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Archaeobotanical investigations of Late Neolithic lakeshore settlements (Lake Biel, Switzerland)

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Abstract. This paper describes the results of the archaeobotanical examination of four Late Neolithic lakeshore settlements on Lake Biel in Switzerland. Due to the excellent preservation conditions in lakeshore settlements, non-carbonized as well as carbonized seeds and fruits were recovered in large numbers. In addition to the diaspore analyses, some samples of charcoal and moss were identified. The spectrum of cultivated plants was markedly different between the sites. In the transition from the 34th to 33rd century B.C. (sites Nidau, Lüscherz and Lattrigen 'VI') naked wheat and barley were predominant, while in the 32nd century B.C. (Lattrigen 'VII') emmer (a glume wheat) was most abundant. Flax and opium poppy were of great importance during the whole late Neolithic period. In addition to cereals, a large number of cereal weeds were detected. The wild flora included a high percentage of aquatic and lake-shore plants which results from the strong influence of water on the cultural layers. Taxa of flood-plain forest are also common. The proportion of potential grassland plants was low (in total only 13 taxa) which suggests that in addition to the cultivated fields only few pastures and grassland areas existed close to the settlements.

Key words: Plant macrofossils – Lakeshore settlements – Late Neolithic – Cultivated plants – Switzerland

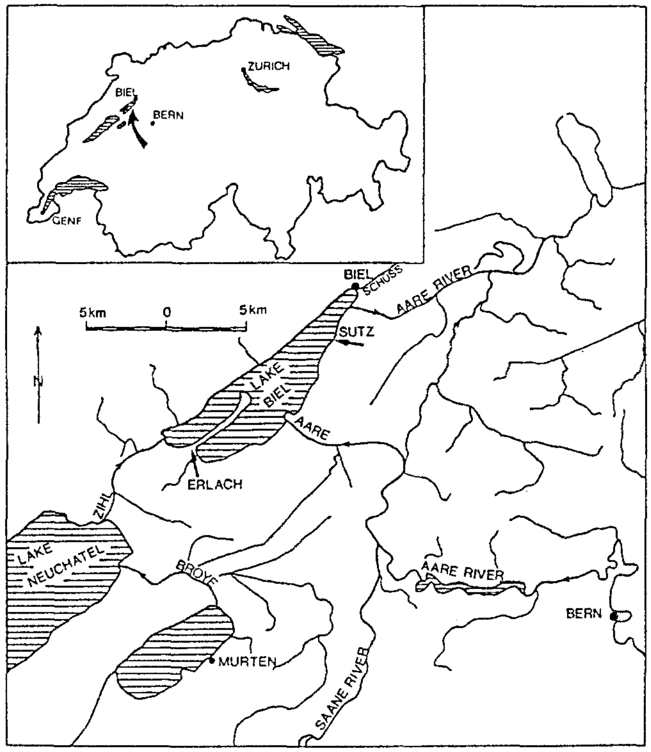


Fig. 1. Situation of Lake Biel in western Switzerland (after Wohlfarth and Schneider 1991)

Introduction

Lake Biel is of glacial origin and is situated in the Alpine foothills (*Alpenvorland*) in western Switzerland south-east of the Jura mountains at ca. 430 m asl (Fig. 1). The area was covered during the upper Würmian by the most recent advance of the Rhone glacier. The north shore of the lake has relatively steep banks which are part of the southern edge of the Jura mountains, and in just 8 km they climb to 1600 m asl. The south facing side borders on the Swiss plateau (the relatively flat lowlands between the Jura mountains and the Alps) and has quite flat banks. In accordance with the topographical situation, the Jura bank is only covered in certain places by a narrow alluvial zone. On the steep-sloped limestone above the banks, mainly xerothermic mixed oak woods with *Quercus pubescens* grow, and on flat ground, natural arid grasslands (*Xerobromion*) occur, vegetation types which are protected (Hegg et al. 1993). These dry places are today largely occupied by vineyards. The opposite, flat bank is a very different natural habitat; on the low lying ground close to the lake with its underlying geology of moraines, river and lake beds, and peat, large areas are dominated by successions starting from open, still water or by fen woods and flood plains (Ammann-Moser 1975). Forests of deciduous hardwoods composed of members of the Fagaceae, mainly beech *(Fagus sylvatica)*, are the natural vegetation of the slightly higher lying Molasse areas (see Hegg 1980).

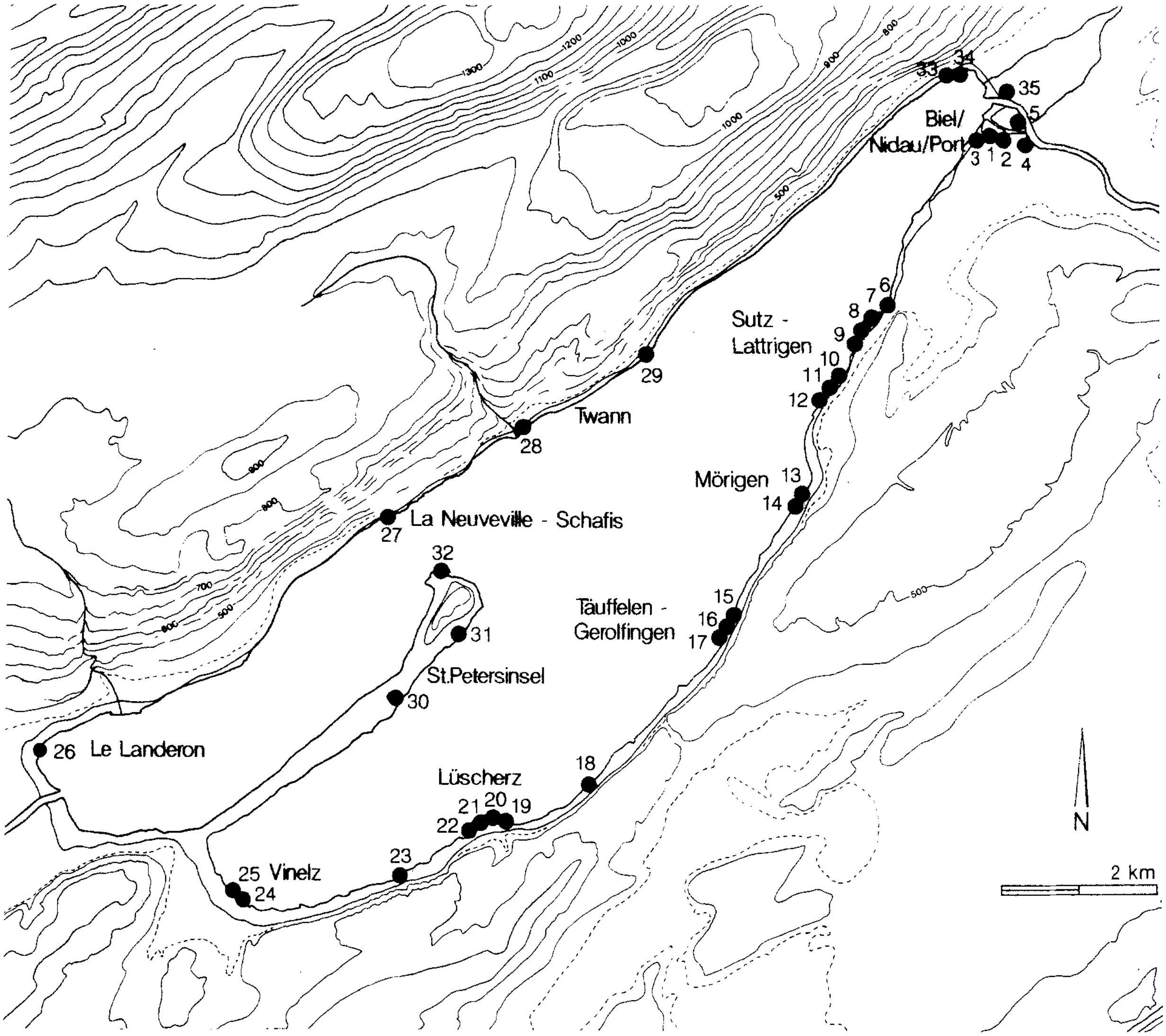


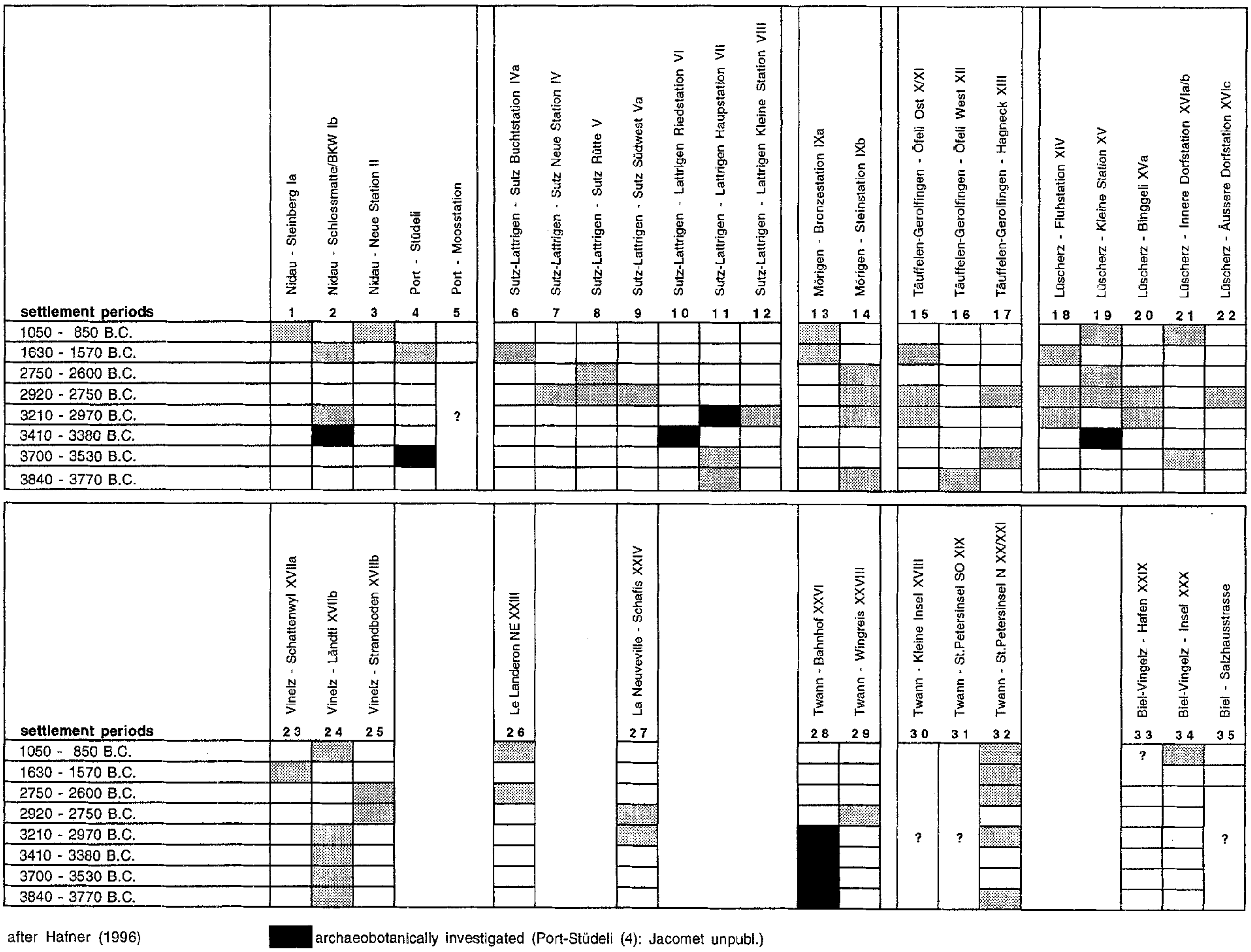
Fig. 2. Map of the excavation sites and settlement periods (after Hafner 1996)

It was known as early as the last century that there were prehistoric lakeshore settlements on Lake Biel. The discovery of pile dwellings on lakes in Canton Zürich in the middle of the last century and the pile dwelling theory of Keller (1854) led to a collecting boom at Lake Biel, as a result of which the building structures and layers of many sites were carelessly destroyed and the archaeological material was plundered.

An artificial lowering of the lake level by about 2 m and the construction of an intensive drainage network in 1888-1892 and 1962-1973 changed the hydrology and the lake shore vegetation to a great extent. This caused a continuous loss of cultural deposits from the prehistoric sites, which during the last decades has been intensified by boat traffic and other leisure activities.

In order to determine the degree of erosion impact, the Archaeological Service of Canton Bern decided to undertake an inventory of the Neolithic and Bronze Age lakeshore settlements around lake Biel: this took place between 1984 and 1987. In addition to examination of the old sites, drilling cores and underwater samples were also taken (Winiger 1989) and pollen analyses of the Late Glacial and early Holocene periods were carried out (Wohlfarth and Schneider 1991). In total, ten settlement concentrations were located which were mainly situated on the southern shore (Fig. 2). All the sites had been occupied several times and are dendrochronologically dated. The Neolithic settlement period was from ca. 3840 B.C.-2600 B.C., shorter periods in the early Bronze Age (ca. 1630-1570 B.C.) and late Bronze Age (ca. 1050-850 B.C.) have also been documented. On the basis of these results, several rescue excavations have been performed in recent years.

Macrobotanical remains have been examined to date from the four Late Neolithic sites, dated between 3400 and ca. 3000 B.C. (Fig. 2). One of these sites, Nidau-Schlossmatte/BKW 1991 (Ib), layer 5, ca. 3410-3380 cal. B.C., is situated at the efflux of the lake in a flood-plain forested area. It was examined in a rescue excavation in 1991 (excavation area ca. 600 m^2). The other three stations: Sutz-Lattrigen - Lattrigen Riedstation (VI), 3393-3388 B.C.; Sutz-Lattrigen - Lattrigen Hauptstation, aussen (VII), 3202-3013 B.C.; and Lüscherz-Kleine Station (XV), 3403-3386 B.C., are situated on the



Legend to Fig. 2

right flat bank of the lake. The cultural layers at these sites lie in the lake below today's water level. In Lattrigen, large underwater excavations have been carried out since 1988: in the winter months of 1988-1990 a 6000 m^2 excavation area of Site 'VI' (Lattrigen-Riedstation) was examined, and between 1988 to 1992 a preliminary survey was carried out of Late Neolithic layers of Site 'VII' (Hauptstation-aussen). Since the beginning of 1996, large scale rescue excavations have also been carried out at this site. In Lüscherz 'Kleine Station' as part of an inventory, an underwater survey was performed in 1987 which yielded a few botanical samples (Winiger 1989).

The degree to which the archaeobotanical examinations have been completed at the individual sites varies. The best studied is Lattrigen 'VII' from where the most samples (69) originate. At this site, the layers representing two archaeological phases could be clearly differentiated. The lower, better preserved group of layers includes cultural layers 1-3 and is dendrochronologically dated to 3203-3139 B.C. In contrast, the upper, later layer which corresponds to the second archaeological phase, layer 0 (dated 31st century B.C.) was more heavily eroded and could only be followed over a small part of the examined area.

The Nidau site (30 samples) can also be classed as well examined, although the cultural layers were strongly affected by water and flooded. Several cultural layers could be distinguished of which only the deepest, layer 5, that corresponds to the settlement period of 3400 B.C. (3403-3386), was examined in detail. This layer was of only limited thickness (5-10 cm) and remained *in situ* in only part of the excavation area. Before the next settlement period in the 32nd century B.C., which is represented by the only slightly organically coloured layer 3, a part of the settlement area was covered by an ancient branch of the efflux of lake Biel. As a result the material of layer 5 was washed up and deposited in a secondary position. Only limited comparisons can be made with Lattrigen 'VI' where the cultural layer was completely eroded and Lüscherz 'Kleine Station'. From these two sites only seven judgement samples (after van der Veen 1987; Jones 1988) were available.

The first comprehensive archaeobotanical investigations at Lake Biel were carried out on the material collected from site Twann which was excavated in 1974-1976. Large sample volumes of the cultural layers of the Cortaillod Culture (37/36th century B.C.) and Late Neolithic were studied for their macrofossils (Bollinger and Jacomet 1981; Piening 1981). These serve as a basic comparison for the investigation described here.

Material and Methods

From the four sites, a total of 106 botanical samples were available (Table 1). They originated in Nidau 'Schlossmatte/BKW' (30 samples with a total volume of 24.5 l), Lattrigen 'VII' (69 samples, total volume 29.6 l), Lattrigen 'VI' (2 samples, total volume 0.1 l), and Lüscherz 'Kleine Station' (5 samples, total volume 0.5 l). The sampling method for the two intensively sampled sites, Nidau 'BKW' and Lattrigen 'VII', was developed from the experience derived from the lake-shore settlements in Zürich (Jacomet et al. 1989); both interval samples from each layer (horizontal distance between samples 1 m to several m) and judgement samples visibly rich in plant material (such as cereal and moss samples) were taken. The volume of the interval samples was between 400 and 2500 ml (average 950 ml), and that of the selected samples between 1 and 150 ml. Only judgement samples (stored grain) were available from Lattrigen 'VI' and Lüscherz. The sampling system at Nidau and Lattrigen 'VII' was in principle identical, but was modified according to the excavation technique. In Nidau, the cultural layer was broken down using the strip-excavation technique both above and below water so that samples could be taken every 2-5 m from the cross and longitudinal sections. The area, which was excavated in 1991, was 600 m^2. The archaeobotanical investigation was confined to the better preserved cultural layer 5. In Lattrigen 'VII', a quadrat of 100 m^2 in the middle of the settlement and extending from it, four 2 m wide and 77 m long sample transects were examined in an underwater excavation (total area examined 730 m^2, with a sample distance of 1-3 m in the middle and about 10 m in the transect area). Material from two occupation phases could be recovered: from the period 3202-3139 B.C. (layers 1-3), and from the 31st century B.C. (layer 0). The cultural layers in Lüscherz were also underwater, the samples being collected during an underwater survey which was carried out in 1987.

The waterlogged sample material analysed was mainly from organic cultural layers, which experience showed to contain most plant material. A few samples were from the contact zone with lacustrine chalk and mixed sandy sediments that lay under and over, respectively, the cultural layers.

The samples were fine sieved with meshes of 8, 4, 2, 1, 0.5, and 0.25 mm. Charcoal isolated from the 8 and 4 mm fractions and seeds and fruits from all the fractions were examined. A maximum of 50 ml of the 0.5 mm fraction and 10 ml of the 0.25 mm fraction were examined, and the number of seeds and fruits of each taxon in these subsamples was used to derive the number for the whole sample.

Results and discussion

Density (Fig. 3)

Generally, the density of grains and fruits in cultural layers of lake shore settlements is very high. From the intensively studied lake shore settlements in Zürich (Jacomet et al. 1989) the better preserved layers of organic sediments yielded on average 1000-5000 items per litre. On comparing judgement samples, the variation is of course higher.

Of the sites described here, the density at Lattrigen 'VII', with averages of 650-2000 in three of the four layers, is significantly higher than in Nidau, which can be accounted for by the better preservation conditions. The frequency distribution for samples has a maximum of 2000 items/l. In Nidau, where the average is only 900 items/l, most of the samples contain between 500 and 1000 items/l.

Presence of plant remains

Considering the two most intensively examined sites, Nidau and Lattrigen 'VII', 36 of about 160 identified taxa appear in more than 50% of the samples, but only a few, however, reach a presence of 90%. At both sites, these are *Papaver somniferum*, *Fragaria vesca*, and *Rubus fruticosus*. In Nidau, *Schoenoplectus lacustris*, and in Lattrigen 'VII', *Linum usitatissimum*, *Malus sylvestris* and *Najas marina* were also found in 90% of the samples. Also appearing with high presence (>80%) at least at one site were *Abies alba* (needles), *Hordeum vulgare* (carbonized grains), *Physalis alkekengi*, *Rosa* spp. and *Triticum dicoccon* (uncarbonized spikelet forks). All of these taxa are exclusively ones that either arrived at the settlement through human activities (cultivated and edible/useful plants) or were washed up from the water or lake shore.

Crop plants

Altogether, seven different cultivated plants could be detected. The large amounts of carbonized cereal grains indicate that cereals played an important role in the nutrition of the Late Neolithic population. The three most important cereals are *Hordeum vulgare*, *Triticum dicoccon* and *T. aestivum/durum/turgidum* (Fig. 4). The most frequently identified is barley (*H. vulgare*) with 8833 grains. From Lattrigen 'VII', even whole or broken ear fragments (52 specimens) were found (Figs. 7, 9). Several samples from Nidau and Lüscherz contained baked grains, which made their identification difficult. The proportion of barley in the cereal spectrum varies between 38% in Lattrigen and 74% in Nidau. As our previous investigations of lake shore settlements showed (Jacomet et al. 1989), chaff fragments of barley are much rarer than grains. In total, only 231 carbonized and 7 uncarbonized rachis segments were found.

Of the wheats, naked wheat (*Triticum aestivum/durum/turgidum*) mainly of tetraploid type and emmer (*T. dicoccon*), a glume wheat, were the most important. However, the number of finds of the two different wheat types at the sites differs markedly. From around 3400 B.C., finds of naked wheat are more numerous. From Nidau, 1042, from Lattrigen 'VI' 23 and from Lüscherz, 2960 grains could be identified. There are clear differences in the spectrum of wheats at Lattrigen 'VII' (ca. 3200-3000 B.C.). Here, emmer (*T. dicoccon*) is the most common wheat, represented by 586 grains, while naked

Table 1. Neolithic plant remains: Lake Biel

Site		Nidau 'BKW'		Lüscherz	Lattrigen 'VI'	Lattrigen 'VII'	
Feature (cultural layer)		NID5	NID5	LUS	LAT	LAT0-3	LAT0-3
Dating (B.C.)		3400	3400	3400	3400	3200-3050	3200-3050
Number of samples		30	30	5	2	69	41
Total volume in litres		24.52	23.57	0.05	0.01	29.68	28.76
		number all samples	presence interval samples	number all samples	number all samples	number all samples	presence interval samples
Uncarbonized plant remains							
cultivated plants							
Anethum graveolens	seed/fruit	1	*5.3*	-	-	6	*9.7*
Apium graveolens	seed/fruit	4	*15.8*	-	-	1	*2.4*
Cerealia	chaff	4	*5.3*	-	-	-	-
Cerealia	pericarp	12	*21.1*	-	-	41	*14.6*
Hordeum vulgare	rachis segments	-	-	-	-	7	*14.6*
Linum usitatissimum	capsule segments	1031	*84.2*	-	-	1944	*92.7*
Linum usitatissimum	seed/fruit	1670	*89.5*	-	-	4659	*97.6*
Papaver somniferum	seed/fruit	2105	*94.7*	-	-	12617	*100.0*
Pisum sativum	seed/fruit	1	*5.3*	-	-	-	-
Triticum aestivum/durum	rachis segments	5	*5.3*	-	-	11	*14.6*
Triticum dicoccon	spikelet forks	-	-	-	-	6353	*80.5*
Triticum monococcum	spikelet forks	-	-	-	-	2	*2.4*
Triticum monococcum/dicoccon	spikelet forks	-	-	-	-	1571	*17.0*
Triticum spec.	rachis segments	6	*10.5*	-	-	-	-
segetal weeds							
Aethusa cynapium	seed/fruit	1	*5.3*	-	-	10	*19.5*
Brassica rapa	seed/fruit	26	*52.6*	-	-	17	*24.4*
Capsella bursa-pastoris	seed/fruit	-	-	-	-	2	*2.4*
Chenopodium polyspermum	seed/fruit	2	*5.3*	-	-	12	*19.5*
Polygonum persicaria	seed/fruit	2	*10.5*	-	-	52	*53.6*
Solanum nigrum	seed/fruit	2	*5.3*	-	-	3	*7.3*
Stellaria media	seed/fruit	4	*15.8*	-	-	39	*48.7*
Aphanes arvensis	seed/fruit	1	*5.3*	-	-	39	*51.2*
Camelina sativa	seed/fruit	2	*10.5*	-	-	12	*21.9*
Campanula rapunculoides	seed/fruit	2	*10.5*	-	-	9	*21.9*
Fallopia convolvulus	seed/fruit	3	*15.8*	-	-	105	*70.7*
Silene cretica	seed/fruit	16	*31.6*	-	-	45	*53.6*
Valerianella dentata	seed/fruit	1	*5.3*	-	-	20	*29.2*
Valerianella locusta	seed/fruit	1	*5.3*	-	-	-	-
Valerianella rimosa	seed/fruit	-	-	-	-	1	*2.4*
Viola tricolor	seed/fruit	1	*5.3*	-	-	7	*14.6*
ruderal weeds							
Arctium cf. minus	seed/fruit	2	*10.5*	-	-	212	*68.3*
Arenaria serpyllifolia	seed/fruit	-	-	-	-	10	*12.2*
Barbarea vulgaris	seed/fruit	-	-	-	-	2	*4.8*
Carex hirta (-type)	seed/fruit	5	*21.1*	-	-	8	*12.2*
Chenopodium album	seed/fruit	6	*21.1*	-	-	122	*58.5*
Chenopodium ficifolium	seed/fruit	1	*5.3*	-	-	-	-
Chenopodium spec.	seed/fruit	1	*5.3*	-	-	4	*9.7*
Cirsium arvense	seed/fruit	1	*5.3*	-	-	-	-
Cirsium vulgare	seed/fruit	-	-	-	-	4	*2.4*
Daucus carota	seed/fruit	1	*5.3*	-	-	12	*24.4*
Galeopsis tetrahit	seed/fruit	-	-	-	-	8	*14.6*
Hyoscyamus niger	seed/fruit	-	-	-	-	1	*2.4*
Lamium cf. maculatum	seed/fruit	1	*5.3*	-	-	-	-
Lapsana communis	seed/fruit	1	*5.3*	-	-	89	*73.1*
Linaria vulgaris	seed/fruit	-	-	-	-	2	*2.4*

Site		Nidau 'BKW'		Lüscherz	Lattrigen 'VI'	Lattrigen 'VII'	
Feature (cultural layer)		NID5	NID5	LUS	LAT	LAT0-3	LAT0-3
Dating (B.C.)		3400	3400	3400	3400	3200-3050	3200-3050
Number of samples		30	30	5	2	69	41
Total volume in litres		24.52	23.57	0.05	0.01	29.68	28.76
		number all samples	presence interval samples	number all samples	number all samples	number all samples	presence interval samples
Malva neglecta	seed/fruit	-	-	-	-	1	*2.4*
Malva sylvestris	seed/fruit	-	-	-	-	2	*2.4*
Nepeta cataria	seed/fruit	-	-	-	-	2	*4.8*
Plantago major	seed/fruit	-	-	-	-	36	*41.6*
Polygonum aviculare	seed/fruit	-	-	-	-	87	*70.7*
Ranunculus repens	seed/fruit	22	*42.1*	-	-	312	*75.6*
Rumex conglomeratus	seed/fruit	-	-	-	-	2	*2.4*
Silene cf. alba	seed/fruit	1	*5.3*	-	-	-	-
Sonchus asper	seed/fruit	2	*10.5*	-	-	76	*68.2*
Sonchus oleraceus	seed/fruit	-	-	-	-	2	*2.4*
Urtica dioica	seed/fruit	5	*21.1*	-	-	162	*70.7*
Verbena officinalis	seed/fruit	17	*47.4*	-	-	27	*29.2*
woodland glades, margin							
Agrimonia eupatoria	seed/fruit	-	-	-	-	5	*9.7*
Carex vulpina (-type)	seed/fruit	-	-	-	-	19	*41.4*
Clinopodium vulgare	seed/fruit	3	*10.5*	-	-	18	*24.4*
Cornus sanguinea	seed/fruit	3	*15.8*	-	-	1	*2.4*
Crataegus monogyna	seed/fruit	-	-	-	-	7	*17.0*
Dianthus armeria	seed/fruit	-	-	-	-	1	*2.4*
Digitalis lutea	seed/fruit	-	-	-	-	1	*2.4*
Eupatorium cannabinum	seed/fruit	1	*5.3*	-	-	15	*21.9*
Fallopia dumetorum	seed/fruit	-	-	-	-	1	*2.4*
Fragaria vesca	seed/fruit	1643	*94.7*	-	-	3387	*95.1*
Hypericum perforatum	seed/fruit	17	*42.1*	-	-	56	*51.2*
Origanum vulgare	seed/fruit	3	*15.8*	-	-	33	*43.9*
Prunus spinosa	seed/fruit	24	*57.9*	-	-	44	*48.7*
Rosa spec.	seed/fruit	9	*26.3*	-	-	396	*82.9*
Rubus fruticosus	seed/fruit	983	*94.7*	-	-	1960	*90.2*
Rubus idaeus	seed/fruit	922	*89.5*	-	-	1001	*85.3*
Rubus idaeus/fruticosus	seed/fruit	-	-	-	-	34	*4.8*
Sambucus spec.	seed/fruit	11	*26.3*	-	-	10	*17.0*
Sambucus ebulus	seed/fruit	41	*68.4*	-	-	73	*60.9*
Sambucus nigra	seed/fruit	3	*15.8*	-	-	6	*12.2*
Sambucus nigra/racemosa	seed/fruit	16	*5.3*	-	-	-	-
Saponaria ocymoides	seed/fruit	1	*5.3*	-	-	-	-
Silene dioica	seed/fruit	1	*5.3*	-	-	-	-
Thalictrum cf. minus	seed/fruit	1	*5.3*	-	-	-	-
Torilis japonica	seed/fruit	-	-	-	-	24	*31.7*
Verbascum lychnitis	seed/fruit	-	-	-	-	1	*2.4*
Viburnum lantana	seed/fruit	5	*21.1*	-	-	14	*26.8*
Viburnum opulus	seed/fruit	4	*15.8*	-	-	-	-
woodland							
Abies alba	needles	111	*89.5*	-	-	51	*48.7*
Alnus spec.	cone fragment	3	*5.3*	-	-	-	-
Alnus glutinosa	seed/fruit	41	*68.4*	-	-	24	*34.1*
Aruncus dioicus	seed/fruit	-	-	-	-	1	*2.4*
Betula pendula/pubescens (alba-type)	seed/fruit	25	*63.2*	-	-	28	*43.9*
Carex sylvatica	seed/fruit	3	*5.3*	-	-	40	*31.7*
Clematis vitalba	seed/fruit	6	*21.1*	-	-	14	*24.4*
Corylus avellana	seed/fruit	50	*47.4*	-	-	297	*68.2*
Fagus sylvatica	seed/fruit	11	*26.3*	-	-	132	*41.5*
Frangula alnus	seed/fruit	2	*10.5*	-	-	-	-
Humulus lupulus	seed/fruit	1	*5.3*	-	-	-	-
Malus sylvestris	pericarp	72	*57.9*	-	-	824	*90.2*

Site		Nidau 'BKW'		Lüscherz	Lattrigen 'VI'	Lattrigen 'VII'	
Feature (cultural layer)		NID5	NID5	LUS	LAT	LAT0-3	LAT0-3
Dating (B.C.)		3400	3400	3400	3400	3200-3050	3200-3050
Number of samples		30	30	5	2	69	41
Total volume in litres		24.52	23.57	0.05	0.01	29.68	28.76
		number all samples	presence interval samples	number all samples	number all samples	number all samples	presence interval samples
Malus sylvestris	seed/fruit	28	*57.9*	-	-	414	*73.1*
Moehringia trinervia	seed/fruit	16	*57.9*	-	-	72	*56.1*
Physalis alkekengi	seed/fruit	391	*89.5*	-	-	100	*43.9*
cf. Phyteuma spicatum	seed/fruit	-	-	-	-	3	*7.3*
Picea abies	wing fragment	1	*5.3*	-	-	-	-
Poa cf. nemoralis	seed/fruit	-	-	-	-	1	*2.4*
Prunus padus	seed/fruit	5	*15.8*	-	-	5	*12.2*
Pteridium aquilinum	leaf	-	-	-	-	11	*19.5*
Quercus spec.	seed/fruit	14	*36.8*	-	-	294	*75.6*
Rubus caesius	seed/fruit	8	*36.8*	-	-	26	*39.0*
Rumex sanguineus	seed/fruit	-	-	-	-	25	*14.6*
Scrophularia cf. nodosa	seed/fruit	2	*10.5*	-	-	8	*17.0*
Stachys cf. sylvatica	seed/fruit	2	*10.5*	-	-	-	-
Teucrium scorodonia	seed/fruit	-	-	-	-	11	*21.9*
Tilia cf. platyphyllos	seed/fruit	3	*5.3*	-	-	-	-
Viola reichenbachiana-type	seed/fruit	3	*15.8*	-	-	3	*7.3*
Viscum album	leaf	9	*5.3*	-	-	-	-
pasture, grassland							
Agrostis spec.	seed/fruit	-	-	-	-	1	*2.4*
Ajuga reptans	seed/fruit	4	*21.1*	-	-	80	*48.8*
Alchemilla vulgaris	seed/fruit	-	-	-	-	1	*2.4*
Campanula glomerata	seed/fruit	-	-	-	-	2	*4.8*
Cerastium fontanum	seed/fruit	3	*15.8*	-	-	209	*75.6*
Deschampsia cf. caespitosa	seed/fruit	-	-	-	-	1	*2.4*
Gentiana cruciata	seed/fruit	-	-	-	-	1	*2.4*
Luzula multiflora	seed/fruit	-	-	-	-	10	*21.9*
Potentilla reptans	seed/fruit	2	*10.5*	-	-	2	*4.8*
Prunella vulgaris	seed/fruit	-	-	-	-	62	*56.1*
Stellaria graminea	seed/fruit	-	-	-	-	35	*41.4*
Taraxacum officinale	seed/fruit	-	-	-	-	1	*2.4*
Trifolium spec.	seed/fruit	1	*5.3*	-	-	4	*9.7*
aquatic, lakreshore							
Alisma spec.	seed/fruit	2	*10.5*	-	-	2	*2.4*
Carex elata/gracilis	seed/fruit	-	-	-	-	26	*31.7*
Chara div. spec.	oogonia	11170	*84.2*	-	-	83	*60.9*
Corrigiola litoralis	seed/fruit	1	*5.3*	-	-	-	-
Cyperus fuscus	seed/fruit	4	*21.1*	-	-	5	*9.7*
Epilobium hirsutum	seed/fruit	-	-	-	-	4	*9.7*
Linum catharticum	seed/fruit	-	-	-	-	2	*4.8*
Lycopus europaeus	seed/fruit	42	*63.2*	-	-	9	*14.6*
Mentha aquatica/arvensis	seed/fruit	19	*36.8*	-	-	9	*19.5*
Molinia caerulea	seed/fruit	1	*5.3*	-	-	18	*34.1*
Myosoton aquaticum	seed/fruit	3	*15.8*	-	-	29	*29.2*
Myriophyllum spicatum	seed/fruit	105	*73.7*	-	-	-	-
Najas cf. intermedia	seed/fruit	1	*5.3*	-	-	-	-
Najas flexilis	seed/fruit	1	*5.3*	-	-	36	*39.0*
Najas marina	seed/fruit	6	*10.5*	-	-	381	*92.6*
Nasturtium officinale	seed/fruit	-	-	-	-	1	*2.4*
Nitella spec.	oogonia	15	*10.5*	-	-	3	*2.4*
Nuphar lutea	seed/fruit	54	*52.6*	-	-	-	-
Nymphaea alba	seed/fruit	1	*5.3*	-	-	-	-
Phragmites australis	seed/fruit	9	*36.8*	-	-	3	*7.3*
Poa cf. palustris	seed/fruit	-	-	-	-	2	*4.8*
Polygonum hydropiper	seed/fruit	2	*10.5*	-	-	21	*29.2*

Site		Nidau 'BKW'		Lüscherz	Lattrigen 'VI'	Lattrigen 'VII'	
Feature (cultural layer)		NID5	NID5	LUS	LAT	LAT0-3	LAT0-3
Dating (B.C.)		3400	3400	3400	3400	3200-3050	3200-3050
Number of samples		30	30	5	2	69	41
Total volume in litres		24.52	23.57	0.05	0.01	29.68	28.76
		number all samples	presence interval samples	number all samples	number all samples	number all samples	presence interval samples
Polygonum minus	seed/fruit	2	*5.3*	-	-	-	-
Polygonum mite	seed/fruit	1	*5.3*	-	-	1	*2.4*
Potamogeton spec.	seed/fruit	244	*63.2*	-	-	24	*17.0*
Potamogeton cf. natans	seed/fruit	2	*5.3*	-	-	-	-
Potamogeton pectinatus	seed/fruit	1	*5.3*	-	-	1	*2.4*
Potamogeton perfoliatus	seed/fruit	14	*10.5*	-	-	5	*7.3*
Potentilla supina	seed/fruit	-	-	-	-	3	*7.3*
Ranunculus aquatilis	seed/fruit	751	*84.2*	-	-	-	-
Ranunculus sceleratus	seed/fruit	-	-	-	-	4	*9.7*
Schoenoplectus spec.	seed/fruit	2	*5.3*	-	-	-	-
Schoenoplectus lacustris	seed/fruit	6908	*94.7*	-	-	136	*75.6*
Typha latifolia	seed/fruit	1	*5.3*	-	-	-	-
Zannichellia palustris	seed/fruit	8	*31.6*	-	-	-	-
various							
Apiaceae (Umbelliferae)	seed/fruit	1	*5.3*	-	-	1	*2.4*
Asteraceae (Compositae)	seed/fruit	1	*5.3*	-	-	4	*7.3*
Brassicaceae (Cruciferae)	seed/fruit	-	-	-	-	1	*2.4*
Calamintha nepeta s.l.	seed/fruit	1	*5.3*	-	-	-	-
Campanula spec.	seed/fruit	-	-	-	-	1	*2.4*
Carex spec. bicarpellat	seed/fruit	6	*10.5*	-	-	30	*51.2*
Carex spec. tricarpellat	seed/fruit	53	*63.2*	-	-	57	*34.1*
Caryophyllaceae	seed/fruit	-	-	-	-	3	*4.8*
cf. Acer spec.	seed/fruit	1	*5.3*	-	-	-	-
cf. Salix spec.	anther	-	-	-	-	1	*2.4*
Chrysanthemum spec.	seed/fruit	-	-	-	-	1	*2.4*
Cirsium spec.	seed/fruit	-	-	-	-	8	*14.6*
Crepis spec.	seed/fruit	-	-	-	-	5	*12.2*
Cyperaceae	seed/fruit	1	*5.3*	-	-	6	*7.3*
Epilobium spec.	seed/fruit	-	-	-	-	3	*4.8*
cf. Euphorbia spec.	seed/fruit	-	-	-	-	1	*2.4*
Fabaceae (Leguminosae)	seed/fruit	1	*5.3*	-	-	2	*4.8*
Lamiaceae	seed/fruit	-	-	-	-	2	*4.8*
Malva spec.	seed/fruit	-	-	-	-	1	*2.4*
Molinia arundinacea	seed/fruit	2	*10.5*	-	-	3	*4.8*
Poa spec.	seed/fruit	-	-	-	-	6	*14.6*
Poa pratensis/trivialis	seed/fruit	-	-	-	-	8	*19.5*
Poaceae (Gramineae)	seed/fruit	2	*5.3*	-	-	5	*9.7*
Rumex spec.	seed/fruit	-	-	-	-	84	*60.9*
Silene spec.	seed/fruit	1	*5.3*	-	-	2	*4.8*
Solanum spec.	seed/fruit	1	*5.3*	-	-	2	*4.8*
Stachys spec.	seed/fruit	1	*5.3*	-	-	-	-
Verbascum spec.	seed/fruit	2	*10.5*	-	-	12	*21.9*
Veronica spec.	seed/fruit	3	*10.5*	-	-	2	*4.8*
Indeterminata	plant remains	45	-	-	-	43	-
Total uncarb.		28969	-	-	-	39770	-
Carbonized plant remains							
cultivated plants							
Anethum graveolens	seed/fruit	-	-	-	-	1	*2.4*
Cerealia	chaff	42	*21.1*	-	-	1	*2.4*
Cerealia	grains	34	*21.1*	-	-	127	*12.2*
Hordeum vulgare	ear	-	-	-	-	52	*7.3*

Site		Nidau 'BKW'		Lüscherz	Lattrigen 'VI'	Lattrigen 'VII'	
Feature (cultural layer)		NID5	NID5	LUS	LAT	LAT0-3	LAT0-3
Dating (B.C.)		3400	3400	3400	3400	3200-3050	3200-3050
Number of samples		30	30	5	2	69	41
Total volume in litres		24.52	23.57	0.05	0.01	29.68	28.76
		number all samples	presence interval samples	number all samples	number all samples	number all samples	presence interval samples
Hordeum vulgare	grains	3765	*84.2*	1825	58	3185	*58.5*
Hordeum vulgare	rachis segments	6	*15.8*	-	-	225	*41.4*
Linum usitatissimum	capsule segments	8	*21.1*	-	-	9	*14.6*
Linum usitatissimum	seed/fruit	31	*47.4*	-	-	139	*48.7*
Papaver somniferum	seed/fruit	1	*5.3*	-	-	12	*14.6*
Pisum sativum	seed/fruit	1	*5.3*	-	-	7	*14.6*
Triticum aestivum/durum	grains	1042	*68.4*	2960	23	108	*34.1*
Triticum aestivum/durum	rachis segments	6	*15.8*	-	-	18	*26.8*
Triticum dicoccon	spikelet forks	-	-	-	-	104	*46.3*
Triticum dicoccon	grains	-	-	-	-	586	*60.9*
Triticum monococcum	spikelet forks	-	-	-	-	1	*2.4*
Triticum monococcum	grains	-	-	-	-	4	*4.8*
Triticum monococcum/dicoccon	spikelet forks	1	*5.3*	-	-	-	-
Triticum spec.	grains	8	*15.8*	3		359	*29.2*
Triticum spec.	rachis segments	-	-	-	-	2	*4.8*
segetal weeds							
Bromus secalinus	seed/fruit	-	-	-	-	1	*2.4*
Vicia hirsuta	seed/fruit	-	-	-	-	3	*4.8*
ruderal weeds							
Sonchus asper	seed/fruit	-	-	-	-	1	*2.4*
woodland glades, margin							
Rubus fruticosus	seed/fruit	-	-	-	-	1	*2.4*
Sambucus ebulus	seed/fruit	2	*10.5*	-	-	1	*2.4*
woodland							
Abies alba	needles	3	*10.5*	-	-	-	-
Alnus glutinosa	seed/fruit	-	-	-	-	6	*7.3*
Corylus avellana	seed/fruit	-	-	-	-	1	*2.4*
Malus sylvestris	seed/fruit	5	*15.8*	-	-	1	*2.4*
Quercus spec.	seed/fruit	3	*5.3*	-	-	29	*2.4*
various							
Fabaceae (Leguminosae)	seed/fruit	-	-	-	-	2	*4.8*
Poa spec.	seed/fruit	-	-	-	-	2	*4.8*
Poaceae (Gramineae)	seed/fruit	4	*5.3*	-	-	-	-
Indeterminata	plant remains	10	-	-	-	2	-
Total carb.		4972	-	4788	81	4990	-
Total (carb. and uncarb.)		33941	-	4788	81	44760	-

wheat is significantly less common (108 grains). Further, among the carbonized chaff remains, there are 104 spikelet forks from emmer and only 18 rachis segments from naked wheat. In contrast, in Nidau as in Lüscherz and Lattrigen 'VI' there are no chaff remains from emmer.

Another glume-wheat species, einkorn (*T. monococcum*) was also found, but in insignificant amounts. The data are not therefore consistent with its active cultivation, rather with its incidental harvest with other cereals.

The cultivation of flax (*Linum usitatissimum*) was of importance throughout the second half of the 4th millennium B.C. Both seeds and capsule fragments of this plant occur frequently in most of the interval samples. The greater proportion of finds are uncarbonized (2975 capsule fragments and 6329 seeds); only a small fraction are carbonized (17 capsule fragments and 170 seeds). Its presence in the interval samples is in Nidau 90% and

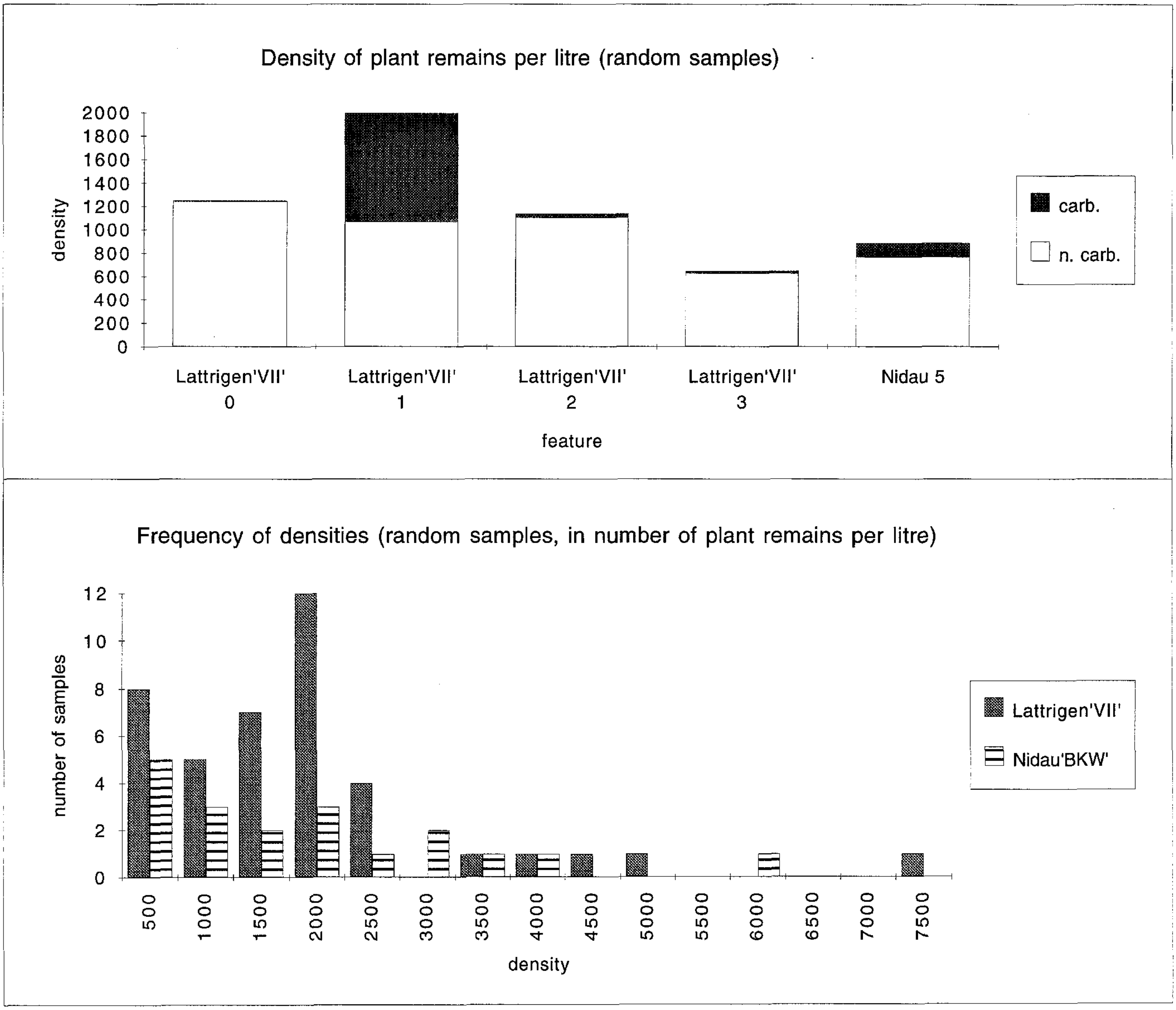


Fig. 3. Density of plant remains

84%, and in Lattrigen 'VII' 98% and 93% for uncarbonized seeds and capsule fragments, respectively. The respective densities were 65.9 and 41.3 items/l in Nidau and 159.7 and 65.7 items/l in Lattrigen 'VII'. Notably, there were also finds of specialized flax weeds such as *Camelina sativa* s.l. and *Silene cretica*. The latter species was frequently identified in sites of the Late Neolithic period in the northern Alpine foothills, but previously there were no archaeobotanical records of it after 2800 B.C. (Brombacher 1993).

An equally important cultivated plant was the opium poppy (*Papaver somniferum*). It occurs in the highest densities in the cultural layers from Lattrigen 'VII' (439 items per litre), where the presence of uncarbonized seeds also reached 100%. Around 3400 B.C. (Nidau) the values are significantly lower (density 89 items/l, but presence still 95%), although this is probably due in part to the preservation conditions.

As the only legume, but also known from other Neolithic sites, a total of 9 peas (*Pisum sativum*; 1 uncarbonized, 8 carbonized) were identified.

Two probably cultivated plant species, dill (*Anethum graveolens*) and celery (*Apium graveolens*) were also found in Nidau and Lattrigen 'VII' with 8 and 5 finds respectively. Both have been recorded from other neolithic sites in Switzerland (Jacomet 1988), but always in insignificant amounts. While dill is indigenous to the eastern Mediterranean and west Asia (Zohary and Hopf 1993), wild forms of celery occur in the Mediterranean basin and in coastal regions of Europe (Körber-Grohne 1987). The records from Swiss Neolithic lakeshore sites must be considered as introduction by humans and may represent a cultivation or an extensive use of these plants.

Collected plants

The numerous remains of collected edible plants clearly indicate that these plants played an important role in the subsistence pattern. In Nidau, berries are the most common: *Fragaria vesca*, *Rubus idaeus* and *R. fruticosus*, various *Sambucus* species and *Physalis alkekengi*. In Lattrigen 'VII', large amounts of *Corylus avellana*, *Malus sylvestris* and *Quercus* species were also found. Other species such a *Prunus spinosa*, *Rosa* spp., and *Fagus sylvatica* were exploited to a much lesser extent.

The highest presence (over 90%) and also the most numerous finds were of *F. vesca*, *R. fruticosus* and *R. idaeus*. However, in terms of the calorific content, *Corylus* and *Malus* were more important.

For many other plant taxa, it is not possible to differentiate between cultivation, collection of useful plants or merely the presence of (uncollected) wild plants. It is most likely that *Brassica rapa*, *Chenopodium album* and *Physalis alkekengi* were used or collected. These three species are not very common at the Lake Biel sites, but were found in particularly high numbers at other Neolithic sites on Lake Zürich and Lake Constance (Bodensee) (Jacomet et al. 1989, 1991; Schlichtherle 1981). *Valerianella dentata* and *Daucus carota* were also possibly used.

Agricultural activities

What did the cultivated land look like that the cereals were grown in? Looking only at the carbonized weed diaspores that are found with the grain samples, no conclusion can be drawn because only a few carbonized wild plant seeds and fruits (Fabaceae and Poaceae) were found. The majority of wild plants that may have come from cultivated land are uncarbonized and thus interpretation is difficult because there are no *Palaeobiocoenoses*, (original combination of the growing plant community) only *Thanatocoenoses* (death assemblages, secondary combination of remains of taxa which did not necessarily grow in the same community) (Willerding 1991, 36). We cannot therefore rule out the possibility that the wild plant material was introduced into the cultural layer during or after its formation and does not originate from the same location. Further, the division of wild plants into ecological groups is particularly difficult in the plant habitats that have been heavily influenced by human activities, such as arable land and pasture, because the species combinations depend on the management practices of the time. During Neolithic times, many plants grew in cultivated fields which today are more common on the edges of woods, in clearings and in ruderal zones (Jacomet et al. 1989; Behre and Jacomet 1991). If we attempt nevertheless to interpret which species may have grown in the fields by drawing from weed rich cereal samples from other Neolithic sites (Piening 1981; Hopf 1968; Jacomet et al. 1989), the following can be seen.

Of the 16 taxa which are segetal today (after Ellenberg 1988), nine are winter weeds and seven summer weeds. Typical winter cereal weeds of today such as *Agrostemma githago* and *Papaver argemone* are absent. Instead, the species found belong to the Late Neolithic spectrum of weeds for the northern Alpine foothills. They include *Fallopia convolvulus*, *Aphanes arvensis*, *Valerianella dentata*, *V. locusta* and *Viola tricolor* which are not particularly tightly associated with winter

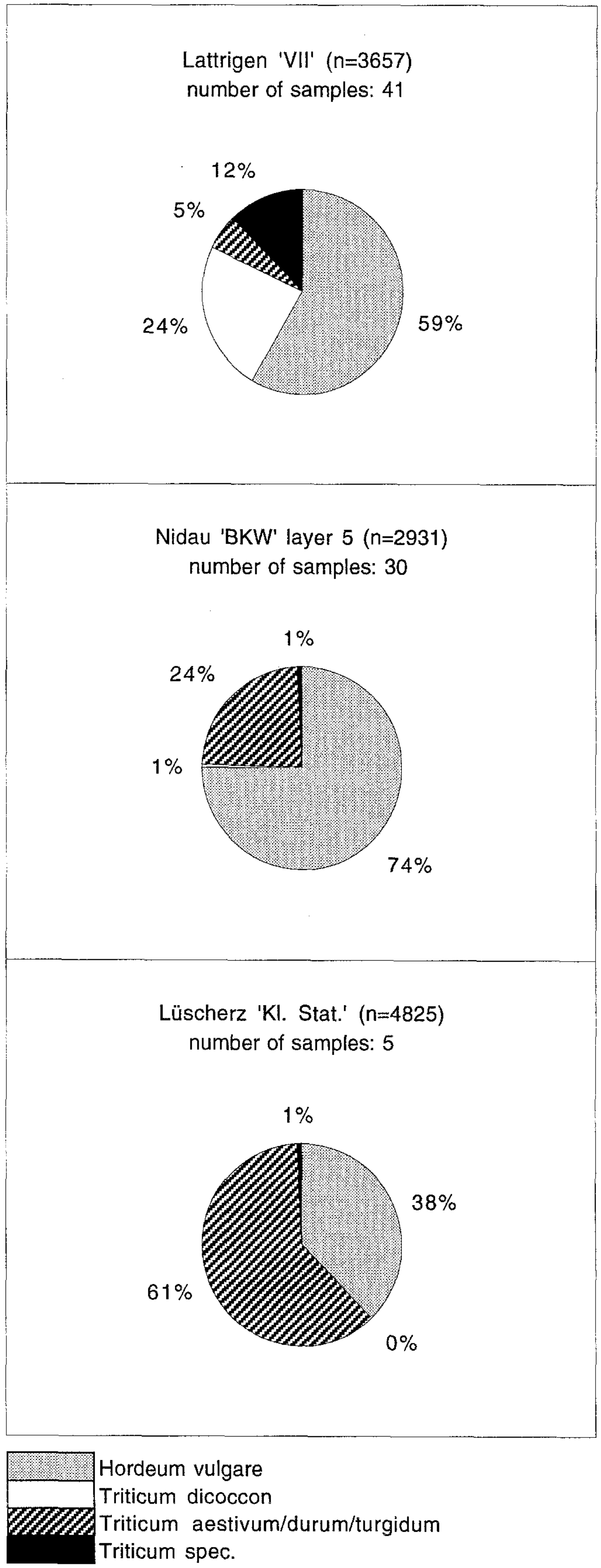


Fig. 4. Proportions of cereal grains

cereal cultivation. The presence of most of these species was not above 60% at any site, with the exception of *F. convolvulus* which was found in 71% of the samples at Lattrigen 'VII'. A similar observation was made for the two flax weeds *Silene cretica* and *Camelina sativa* s.l. Both species are closely linked with flax cultivation, but are found at frequencies of only 32% and 11% in Nidau and 54% and 2% in Lattrigen 'VII', respectively. Among the other possible winter cereal weeds, *Aphanes arvensis* is most common, being found in 51% of samples. The other species occur at frequencies of less than 30%. The summer weeds are also found at low frequencies; only *Brassica rapa* (53%) in Nidau and *Polygonum persicaria* (54%) and *Stellaria media* (49%) in Lattrigen 'VII' were found at frequencies above 30%. The rest (including *Aethusa cynapium*, *Chenopodium polyspermum* and *Solanum nigrum*) were only rarely found. In Lattrigen 'VII' the presence between samples as well as the actual numbers of remains of each species are significantly higher than in Nidau, where, except for *Brassicarapa* and *Silene cretica*, the frequencies were below 10% (Table 1).

Most of the identified winter cereal weeds grow best on a slightly acidic, loamy clay soil. Weeds of more alkaline soils (*Viola tricolor* and *Valerianella dentata*) are in the minority. Similarly the summer cereal weeds indicate that the soil was slightly acidic, as is expected for the prevailing Würm moraine material. The cereal weeds cannot be considered in isolation from the ruderal plants. In the Neolithic age ruderal plants often grew on cultivated land, as shown by the diaspore evidence from grain store samples from various sites (Jacomet et al. 1989). The frequencies with which most of these plants were found was again lower in Nidau (around 3400 B.C.) than in Lattrigen 'VII' (3200-3000 B.C.). Considering the species list (Table 1), the dominant ones among the 27 species attributed to this group are from moist to average locations. The most common at Lattrigen 'VII' are *Arctium minus* (68%), *Chenopodium album* (59%), *Ranunculus repens* (76%) and *Urtica dioica* (71%), though *Lapsana communis*, *Polygonum aviculare* and *Sonchus asper* are also often seen. In Nidau, *Ranunculus repens* was found at the highest presence, 42%, all other species at less than 30%.

The extremely low weed presence at Nidau indicates that there were no fields close to this site and that the grains found were brought from some distance. Similarly the rarity of carbonized and uncarbonized chaff remains here suggests that grain was not processed in large amounts at the site. Carbonized chaff was also rare in the samples from Lattrigen 'VII'; uncarbonized chaff remains were, however, found in large amounts (presence of *Triticum dicoccon* 46%). The small number of uncarbonized chaff finds at Nidau could also be due to the rather poor preservation state of the cultural layer, but since carbonized remains, which would not be affected by the preservation state, are also rare, we conclude that no threshing floor was included in the Nidau site.

In summary, the spectrum of identified wild plants shows that for both Lattrigen 'VII' and Nidau the plant remains brought into the settlement originate in the surrounding area. Thisincludes a utilized area with a radius of around 1-3 km.

Crop cultivation during the Late Neolithic in Switzerland

Comparing the various Neolithic sites with wetland preservation in the Alpine foothills it becomes clear that crop plant species did not change during the Late Neolithic period. However, the prevalence of the different species varies with time and location. Generally, at least two different cereals were cultivated together with flax and poppy.

During the first half of the 3rd millennium B.C., the predominant cereals on the Swiss plateau were naked wheat (*Triticum aestivum/durum/turgidum*) and barley (*Hordeum vulgare*). Glume wheats (*T. dicoccon* and *T. monococcum*) were unimportant at this time. Flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) also played a major role. The small numbers of peas (*Pisum sativum*) remains in the cultivated plant samples could be due to poor preservation and thus cannot reliably indicate the role of peas in this period.

The second half of the 3rd millennium is associated chiefly with changes in cereal cultivation. The importance of naked wheat, which was still predominant at Nidau, Lüscherz and Lattrigen 'VI' declined and was replaced by a glume wheat (usually emmer). The ascendancy of emmer took place between 3300-3200 B.C., but there are marked differences in its prevalence between sites. While naked wheat is unimportant in Lattrigen 'VII' and at Lake Zürich (Seefeld layer 3; Brombacher and Jacomet 1997) it still makes up a large proportion of the cereal remains at other sites (Twann: Ammann et al. 1981; Allensbach/Lake Constance: Karg 1990). Not until the time of the Corded Ware culture, after 2800 B.C., did naked wheat disappear almost completely from the settlements of the Alpine foothills.

There are no such strong differences in flax cultivation, although it is found in larger amounts after 3200 B.C. and especially from the beginning of the Corded Ware culture in east Switzerland and in the Saône-Rhône culture in west Switzerland. A different distribution is seen for the opium poppy which is found in greatest amounts in the remains of the Horgen culture at Lake Zürich (Jacomet et al. 1989) and at Lake Constance (Rösch 1990a). In western Switzerland, to which Lake Biel is also counted, poppy seems to have been much less important.

The developing preference for the less demanding glume wheat during the Late Neolithic could be connected with a more intensive cereal cultivation that, with the expansion of cultivated land and introduction of greater yield densities, led to a loss in soil quality. Evidence for this at Lake Constance is described by Rösch (1990a) and Billamboz (1990), and at Lake Zürich by Jacomet et al. (1989). The most intensive documented settlement of Lake Biel occurred in this period. Here too, there is evidence for a switch to more frugal cereal species together with the bringing of level ground into culti-

Table 2. Crop cultivation during the Late Neolithic in Switzerland

B.C.	site	layer	Hordeum vulgare	Triticum aestivum/durum	Triticum dicoccon	Triticum monococcum	Linum usitatissimum	Papaver somniferum	Pisum sativum	culture	authors
2700	Zürich KANSAN	B/C	XXX	X	XXX	X	XXX	XX	X	Corded Ware	Brombacher, Jacomet 1997
	Zürich KANSAN	D/E	XX	X	XX	X	XXX	XX	?	Corded Ware	Brombacher, Jacomet 1997
	Yverdon Av. des Sports		XXX	XX	XXX	X	XXX	XX	X	Saône-Rhône	Schlichtherle 1985
2800											
	Allensbach-Strandbad	C	XX	XX	XX	X	XXX	XXX	X	Horgen	Karg 1990
2900	Zürich KANSAN	2A	X	X	XX	X	XXX	XXX	?	Horgen	Brombacher, Jacomet 1997
	Sipplingen15	15	X	X	XXX	X	XXX	XXX	?	Horgen	Jacomet 1990
3000											
	Sipplingen14	14	XXX	XX	XX	X	XXX	XXX	?	Horgen	Jacomet 1990
3100	Zürich Mozartstrasse	3	XX	XXX	XXX	X	XXX	XXX	X	Horgen	Dick 1989
	Lattrigen VII	0-3	XX	X	XXX	X	XX	XX	X	Late Neol.	Brombacher (this paper)
	Zürich KANSAN	3	XX	X	XXX	X	XXX	XXX	X	Horgen	Brombacher, Jacomet 1997
	Twann	MH	XXX	XXX	X	X	?	?	?	Late Neol.	Piening 1981
3200	Zürich KANSAN	4	XX	XX	XX	X	XXX	XXX	?	Horgen	Brombacher, Jacomet 1997
	Horgen-Scheller	3	XXX	XX	XX	X	XXX	XXX	?	Horgen	Favre (pers comm.)
3300	Sipplingen11	11	X	X	XX	X	XX	XX	?	Horgen	Jacomet 1990
3400	Nidau BKW	5	XX	XXX	X	X	XX	XX	X	Late Neol.	Brombacher (this paper)
	Hornstaad V		XXX	XXX	X	X	XX	XX	?	Horgen	Rösch 1990b

The importance of the various species is expressed by the number of crosses
Grain specimens are taken into consideration with first priority

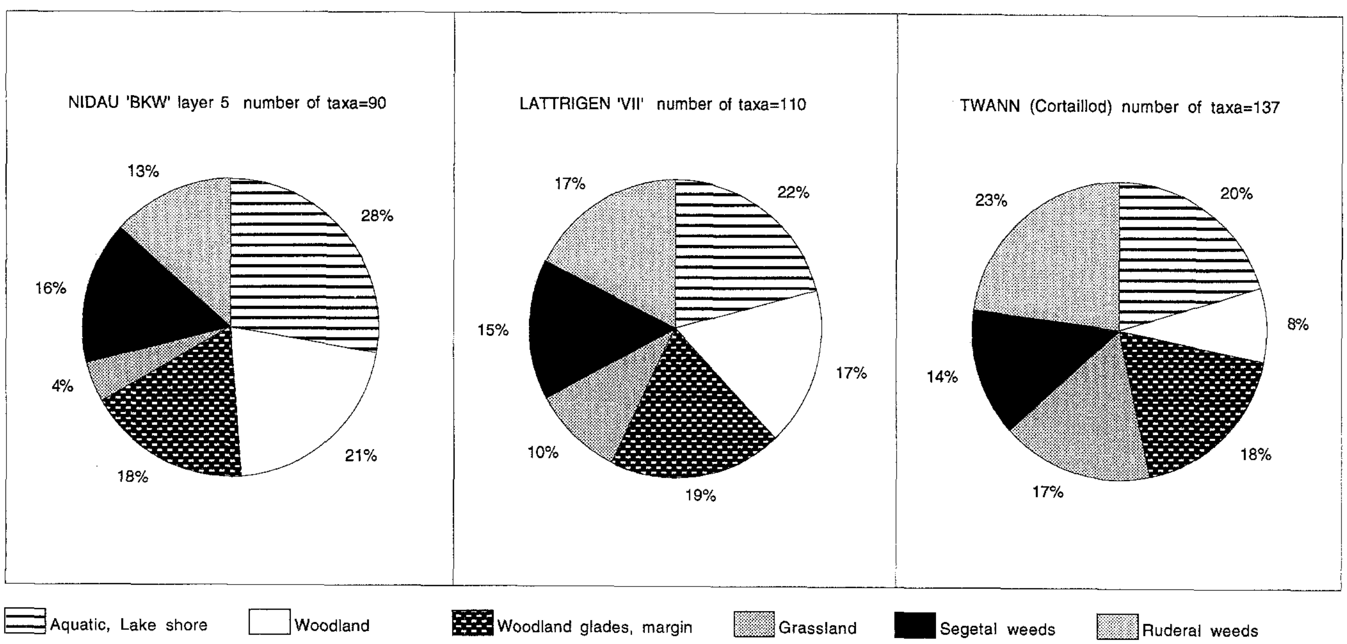


Fig. 5. Proportions of plant remains (seeds and fruits), arranged in ecological groups

vation. Evidence for this derives from the weed flora: Jacomet et al. (1989, 1991) found more species typical of nutrient poor soil in this period such as *Vicia tetrasperma*, *Euphorbia exigua* and *Trifolium arvense*. At the lake Biel sites examined so far, remains of these weeds are rare with the exception of Twann. An intensification of glume wheat cultivation can, however, be clearly seen.

Overview of the natural surroundings

The different natural surroundings of the sites is clearly reflected in their plant spectra. Since there are only judgement samples from Lüscherz, the spectrum of Twann, a site on the left side of the lake (Cortaillod culture, Ammann et al. 1981) has been added. In Nidau, water, lake shore and forest plants reach up to 50% of all identified taxa, whereas in Lattrigen 'VII' only 39% and in Twann 28% belong to this group (Fig. 5). This difference clearly reflects that in Neolithic times, Nidau was in a riverbank area at the efflux of the lake. In contrast, only 20% of the taxa from Nidau are segetal weeds and grassland species, but 25% in Lattrigen 'VII' and 31% in Twann. It is not surprising that Twann has the highest proportion of grassland species since natural open vegetation (arid grassland) occurs close to the site (Ammann et al. 1981).

Lake shore vegetation

A large portion of the identified plant remains originate from the immediate surroundings of the settlements, the lake shore and the alluvial zone. Water and lake shore plants, 28% of all taxa in Nidau and 22% in Lattrigen 'VII', make up the greatest proportion of species identified. In Nidau, this fraction is particularly large in samples from those parts of the cultural layer that were disturbed by the river. In Lattrigen 'VII', the flooded areas of the cultural layer have the highest proportion of water and lake shore plants, while the better preserved organic parts of the layer contain relatively few such remains. In Nidau oospores of stoneworts are very common, over 10 000 specimens; but seeds and fruits of various *Potamogeton* spp., *Myriophyllum spicatum* and *Ranunculus aquatilis* were also found in large numbers. The lake was already at this time relatively nutrient rich as

Table 3. Lattrigen 'VII' and Nidau 'BKW'. Moss remains

Site Feature Ecological indicator value (after Ellenberg 1991)		L	T	K	F	R	life form	Lattrigen VII 0-3	Nidau BKW 5
Anomodon cf. *longifolius*	(Brid.) Hartm.	4	3	6	5	8	C, E	X	X
Anomodon viticulosus	(Hedw.) Hook. & Tayl.	4	3	5	4	8	C, E	XXX	X
Antitrichia curtipendula	(Hedw.) Brid.	6	3	4	4	6	C, E	XX	
Brachythecium spec.	Schimp.							X	
Bryum spec.	Hedw.							X	
Calliergon giganteum	(Schimp.) Kindb.	8	3	5	8	8	C	X	
Cratoneuron filicinum	(Hedw.) Spruce	7	x	5	7	7	C	X	
Eurhynchium hians	(Hedw.) Sande Lac.	7	4	5	5	7	C	X	
Eurhynchium striatum	(Hedw.) Schimp.	5	6	3	5	6	C,(E)	X	
Homalothecium sericeum	(Hedw.) B., S. & G.	8	3	5	2	7	C,(E)	X	
Hylocomium brevirostre	(Brid.) B., S. & G.	5	5	4	5	6	C	X	
Hypnum spec.	(Hedw.)							X	X
Hypnum cupressiforme	Hedw.	5	x	5	4	4	C, E	X	
Isothecium alopecuroides	(Dubois) Isov. var.	5	4	6	5	6	C, E	X	X
Leucodon sciuroides	(Hedw.) Schwaegr.	8	5	5	4	6	C, E	XX	X
Neckera complanata	(Hedw.) Hueb.	4	3	5	4	7	C, E	X	
Neckera crispa	Hedw.	3	3	5	4	7	C, E	XXX	XX
Neckera cf. *pennata*	Hedw.	5	4	6	5	6	C, E	X	
Platygyrium repens	(Brid.) B., S. & G.	6	5	6	4	6	C, E	X	
Porella platyphylla	(L.) Pfeiff.	5	3	5	4	6	C, E	X	
Pylaisia cf. *polyantha*	(Hedw.) Schimp.	8	3	6	5	7	C, E	X	
Thuidium delicatulum	(Hedw.) B., S. & G.	7	4	5	4	7	C	X	
Thuidium philibertii	Limpr.	6	3	4	4	7	C	X	
Ulota cf. *crispa*	(Hedw.) Brid.	4	3	5	6	3	C, E	X	

C=Chamaephyte, overwinters on the substrate, E=Epiphyte, growing on living plants (mostly trees)
R: indicator of mostly weakly acidic to weakly basic soils
F: mostly coolness indicator, only Calliergon indicates dampness

The importance of the various taxa is expressed by the number of crosses

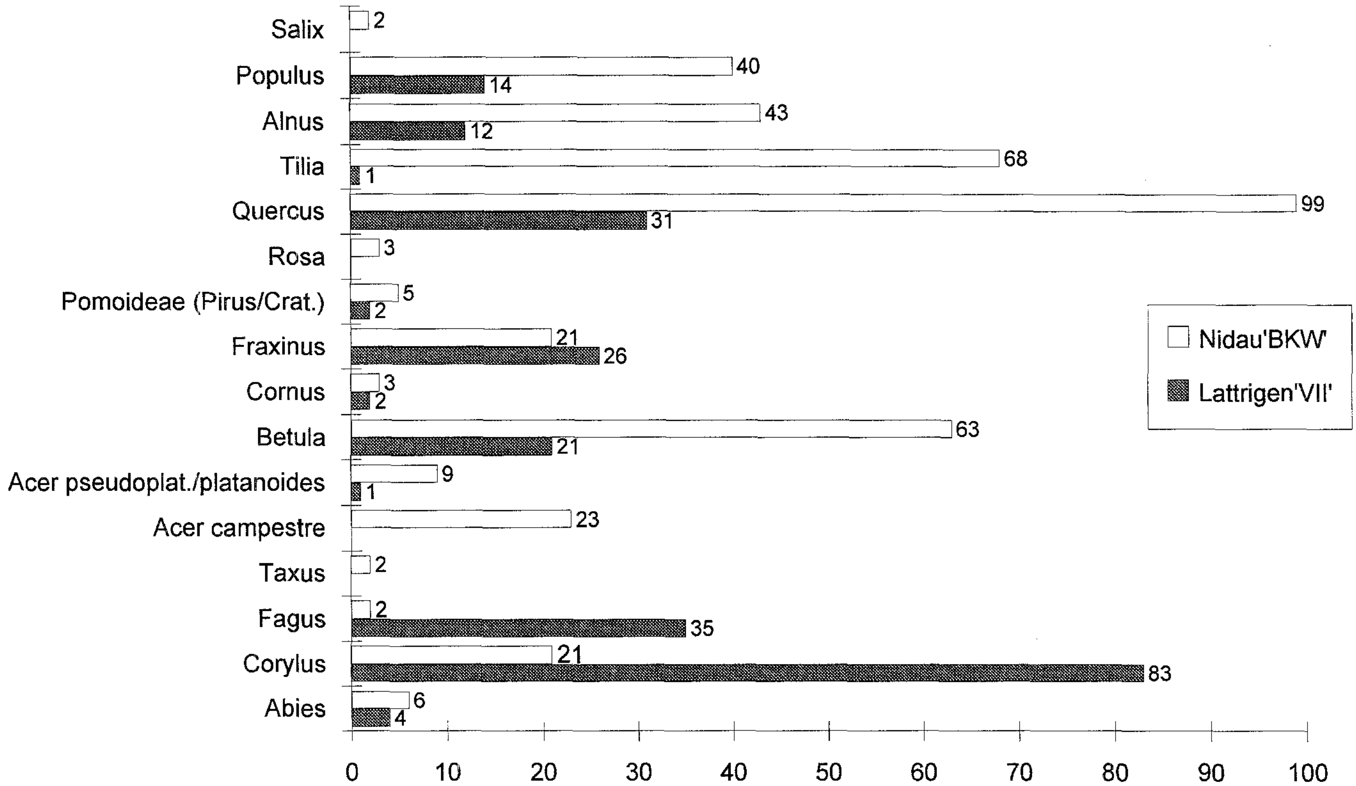


Fig. 6. Charcoal (number)

shown by the diaspore finds of *Zannichellia palustris*. Evidence of plants with floating leaves (*Nuphar lutea* and *Nymphaea alba*) indicate that the water was relatively calm close to the efflux. In Lattrigen 'VII' there are significantly fewer water plants: *Najas marina* is the most common, but *Najas flexilis* remains are also found in small numbers. On the basis of the frequent diaspore finds of reed-bed plants (*Schoenoplectus lacustris* and *Phragmites australis*) in Nidau we can conclude that at least close to the efflux there was an extensive reed bed around the lake. Plant remains from the large-sedge swamp (large numbers of *Carex* fruits) and from the neighbouring meadows with *Molinia caerulea* and *Eleocharis palustris* also occur regularly in many samples from Nidau and Lattrigen 'VII'. Of the rare species, we mention only the evidence of *Corrigiola littoralis* and *Najas flexilis* which are now extinct in the Swiss plateau. The first is a riverbank plant, which grows in sandpits and sandy riverbanks, the latter is an annual temperate water plant that is sensitive to temperature changes (Haas personal communication).

Woodland

Species typical of fen woods and flood-plain forest vegetation were also often identified. Diaspores from *Alnus glutinosa* and *Frangula alnus* reflect the alder swamp woods present at the time. Of the numerous identified taxa in the woods, woodland edges and clearings group, *Clematis vitalba*, *Scrophularia nodosa*, *Prunus padus* and *Physalis alkekengi* are frequently found in flood-plains. Utilization of the flood-plain forests is clearly demonstrated by the charcoal samples of which sub-samples were identified (five samples from Nidau, six samples from Lattrigen 'VII'; mesh fractions ≥ 4 mm). A total of 800 pieces could be identified. The spectra of wood taxa at the two sites are shown in Fig. 6. In total 16 different taxa are represented (Lattrigen 'VII': 12, Nidau: 16). In Nidau taxa of river bank forests (*Alnus*, *Populus*, *Salix*) as well as *Betula*, *Quercus* and *Tilia* were prevalent. In Lattrigen 'VII' broadleaved woodland taxa (*Corylus* and *Fagus*) are more dominant among the charcoal samples.

The most common type of wood at Nidau is oak (*Quercus*) at 25% of the total. Oak was the most valuable building timber and so, despite its high energy content, we can suggest that it was not used as fuel in first priority. The oak charcoal is therefore mainly assumed to be building or carpentry waste or from a fire in the settlement. Other woods which were probably used as timber are white fir (*Abies alba*), ash (*Fraxinus*) and alder (*Alnus*). Lime (*Tilia*), birch (*Betula*) and poplar (*Populus*) appear frequently (18, 15, and 10%, respectively) in the charcoal spectrum from Nidau. Of the three, birch and poplar are most suitable for fuel, and lime was probably used for making bast. The spectrum from Lattrigen 'VII' is significantly different; hazel (23%) and beech wood (10%) are predominant, while oak is the third most common kind of charcoal identified at 9%. The more valuable timber types such as maple (*Acer*) and yew (*Taxus*) are rare. Of note are the specimens of spruce cones (*Picea abies*) from Nidau since spruce cannot be expected to have grown as natural vegetation in the vicinity. These cones were presumably washed down from the nearest spruce stands in the Jura mountains in the Chasseral area 10 km away at ca. 1200-1400 m asl. Regarding the whole wood spectrum, the presence of the different taxa correlates well with the probable vegetation in the environment of the settlements. This strongly suggests that the wood was felled as close as possible to the settlement.

Grassland

In contrast to Twann, where a large number of grassland plants were found as early as the first half of the 4th millennium B.C. (ca. 3840-3530 B.C.), relatively few grassland plants were found in the lakeshore settlements on the south bank of Lake Biel described here. In Lattrigen 'VII' the portion of plants belonging to the grassland group was only 10%, in Nidau, just 4%. The most common types (*Ajuga reptans*, *Cerastium fontanum*, *Potentilla reptans*, *Prunella vulgaris* and *Stellaria graminea*) all have a wide ecological amplitude and can also grow in woodland borders, paths, grazed fields and ruderal zones. *Potentilla reptans* and *Prunella vulgaris* indicate a rather wet or boggy ground. Evidence of moist meadows close to the shore is, however, infrequent; from these habitats only *Molinia caerulea* and *Eleocharis palustris* are found. The other taxa which could originate in grasslands are rare and chiefly found in the Lattrigen 'VII' samples. This suggests that in the vicinity of both settlements there were no extensive grasslands. Evidence of calcareous swards, as found on the north bank of lake Biel at Twann (Ammann et al. 1981) and at the Auvernier-Brise-Lames site on the north shore of lake Neuchâtel (Baudais-Lundstrøm 1978), is except for a single seed specimen of *Saponaria ocymoides* not found at the sites described here.

Mosses

Mosses were identified in sub-samples taken from the < 2 mm material of many of the samples from Lattrigen 'VII' (22 samples) and from Nidau (4 samples). The aim of this study was to gain further palaeoecological information about the region surrounding the settlements through knowledge of the ecology of the species and to find which moss species were preferred by people. Recent classification and analyses of mosses from prehistoric settlements are rare (Rösch 1988, 1990c). Older evidence from Swiss lakeshore sites can be found in Neuweiler (1924).

Three hundred moss fragments were available and were assigned to 25 different taxa; 24 were mosses and one, *Porella platyphylla*, was a liverwort (Table 3). As in other Neolithic wetland sites, the two most common species were *Anomodon viticulosus* and *Neckera crispa*, being found in 95% and 82%, respectively, of all the

Table 4. Measurements (in mm) and indices of cereals (N = number of grains measured)

Taxon			mean values						standard deviation					
	number of sample	N	Length	Breadth	Thickness	L/B	B/T	L/T	Length	Breadth	Thickness	L/B	B/T	L/T
Hordeum vulgare	NID 1	41	4.70	3.50	3.06	1.35	1.15	1.55	0.565	0.407	0.372	0.15	0.10	0.20
	NID 101	5	4.86	3.08	2.46	1.58	1.27	2.02	0.385	0.217	0.385	0.17	0.21	0.34
	NID 107	37	4.58	2.96	2.36	1.56	1.26	1.96	0.589	0.406	0.387	0.18	0.11	0.27
	NID 108	17	4.68	2.88	2.34	1.64	1.24	2.02	0.536	0.417	0.359	0.14	0.11	0.20
	NID 109	24	4.71	2.95	2.39	1.63	1.24	2.01	0.475	0.494	0.418	0.21	0.14	0.25
	NID 111	50	4.92	3.11	2.41	1.59	1.31	2.08	0.496	0.385	0.426	0.14	0.15	0.31
	NID 113	20	4.70	2.95	2.35	1.62	1.26	2.03	0.517	0.495	0.346	0.22	0.17	0.31
	NID 118	16	4.92	2.96	2.38	1.70	1.27	2.16	0.753	0.637	0.601	0.27	0.14	0.46
Triticum aestivum /durum/turgidum	NID 2	50	5.60	3.89	3.47	1.46	1.13	1.63	0.549	0.466	0.403	0.16	0.11	0.20
	NID 3	17	5.06	3.36	2.94	1.51	1.15	1.74	0.477	0.318	0.352	0.16	0.14	0.20
	NID 4	50	5.31	3.59	3.16	1.49	1.14	1.69	0.637	0.464	0.370	0.15	0.10	0.20
	NID 107	9	4.81	3.26	2.89	1.49	1.14	1.69	0.565	0.407	0.372	0.15	0.10	0.20
	NID 118	10	4.67	3.57	2.99	1.33	1.20	1.58	0.713	0.724	0.540	0.13	0.15	0.16
	LÜS 1	50	4.86	3.44	2.81	1.42	1.23	1.75	0.662	0.516	0.419	0.15	0.19	0.24
Triticum dicoccon	LAT204	8	5.10	2.61	2.61	1.97	1.00	1.35	0.463	0.368	0.280	0.23	0.10	0.25
	LAT207	7	5.06	2.71	2.74	1.89	1.00	1.47	0.369	0.393	0.190	0.24	0.17	0.17
	LAT108	6	5.23	2.80	2.48	1.88	1.14	1.33	0.674	0.447	0.500	0.10	0.12	0.31
	LAT105	5	5.00	2.76	2.44	1.83	1.13	2.05	0.436	0.297	0.182	0.22	0.06	0.15
	LAT110	15	5.07	2.65	2.43	1.93	1.09	1.27	0.595	0.376	0.301	0.20	0.12	0.21

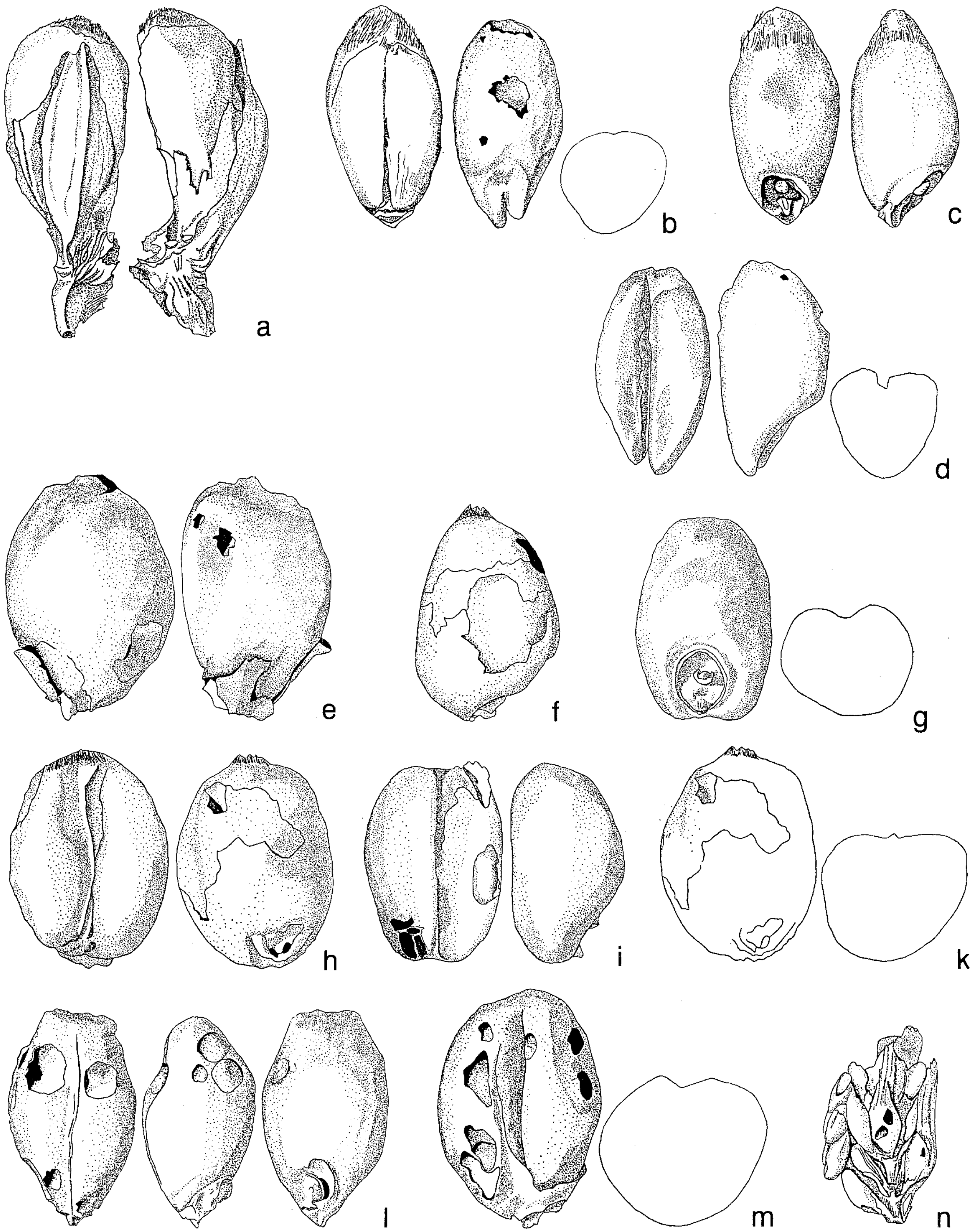


Fig. 7. Cereals (13 drawings): Various types of wheat grains: *Triticum dicoccon* (4, a-d), *T. aestivum/durum/turgidum* (6, e-k), *Hordeum vulgare* (3, l-n)

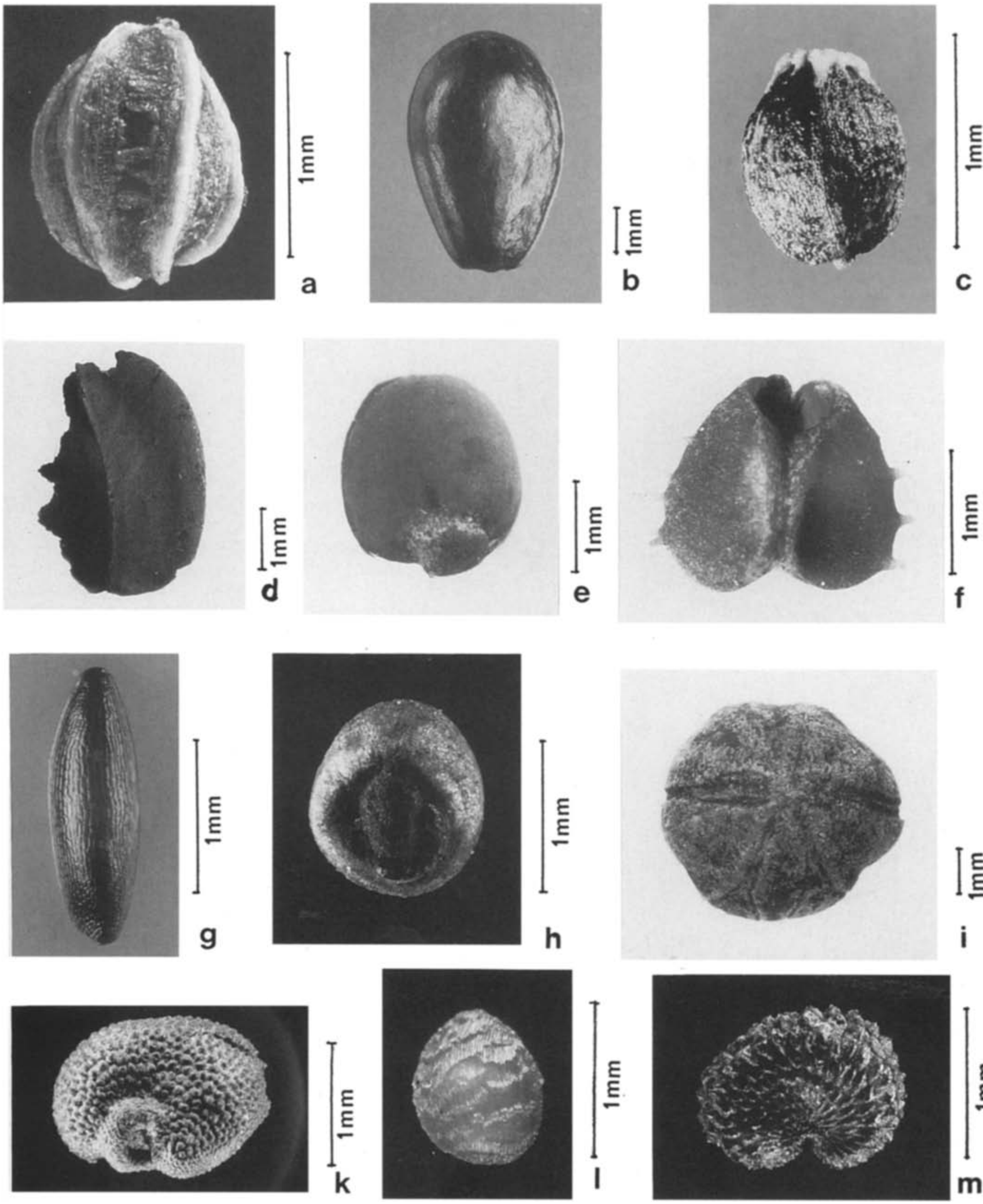


Fig. 8. Seeds and fruits (12 photos): **a** *Apium graveolens*, **b** *Nuphar lutea*, **c** *Corrigiola litoralis*, **d** *Frangula alnus*, **e** *Humulus lupulus*, **f** *Myriophyllum spicatum*, **g** *Najas flexilis*, **h** *Teucrium scorodonia*, **i** *Cornus sanguinea*, **k** *Saponaria ocymoides*, **l** *Ranunculus aquatilis*, **m** *Silene cretica*

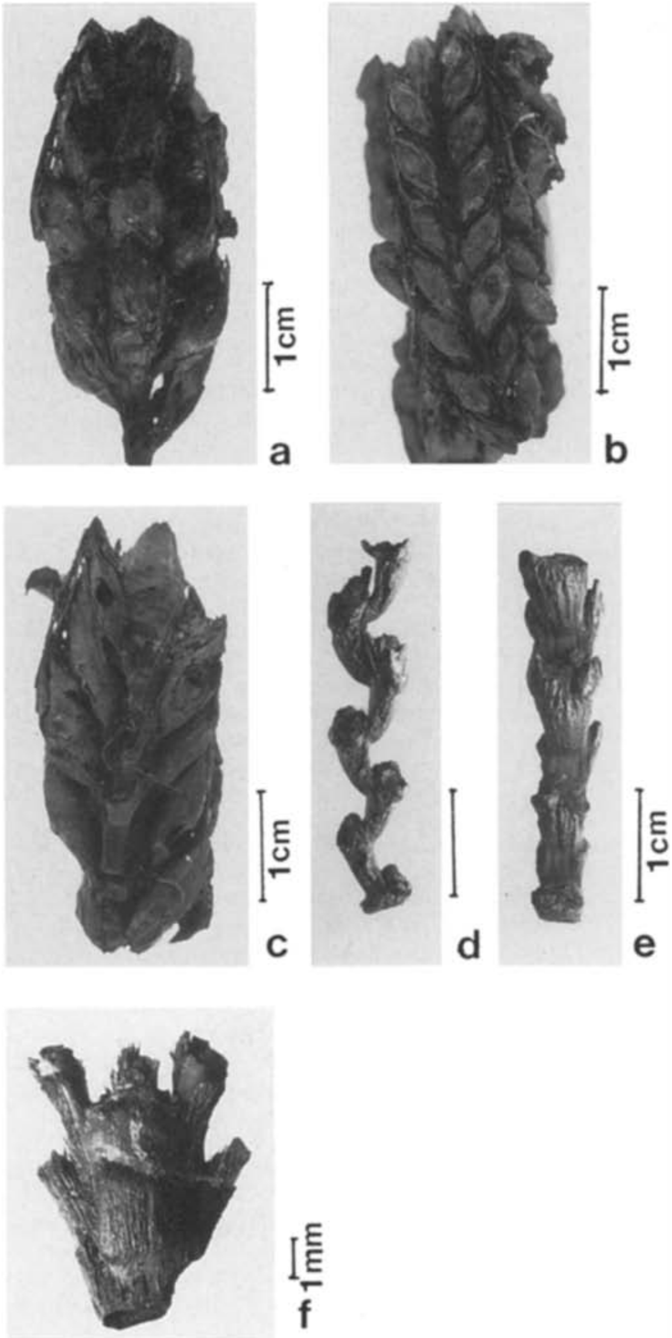


Fig. 9. Cereals (6 photos): *Hordeum vulgare* (3, a-c), *Triticum aestivum/durum/turgidum* (3, d-f)

samples examined. *Antitrichia curtipendula* and *Leucodon sciuroides* were also relatively common. These four moss species are all epiphytes which occurred on bark and sometimes on rocks in the Neolithic woods. All the other taxa were seldom found: dividing them according to habit, nine are epiphytes, four are ground mosses, eleven are found in broad habitat types and one, *Calliergon giganteum*, belongs to the bog and water mosses. The prevalence of the epiphytes shows that most of the mosses were gathered from or originated on tree trunks and branches in the nearby woods. Considering the ecological requirements of the different taxa, the predominant ones are the shadow loving bark mosses *Neckera crispa* and *Anomodon viticulosus*. Species normally found in open woodland e.g. *Leucodon sciuroides* and *Antitrichia curtipendula* were, however, also found. Among the ground mosses and broad habitat species, are some indicators of more open ground, such as *Thuidium delicatulum* which grows on unwooded ground.

Comments on some of the identifications

Wheat

Free threshing wheat, *Triticum aestivum* L./*durum* Desf./*turgidum* L., was the most numerous wheat type in the samples. Of the 4133 carbonized grains found, 186 were measured. Most were of the dense-eared form (club wheat) with short, compact grains (Figs. 7, 9). This was also apparent from the L/B (length/breadth) index which in the grains in this group was 1.03-1.59 (Table 4). Jacomet (1987) defined the cut-off point between the long, slim grains of *T. aestivum* s. str. type and the short compact grains of compact-type as 1.5. Only 38 grains had a L/B index of over 1.6 clearly above this value (1.6-1.85). Differentiation of tetraploid naked wheat of the *T. durum/turgidum* (macaroni/cone wheat) type from the *T. aestivum* (bread wheat) type is not possible from the grains. Rachis remains can indicate whether a wheat is tetraploid or hexaploid (Maier 1996), but were seldom found in the samples, however the swellings underneath the glume attachment and the straight course of the side edges fitted much better with tetraploid naked wheat (Fig. 9).

The second most common wheat was emmer (*T. dicoccon*) which only occurred in the younger layers (site Lattrigen 'VII': 586 grains). Emmer grains are distinctly narrower but with a L/B index higher than that of the naked wheat grains. The values for the 41 grains measured lay between 1.55 and 2.41 (average 1.83-1.97). Many grains were deformed and no longer had distinguishing characteristics.

Barley

Barley was the most commonly identified grain at all of the sites examined. As well as the large number of grains (8833) 52 more or less highly fragmented ears were also found (Figs. 7, 9). These showed that this was a many-rowed barley. On several of these ear fragments the rachises, which bear the diagnostic characteristics distinguishing lax-eared (4 rowed) barley from dense-eared (6 rowed) barley, were visible. The rachis segments were very hairy which, according to Jacomet (1987), suggests they belong to dense-eared barley. The short length (1.7-2.7 mm) and the L/B index of the rachis (2.5-3.1) are also consistent with dense-eared barley. These features can be clearly seen on the ear fragments (Fig. 9).

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