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ORIGINAL ARTICLE

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Plant remains from a Bell Beaker site in Switzerland, and the beginnings of *Triticum spelta* (spelt) cultivation in Europe

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Abstract Little is known of the archaeobotany of the Bell Beaker period. The village of Cortaillod/Sur les Rochettes-est in Switzerland is one of the first settlements of this date discovered so far; and one of the few sites where systematic archaeobotanical research could be undertaken. The 114 features, mainly postholes, produced 5080 charred plant macrofossils. The composition of the cereal spectrum was dominated by hulled wheats and notably by *Triticum spelta* (spelt). Other important components were *Triticum dicoccum* (emmer) and *T. monococcum* (einkorn), and probably also *Hordeum* (barley). The abundance of spelt represents a fundamental change compared with the plant finds from earlier sites of the region. The origin of this cereal species is discussed in the light of recent results of cytogenetic and molecular research.

Keywords Neolithic · Bell Beaker · Plant macrofossils · *Triticum spelta* · Switzerland

Introduction

Remains from the Bell Beaker Culture are found in an area from Portugal to Poland, and from Morocco to the British Isles. Despite this wide geographical range and its relative long duration (from ca. 2800–2000 B.C., with marked variations depending on the location), this culture is still largely unknown from an archaeobotanical point of view. Only 16 sites have been investigated to date: one in Portugal (Hopf 1981), two in Spain (Buxó 1997), five in France (Billard et al. 1994; Bouby 1998; Hénon and Vérot-Bourrély 1998; de Hingh 2000), one in Italy (Pals and Voorrips 1979), one in Germany (Matthias and Schultze-Motel 1969; Schultze-Motel and Gall 1994), one in Switzerland (Rigert et al. in press), one in the Czech Republic (Tempír 1985), three in Hungary (Gyulai 2003) and one in Denmark (Robinson 1992). Most of these sites yielded very few plant remains. Almost nowhere was it possible to systematically sample a larger quantity of archaeological features.

This unsatisfactory state of knowledge may be explained by the fact that most of the archaeological features discovered up to the present day are graves. Bell Beaker houses and settlements are almost unknown. Therefore the discovery of the village of Cortaillod/Sur les Rochettes-est raised the hope of finding out more about the spectrum of cultivated and wild plants of this archaeological period.

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Materials and methods

The site of Cortaillod/Sur les Rochettes-est is located at N 46°57' / E 6°50', at 485 m asl, on a plateau ca. 1 km northwest of the shore of Lake Neuchâtel (Fig. 1). It was discovered during systematic surveys for the construction of motorway A5, which revealed 29 sites with features or finds that could be attributed to Bell Beaker (von Burg 2002). At Cortaillod/Sur les Rochettes-est, the predominant archaeological features were postholes, 71 of these forming the ground plans of seven houses. The houses were between 13.4 and 17 m long and between 3.8 and 4.6 m wide. Houses 1 to 5 belong to a first phase of occupation. Houses 4 and 5 were destroyed by a fire, with houses 6 and 7 built to replace them shortly afterwards (although on a slightly different alignment). No archaeological layers were preserved and all the material recovered was preserved in the fills of postholes. Radiocarbon dating was carried out on material from 17 postholes, and all returned Bell Beaker dates. 15 postholes could not be attributed to one of the houses. Two Hallstatt pits were found ca. 15 m south of the houses. Some more features were excavated which contained no material and could therefore not be identified or dated.

Soil samples with a total volume of 1012.1 l were collected from all of the 114 archaeological features. Each sediment sample was washed through a set of three sieves, with meshes of 4, 1, and 0.5 mm. Organic and inorganic remains were separated by flotation. All of the resultant fractions were sorted completely. Nomenclature follows Miller (1992) for *Triticum*, and Aeschimann and Heitz (1996) for all other plant taxa.

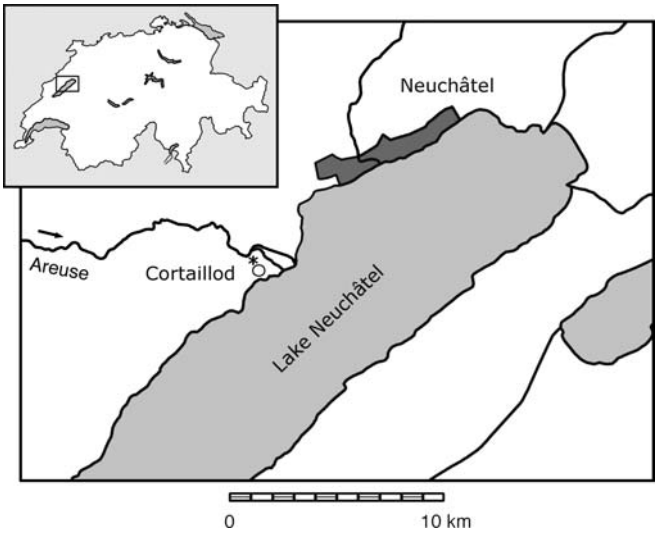

Fig. 1 Map showing the location of the site of Cortaillod/Sur les Rochettes-est (*)

Results

A total of 5080 plant remains were identified, all of which were charred and, in general, poorly preserved (Table 1). This poor preservation is reflected in the high proportion (71.2%) of cereal remains that could not be assigned to a genus or species. For the grains this value was 79.1%, and for the chaff 46.4%.

The concentrations of plant remains in the deposits associated with the two houses of the second phase were considerably higher than in their counterparts from the first phase (an average of 7.7 and 1.7 items per litre, respectively). This can be explained by the fact that the new houses were constructed on the sites of the preceding houses that were destroyed in a catastrophic fire, parts of the burnt layer becoming trapped within the new postholes in the process. Only seven plant macrofossils were found in the two Hallstatt pits. Consequently, the following text focuses exclusively on the Bell Beaker remains.

Almost all of the remains of cultivated plants were from cereals. Besides these, only nine seeds of *Linum usitatissimum* (flax), one seed of *Lens culinaris* (lentil) and one of *Vicia ervilia* (bitter vetch) were found. The composition of the cereal spectrum is illustrated in Fig. 2. Note that only remains identified to genus or species level are considered. Grain and chaff are illustrated in separate rows.

Hulled wheats predominated; the only other cereal identified being *Hordeum distichon/vulgare* (barley) - the poor preservation of the grains prevented an attribution to either the hulled or naked form). The low frequency of barley may be a result of the relative fragility of its threshing remains. At all other terrestrial sites of the region with a poor state of preservation, barley chaff was only rarely found, in contrast to the chaff of hulled wheats (Ö. Akeret, unpublished observations). Charring experiments have shown that rachis segments of free-threshing wheat and barley tend to disintegrate more quickly and at lower temperatures than the glumes of hulled wheats (Boardman and Jones 1990). Furthermore, glume bases of hulled wheats are more robust than rachis segments of barley and hence more resistant to mechanical stress. The grains have a better chance of surviving fire than the fragile rachis segments, but here they could rarely be identified, as most of them were too heavily fragmented.

Three species of hulled wheat were identified: *Triticum monococcum* (einkorn), *T. dicoccum* (emmer) and *T. spelta* (spelt) – Fig. 3. The relative proportions of the three species were determined on the basis of identifications of both the grains and the chaff, and were seen to be markedly different (Fig. 2). This can be explained by the difficulty of distinguishing grains of emmer and spelt (Hillman et al. 1995). Here only a few spelt grains could be identified with certainty, and the chaff diagram probably reflects the true proportions of the glume wheats more accurately. If only chaff identified to species level is considered, then spelt was the most frequent cereal (30.6%), followed by einkorn (9.7%) and emmer (8.4%). There remained 51.2% of the fossils that were too fragmented to be identified with certainty: einkorn/emmer (29.3%) and emmer/spelt (21.9%). The abundance of spelt was not the result of a single feature with large concentrations; rather *Triticum spelta* was found in 16 postholes belonging to five different houses from both building phases described above. Indeed the number of spelt finds is possibly underestimated, as a certain proportion of the 78 grains identified as *T. dicoccum/spelta* (emmer/spelt) might be spelt too. The importance of the finds of this species is considered further in the discussion.

The collection of wild food plants played an important role in the economy of the village of Cortaillod/Sur les Rochettes-est. Nine species of nuts and fruits were identified. The most frequent among them were *Corlyus avellana* (hazelnut) and *Malus sylvestris* (crab apple) together with members of the apple subfamily (Maloideae) which could not be identified more closely. Acorns were obviously collected too: 41 of the 44 fruits of *Quercus* were found in house 1. Here an acorn store was probably destroyed in a fire or in an accident during roasting. These large fruits have a high calorific value, but contain bitter tannic acid that makes them unpalatable. To make them suitable for human consumption they have to be leached or roasted (Bouby 1998; Buurman 1990; Karg and Haas 1996; Schneider 1990). Acorns were apparently a widely used food in the Bell Beaker period. Charred stocks have been unearthed at two French sites of this date: at Poses - Le Vivier - Le Clos-Saint-Quentin (Billard et al. 1994) and Géovreissiat „Derrière-le-Château" (Bouby 1998; Hénon and Vérot-Bourrély 1998). Further contemporary remains of acorns were found in Zambujal, Portugal (Hopf 1981) and in Monte Còvolo, Italy (Pals and Voorrips 1979).

A rather uncommon find from Neolithic sites in Switzerland were seeds of *Juniperus communis* (juniper).

Table 1 Identified, charred plant remains other than charcoal

	Archaeological period		Bell Beaker								Proba-bly B.B	Hall-statt	Unassig-ned
	Phase		1	1	1	1	1	2	2	unassig-ned			
	House		1	2	3	4	5	6	7	unassig-ned			
	Structures analysed:												
	Postholes		9	8	7	16	7	13	11	3	10		5
	Pits									1		2	3
	Indeterminate										1		18
		Total											
	Volume (litres)	1012.1	67.5	56.5	44.5	150.7	20.5	249.2	110.3	23.0	49.4	20.5	220.0
Cultivated food plants													
Cerealia	grain	2187	9	6	4	74	3	638	794	1	509		149
Cerealia	chaff	409		27	8	9	1	167	138		51	1	7
Hordeum distichon/vulgare	grain	28	2	1		4		2	14				5
Lens culinaris	seed	1		1									
Linum usitatissimum	seed	9				2		6					1
Triticum dicoccum	grain	105	1			2		42	16		41		3
Triticum dicoccum	chaff	44		6	2		1	16	8		11		
Triticum dicoccum/monococcum	grain	156				1		74	28		52		1
Triticum dicoccum/monococcum	chaff	141		17	3	6		73	16		21	1	4
Triticum dicoccum/spelta	grain	79				2		40	27		10		
Triticum dicoccum/spelta	chaff	95		8		5		44	27	1	6	1	2
Triticum monococcum	grain	75				3		12	16		42		2
Triticum monococcum	chaff	58				5		22	11		17		3
Triticum sp	grain	122				2		43	36		30		11
Triticum spelta	grain	14						1	3		10		
Triticum spelta	chaff	134		8	3	5		52	52		13		1
Vicia ervilia	seed	1						1					
Wild food plants													
Corylus avellana	fruit	156	58	9	2	15	1	34	23		4		10
Crataegus monogyna aggr	fruit	1						1					
Juniperus communis s.l	seed	9			3	3		2	1				
Maloideae	fruit/seed	192	1			62		116	2		11		
Malus sylvestris	fruit/seed	26	1			16		9					
Prunus sp	fruit	3						2			1		
Prunus spinosa	fruit	1						1					
Quercus sp	fruit	44	41			2		1					
Rosa sp	fruit	18				1		15			2		
Rubus sp	fruit	3						3					
Sambucus ebulus	seed	5						2	2				1
Sambucus sp	seed	10				1		8	1				
Other wild plants													
Arrhenatherum elatius	bulb	10				2		8					
Asteraceae	fruit	5						5					
Bromus sp	fruit	1						1					
Carex sp	fruit	1				1							
Chenopodiaceae	fruit	6						4	2				
Chenopodium album	fruit	8				1		2	1			3	1
Cornus sanguinea	fruit	1						1					
Fallopia convolvulus	fruit	3				2		1					
Festuca/Lolium	fruit	1				1							

Table 1 continued

	Archaeological period		Bell Beaker								Proba-bly B.B	Hall-statt	Unassig-ned
	Phase		1	1	1	1	1	2	2	unassig-ned			
	House		1	2	3	4	5	6	7	unassig-ned			
	Structures analysed:												
	Postholes		9	8	7	16	7	13	11	3	10		5
	Pits									1		2	3
	Indeterminate										1		18
		Total											
	Volume (litres)	1012.1	67.5	56.5	44.5	150.7	20.5	249.2	110.3	23.0	49.4	20.5	220.0
Galium aparine	fruit	13	1		1	2	2	2	1				4
Galium spurium	fruit	2	1		1								
Lapsana communis s.l	fruit	2				1					1		
Luzula sp	seed	1				1							
Medicago/Melilotus/Trifolium	seed	1									1		
Melilotus altissimus	seed	1	1										
Phleum sp	fruit	28	1	3	3	3		12			4		2
Pinaceae	cone-scale	13	2		1	1		1	2		4		2
Poa annua	fruit	1											1
Poa sp	fruit	1									1		
Polygonaceae	fruit	7				1		3	3				
Polygonum aviculare aggr	fruit	1											1
Polygonum lapathifolium s.l	fruit	1									1		
Polygonum persicaria	fruit	5						5					
Polygonum sp	fruit	8						3			1		4
Rubiaceae	fruit	1							1				
Rumex sp	fruit	17			1	13		3					
Scrophularia nodosa/umbrosa	seed	1						1					
Stellaria media aggr	seed	1											1
Tilia sp	fruit	2				1		1					
Trifolium repens s.l	seed	1			1								
Trifolium sp	seed	5				2		1	2				
Vicia hirsuta	seed	3						2					1
Vicia hirsuta/tetrasperma	seed	27	4		5	9		5	1		3		
Vicia tetrasperma	seed	1				1							
Miscellaneous													
Avena sp	basis of floret	1			1								
Brassicaceae	seed	1						1					
cf. *Camelina*	seed	1						1					
cf. *Lens*	seed	3	1		1	1							
cf. *Linum*	seed	11				6		5					
Fabaceae	seed	2				1			1				
Lathyrus/Pisum/Vicia	seed	37	5		7	6	5	12	2				
Panicoideae	fruit	2						2					
Poaceae	embryo	707		24		3		8	28		644		
Poaceae	fruit	9						4	3			1	1
Total		**5080**	**130**	**110**	**47**	**279**	**13**	**1521**	**1262**	**2**	**1491**	**7**	**218**
Concentration (total/volume (litres))		**5.0**	**1.9**	**1.9**	**1.1**	**1.9**	**0.6**	**6.1**	**11.4**	**0.1**	**30.2**	**0.3**	**1.0**

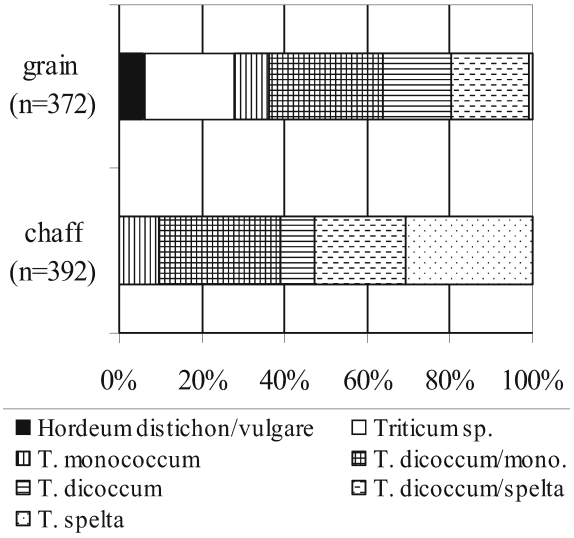

Fig. 2 Relative proportions of the different cereal taxa. Only remains identifiable to genus or species level are considered

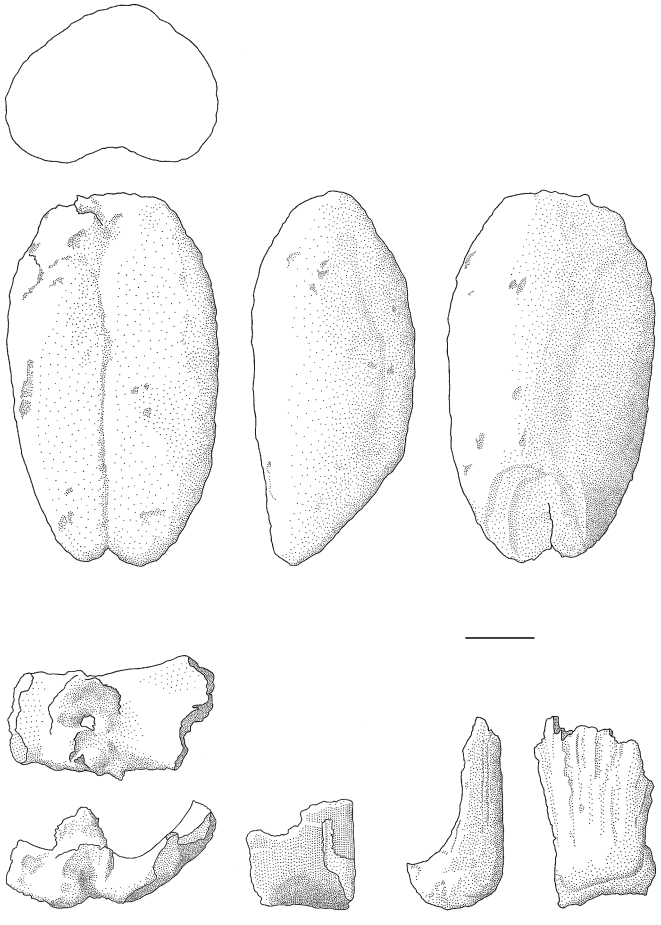

Fig. 3 Grain, spikelet fork and glume base of *Triticum spelta* (spelt). Bar =1 mm

Fig. 4 shows a seed together with a fruit of *Rosa* sp. (rose), which is rather similar and was also found at the site. There seems to be a highly local continuity of juniper

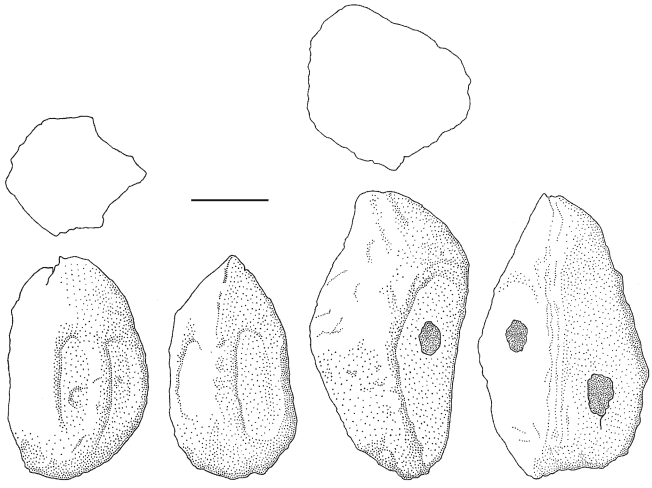

Fig. 4 Left: seed of *Juniperus communis* (juniper); right: fruit of *Rosa* sp. (rose). Bar = 1 mm

growing near this archaeological site. Only a few hundred metres away, seeds of this species were found in one feature from the late Neolithic and in another from the Middle Ages (unpublished finds of the author). None of the other 28 sites from different periods investigated in the surroundings of several kilometres have yielded juniper seeds. Nowadays the species has been eradicated in the vicinity, but it must have existed there until recently, as indicated by the field name "la Grassilière", which is located next to Les Rochettes. In the local dialect this means a place where junipers grow (Combe and Rieder 2004).

Discussion

Systematic sampling of all archaeological features at Cortaillod/Sur les Rochettes-est has allowed a reconstruction of the range of plants used by the population of a Bell Beaker period village. Clearly, the cultivation of hulled wheats played an essential role, but collected wild resource also contributed an important part to the people's diet. Overall, the economy was comparable to others reported from the late Neolithic lake shore settlements of Switzerland (see, for example, Brombacher 1995).

The most surprising observation at this site is the frequency of remains of spelt wheat. It is the cereal taxon with the largest number of finds. There can be no doubt that spelt was cultivated in the surroundings of the Bell Beaker village and that it was not just a weed, as might be suggested if only a few remains had been encountered. On the contrary, it can be stated that spelt was one of the principal cereals in the economy of Cortaillod/Sur les Rochettes-est at this time.

This is a significant and rapid change compared with a slightly earlier site of the region, the lake shore settlement of Saint-Blaise/Bains des Dames, which lies 12 km further northeast at Lake Neuchâtel. This was a multi-phase site, one of which belonged to the Auvernier cordé cul-

ture, which combines elements of the western Auvernier culture with the eastern Corded Ware Culture (Mermod 2000). Based on dendrochronology, this phase lasted from 2640 to 2450 B.C. at this site, and so ended not more than 200 years before the occupation of the site at Cortaillod/Sur les Rochettes-est. Of 3994 identified cereal remains from Saint-Blaise/Bains des Dames 57% were *Hordeum distichon/vulgare* (barley), 15% *Triticum dicoccum* (emmer), 12% unidentified *Triticum* (wheat), 7% *T. aestivum/durum/turgidum* (naked wheat) - both hexaploid and tetraploid species could be confirmed in small quantities), 6% *T. dicoccum/monococcum* (emmer or einkorn), and 3% were *T. monococcum* (einkorn). No remains of *T. spelta* (spelt) were identified.

The beginning of spelt cultivation in this part of Switzerland can, therefore, be dated at sometime between 2400 and 2200 B.C. Until now it has been impossible to determine this date so closely, because of the large temporal gap between the last known Neolithic sites (at around 2400 B.C.) and the earliest archaeobotanically investigated Bronze Age settlements (from about 1800 B.C. onwards). From the Early Bronze Age on, spelt is regularly present at sites in the Alpine foothills (*Alpenvorland*) (Jacomet et al. 1998).

The rapid emergence of spelt cultivation in the Lake Neuchâtel region initially suggested that the Bell Beaker people had introduced this cereal. However, this hypothesis has been abandoned after comparison with the other sites of the period analysed so far (see sites mentioned in the introduction), where spelt is completely absent. Only in Wetzikon-Kempten/Tösstalstrasse, eastern Switzerland, were "spelt-like" grains found, but these grains could also be emmer, and only very little chaff was encountered at the site (Rigert et al. in press). The principal cereals at the other Bell Beaker sites were barley and other glume wheat taxa. Barley was the most common cereal from Lodbjerg Sb 37, Denmark (Robinson 1992), Cerro de la Virgen, Spain (Buxó 1997), Géovreissiat/Montréal "Derrière-le-Château", France (Hénon and Vérot-Bourrély 1998; L. Bouby pers. comm.), and also Csepel-Hollandi út and Szigetszentmiklós, both Hungary (Gyulai 2003). Sites where emmer was the most numerous cereal are Monte Còvolo in Italy (Pals and Voorrips 1979) and Holubice in the Czech Republic (Tempír 1985). Finally, there is one site where einkorn outnumbered all other cereal taxa, Albertfalva in Hungary (Gyulai 2003).

A considerable amount of spelt was found at the Danish site of Brd. Gram, Vojens (Robinson 2003). House V of that site, dated between 2460 and 2200 B.C., is more or less contemporaneous with the village of Cortaillod/Sur les Rochettes-est, but no Bell Beaker remains were encountered there. Grains of naked barley and, to a lesser extent, emmer dominated in a layer of burnt grain, but there was also a good deal of spelt and it seems reasonable to conclude, that *Triticum spelta* was cultivated here too. Based on the observations from these two sites we can conjecture that spelt cultivation started in parts of Europe north of the Alps at around 2300 B.C. The question arises where this cereal species came from. The first hexaploid wheats were the result of a hybridisation of tetraploid wheat, probably emmer (*Triticum dicoccum*) with the wild grass *Aegilops tauschii* Coss. The latter species occurs in an area that ranges from the Caspian Sea eastwards. It is suggested that the hybridisation first took place somewhere near the Caspian Sea, because this is the place closest to the domestication centre of emmer in the Middle East (for example, Nesbitt and Samuel 1996; Zohary and Hopf 2000). These first crosses must have been hulled wheats, as was shown by producing synthetic hexaploids (Kerber and Rowland 1974). The naked hexaploid bread wheat (*Triticum aestivum*) was later derived from two complementary mutations from hulled hexaploid progenitors.

Until now it was often suggested that spelt in Europe derived directly from the first Asian hexaploid wheat, the so-called "Asian spelt". However it is not documented when and by which route it came to Europe. Old archaeobotanical records from western Asia and eastern Europe are based on doubtful identifications, at least some of these specimens belong to *Aegilops* or possibly to "new glume wheat" (Nesbitt 2001; E. Marinova, pers. comm.). In contrast, the spread of the phylogenetically younger hexaploid bread wheat is better known (for example, Maier 1996, 1998). This taxon is well documented in Europe from the Linearbandkeramik Culture onwards.

On the other hand it was observed that artificial crossing of *T. aestivum* and *T. dicoccum* produces progeny very similar in morphology to spelt wheat (MacKey 1966; Ohtsuka 1998). Recent genetic and molecular research has shown that European spelt and Asian hexaploid hulled wheats have different origins and that European spelt originates from an introgression of a tetraploid wheat (emmer) into free-threshing hexaploid wheats (bread wheat). This is corroborated by the results of investigations using diverse methods and analysing different DNA sequences (Blatter et al. 2002; Blatter et al. 2004; Dvorák and Luo 2001; Jaaska 1978; Liu and Tsunewaki 1991).

Conclusions

Archaeobotanical investigations of a Bell Beaker period village at Cortaillod/Sur les Rochettes-est showed that spelt wheat was a principal cereal at the site, whereas the species had apparently been absent from the Lake Neuchâtel region only a few generations earlier. This raised the question of the origin of this taxon. The history of spelt cultivation in Europe has to be reconsidered in the light of recent cytogenetic and molecular research. It now seems very unlikely that it derived directly from Asian spelt; it is much more probable that it originated from the introgression of tetraploid emmer into free-threshing hexaploid bread wheat. Theoretically this event could have happened at any time and place where the two cereals occurred together, from just before 5000 BC onwards. Archaeobotanical literature mentions single Ne-

olithic finds of spelt at different places and periods. Some of these citations seem doubtful and deserve careful re-examination, especially where the identifications were based solely on grains but others could very well be the product of local cross-pollination. The question arises why these early "spelts" were not cultivated subsequently and why this process only started at the very end of the Neolithic.

At the moment we can date the beginning of the cultivation of European spelt at around 2300 BC, but cannot exclude the possibility that this process started at several different places. However, our knowledge at this stage is based on limited data and further studies are essential to clarify the time and region of the generation as well as the beginning of the cultivation of *Triticum spelta*.

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