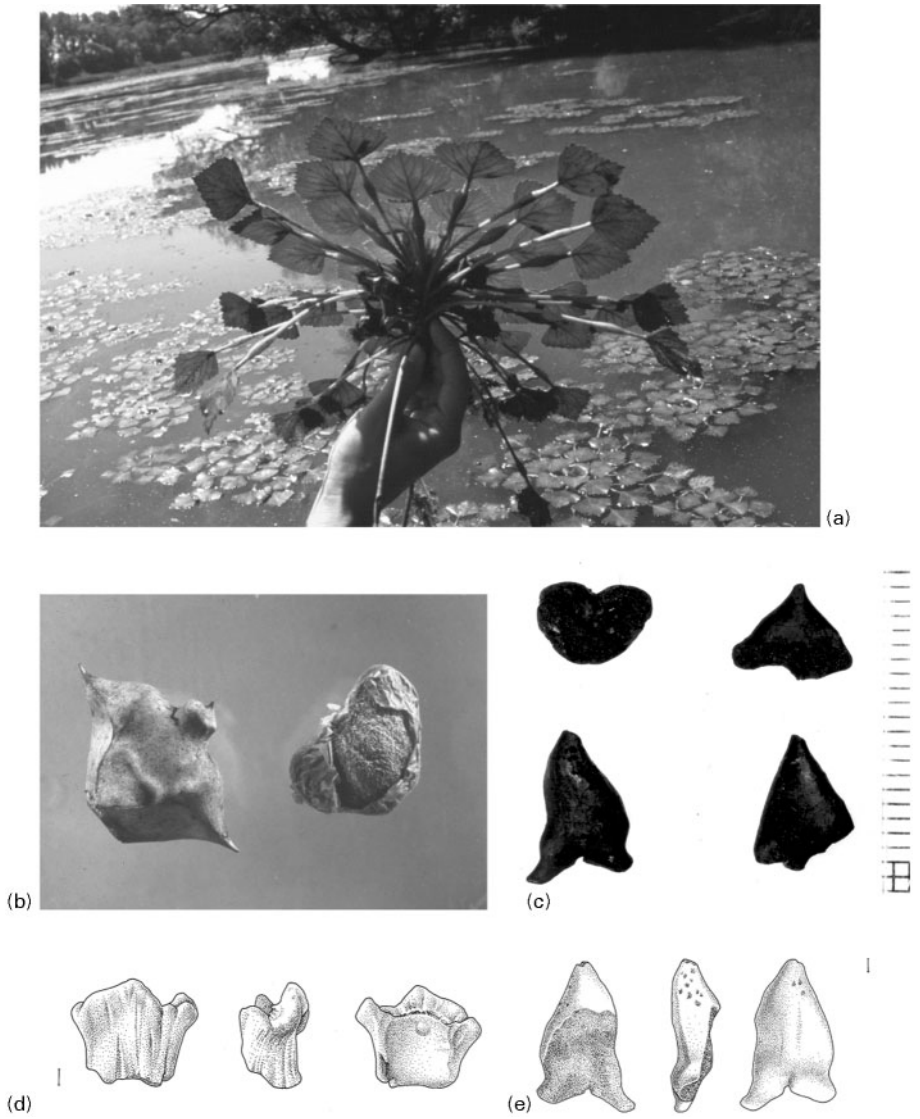

Figure 3 Modern plant of a water chestnut from 'Kleiner Bodensee', an oxbow lake on the Rhine near Karlsruhe (a). Modern nut with endocarp (b). Photographs (c) and drawings (d, e) of charred water chestnut fragments from the clay concentrations of the second occupation phase of the Siedlung Forschner. Photos: Sabine Karg. Drawings Irma Hausener, Bern. Scale: 1 mm

suggest that the water chestnuts, as well as the other burnt plant remains found within the clay deposits, were used in preparing food.

The biology of the water chestnut

The water chestnut (*Trapa natans*) is the only European species of the genus *Trapa* and of the family Trapaceae. Until recently the species grew and was even cultivated in many water bodies providing an appropriate environment. Today water chestnut can be found only in some remote lakes and protected nature reserves. Muddy lakes, ponds or oxbow lakes, one to two metres in depth and highly nutrient- and humus-rich, are the preferred habitats, because the calm, shallow water warms up rapidly in spring. A water temperature of 12–15°C is absolutely necessary for the fruits to germinate; 20°C is required for development of the flowers. The geographic range is dependant on continental climatic conditions, i.e. high temperatures during spring and summer (Apinius 1940). The fruits over-winter at the bottom of the water bodies and germinate in early spring. A thin stalk with compound roots grows up to the water surface where floating leaves develop. One stem can create up to 10 leaf rosettes which float on the water surface as a carpet (Fig. 3a). The plant flowers in July and August. The inconspicuous white flowers, only 4 mm in size, are situated in the leaf axils. During the summer months the fruits develop at the basal parts of the rosettes. In autumn the leaves change colour from green to purple-brown, the rosettes dissolve, and the fruits sink to the bottom of the lake and anchor with

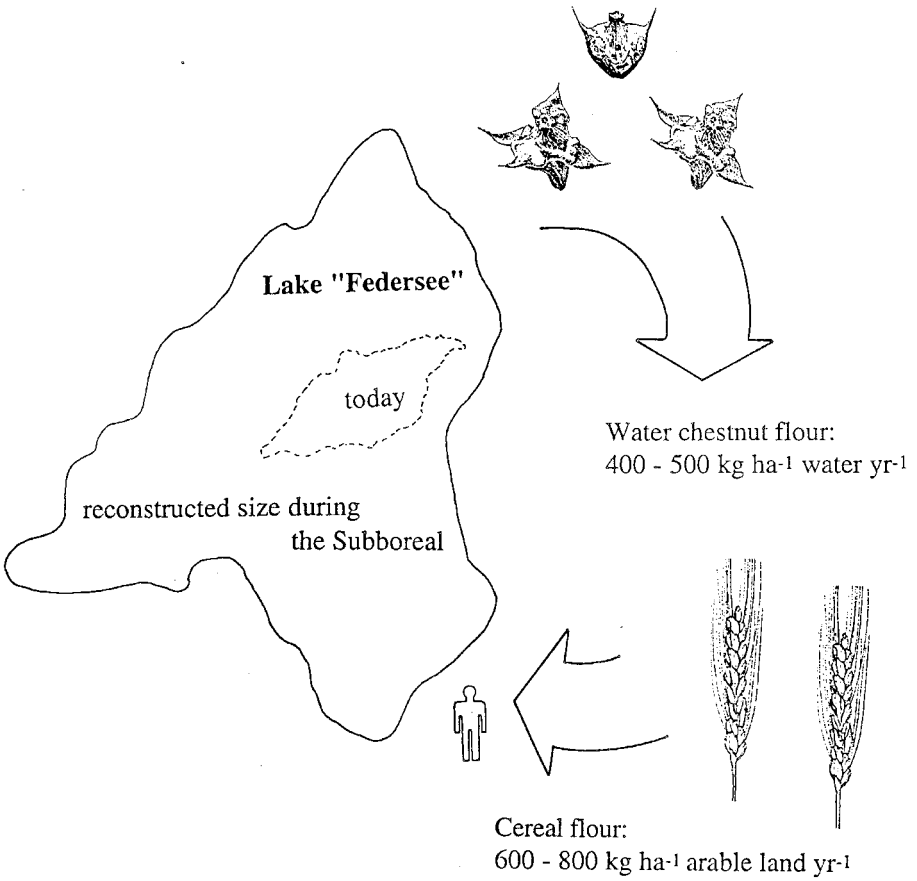

Figure 4 Calculation of the potential yield of water chestnut in the Bronze Age Lake Federsee. Designed by Sabine Karg

their thorns in the silty sediment. The cycle starts again in the following spring. Large birds, beavers and otters transport the fruits from one habitat to another. It is also speculated that prehistoric people dispersed the nuts intentionally (Lang 1994).

Water chestnuts as human nutrition

Until 1880 AD it was possible to buy water chestnuts at many markets all over Europe (Jäggi 1883). In northern Italy the nuts were offered roasted, much as sweet chestnuts (*Castanea sativa* Mill.) are still sold today. At many places in Europe water chestnuts were known and used for human food until the beginning of the 20th century (Brockmann-Jerosch 1914).

The thorny fruits contain one white seed the size of a hazelnut. This seed is extremely rich in starch and therefore very much appreciated as food for fish, as well as for humans. The seeds contain about 50% starch (by comparison, cereals contain 60–70%). The protein content of both cereals and water chestnuts is the same (10%). By roasting the whole nuts, the seeds can be preserved for several weeks. The nuts were probably also roasted in order to make them easier to open. During the roasting process, the woody pericarp becomes brittle and can be cracked easily with the help of a stone or in a mortar. The flavour of the nuts is improved by roasting and they can then very easily be ground to flour on a millstone. The oldest written source from Roman times describes the making of bread from water chestnut seeds by the Thracians (Plinius Historia Naturalis 22, 27). In 1865, Oswald Heer, the pioneer of archaeobotany, described records of water chestnut from two Swiss pile-dwelling sites. He was the first to mention that the prehistoric settlers probably used the nuts for human food.

Calculation of the yield of water chestnuts at Lake Federsee

The charred finds from the Siedlung Forschner prompted me to calculate their potential food value with the help of modern ecological data. Philippi (1980) reports from the oxbow lakes of the River Rhine in southern Germany that one plant can produce up to 10 leaf-rosettes and that one rosette produces around five nuts. This corresponds to a production of 300,000 nuts per hectare of water surface, a yield equating to about 420 kg of cereal flour.

High-resolution palaeoenvironmental analyses of several sediment cores from the surrounding area of the Lake Federsee showed that lake level fluctuations were determining the lateral extent of Lake Federsee during the Holocene period (Liese-Kleiber 1993). According to this reconstruction, the original area of the lake surface was about 1450 ha in the Bronze Age. If, for example, water chestnut plants had covered only one percent of the lake surface, the annual potential yield could have been as high as 6000 kg of cereal flour (Fig. 4). It has to be pointed out that Federsee was in general a shallow lake. The stems of the water chestnut plants can grow up through 2 m of water. Much more flour than this calculated minimum could have been available.

Assuming a daily diet based on 50% carbohydrates, the calculated minimum amount of flour would permit a population of 120 inhabitants to survive during five long, cold and foggy winter months. The use of water chestnut by prehistoric man is not restricted to Lake Federsee in southern Germany. Similar observations have been made at other Neolithic wetland sites, for example in southern Finland (Vuorela and Aalto 1982).

Conclusions

The presented results indicate that the prehistoric population of the Federsee region may well have relied significantly upon this wild food plant to supplement their normal diet and, in times of cultivated cereal crop failure, it may even have been the main dietary component. Today the water chestnut is a very rare plant. The reasons for its near extinction might be due to several factors, such as climatic fluctuations, changes in the nutrient content of the water bodies, and the drainage of many wetlands, ponds and oxbow lakes.

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