Acta Palaeobotanica 52(1): 33–58, 2012

The impact of the Przeworsk culture settlement (200–500 AD) on the vegetation in the Liswarta River basin, south-central Poland: combined pollen and plant macrofossil evidence

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Received 29 September 2011; accepted for publication 18 April 2012

ABSTRACT. The vegetation of the lower Liswarta River basin during the development of the Przeworsk culture settlement is described. In the 2nd century AD the settlement of this culture entered the area and developed continuously to the beginning of the 5th century AD when it suddenly disappeared. A complex of settlements and cemeteries covered about 450–500 km^2. The main occupation of the dwellers were soil cultivation and cattle raising. The reconstruction of the vegetation is based on botanical evidence provided by the study of charred plant remains and impressions from four localities of the Przeworsk culture, Wąsosz Górny site 3 and Opatów sites 1, 4, 6, as well as pollen from a mire near the village Waleńczów. Syntaxonomic classification of plant associations is used in order to reconstruct the presumed plant communities that could develop under human impact. Plant cultivation and animal keeping caused the reduction of forest stands with elm, oak, lime, spruce, and hazel and promoted the expansion of hornbeam, beech, and fir. Cultivated plants included barley, rye, spelt wheat, oat, millet, pea, and flax, possibly also emmer wheat and hemp. The presence of plants which can grow on fallows suggests that some kind of field rotation was practised. Animals were grazed in meadows, fallows and forests. The exploitation of forests included procurement of timber, mostly oak and pine, clearing of forests with the use of fire, forest grazing, and gathering useful plants for food and other uses. The comparison of macrofossil and pollen data showed that most of the information about field and ruderal weeds and plants growing in forest mantles derives from samples of charred grain from Wąsosz Górny, while the daub samples from Opatów and pollen samples from Waleńczów are much poorer in this respect. The most complete evidence concerning cultivated plants also comes from Wąsosz Górny, slightly less information is obtained from impressions found in Opatów, and still less from the pollen diagram. On the other hand, the grassland flora is best represented in the pollen diagram and the forest flora in pollen and anthracological analyses.

KEYWORDS: pollen analysis, charred seeds/fruits, wood charcoal, impressions, human impact, cultivated plants, Przeworsk culture, Roman Period, south-central Poland

INTRODUCTION

The article describes the vegetation of the lower Liswarta River basin, in the north-eastern part of the Silesia-Kraków Upland, from the younger Roman Period to the early phase of the Migration Period, when this area was settled by the Przeworsk culture population. The reconstruction is based on botanical evidence provided by the study of plant remains from five localities situated 5 to 18 km apart. Four of them, Wąsosz Górny site 3 and Opatów sites 1, 4, 6, were archaeological sites, in which plant material was preserved in charred

condition and as imprints. The fifth one was a small mire near the village Waleńczów, from which pollen analysis was performed. The results of the examination of fruits, seeds, and wood charcoal from Wąsosz Górny were comprehensively reported in earlier publications (Orlicz 1967, Bieniek 1999) and the list of tree taxa found in the site Opatów 4 was also published (Koczwańska 1973). These materials will be described here only to the extent that is necessary in order to understand the way of arguing proposed in this article. The results of plant identifications from sites Opatów 6 and 1 were never published before and therefore they will be described more in detail. The preliminary results of pollen analysis were previously discussed by Ralska-Jasiewiczowa (1977) who, however, presented only a simplified form of pollen diagram. For this reason a complete version of this diagram is included in the present article.

STUDY AREA

The examined sites Opatów (51°22′N, 18°14′E), Waleńczów (50°92′N, 18°86′E) and Wąsosz Górny (51°05′N, 19°00′E), Kłobuck county, Silesia province, are located in the basin of the Liswarta River and at its mouth to the Warta River (Fig. 1). This area belongs to the province of Polish Uplands and spreads over three macroregions: Kraków-Częstochowa Upland, Woźniki-Wieluń Upland, and Silesia Upland. With an elevation between about 200 and 280 m a.s.l. it is characterized by the slightly diversified topography and a network of smaller rivers and streams. Climate, according to the data for the Kłobuck Forest Region, is characterized by the mean annual temperature oscillating between 7–8.5°C, mean July temperature of 17.8°C and mean January temperature of –3.1°C. Annual total precipitation in dry years is 400–500 mm, in wet years 800–900 mm (Plan Urządzenia Lasu, on line). Uplands are covered mostly by podsolic and brown soils, in places with carbonate rendzinas, and hydromorphic soils occur in river valleys. Depending on soil type, forest cover is composed of associations of various pine, oak-pine, and oak-hornbeam forests and beechwoods as well as xerothermic forest-scrub communities. Low lying terrains in river valleys are occupied by different carr communities (Hereźniak 1993). At present forests occupy on the average 24% of the area of the Kłobuck Forest Region, which is a little less than the average for the whole Poland (Plan Urządzenia Lasu, on line). Pine is the most frequent tree (88.98%), next are oak (4.23), larch (1,69%), alder (1.47%),

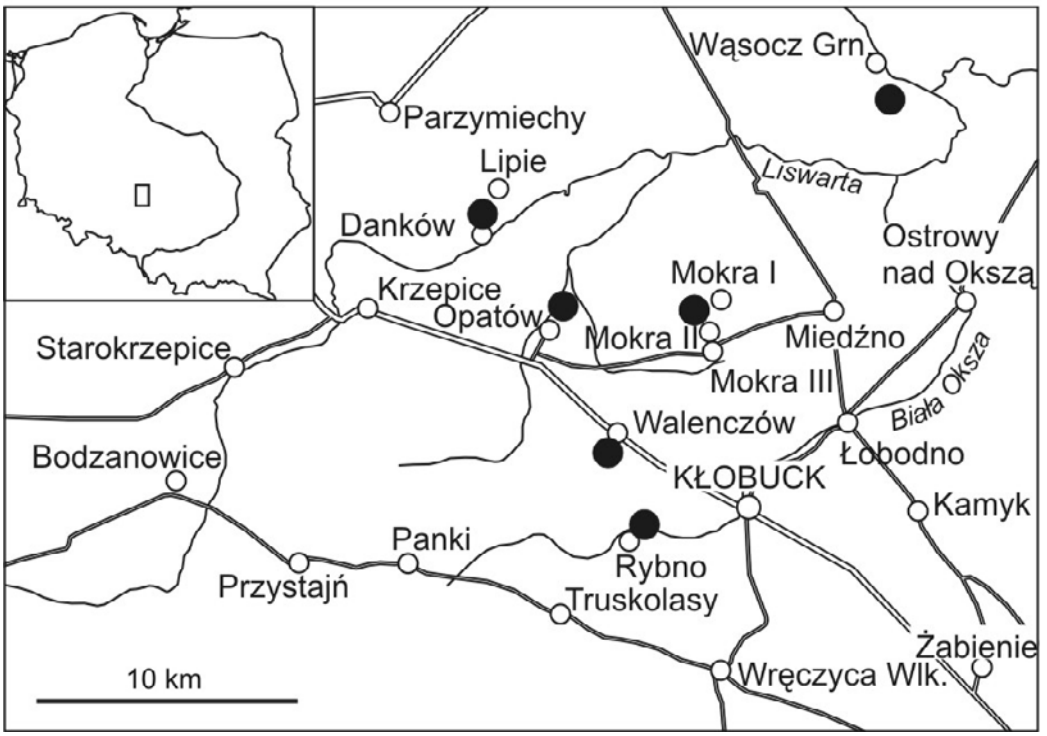

Fig. 1. The most important archaeological sites of the Roman Period in the Liswarta River region

birch (1.22%), and fir (1.00%), the other genera constitute less than 1% each (Państwowe Gospodarstwo Leśne, on line).

ARCHAEOLOGICAL SETTING

The area where the settlements from the Roman Period and the early stage of the Great Migration Period (from the 2nd century till the beginning of the 5th century AD) can be found, Waleńczów, Wąsosz Górny, site 3 and Opatów, sites 1, 4, 6 (Fig. 1), belongs to the settlement region of the lower Liswarta River basin including its mouth to the Warta River. It was re-settled after a period of about 600 years separating an intensive settlement of the Lusatian culture from the moment when on this area the Przeworsk culture (Fig. 2) of the Roman Period appeared (Gedl et al. 1971 pp. 71–117, Godłowski 1980 pp. 146–157, 86–87). This settlement suddenly entered the area of sandy soil locating itself most frequently by the rivers and streams and developed continuously to the beginning of the 5th century, when it suddenly disappeared.

The most extensive site in the region of Liswarta basin is a vast cremation cemetery at Opatów site 1, with about 1000 graves. To the west of the cemetery spreads a group of settlements, sites 2, 4, 6, and 15, stretching out along around 2.5 km and creating, together with the cemetery, a complex of settlements (Fig. 3). To the south of them there are two more settlements with pottery of the Roman Period, nr 2 and 11, but they are not connected directly with the cemetery due to the bigger distance, especially site 11. On site 4, located under a contemporary village, systematic excavations were not possible, thus rescue excavations were carried out (Mączyńska 1973, Koczwańska 1973). On site 6 the area of 3800 m² was examined and 57 features were discovered of which 52 came from the Roman Period (Tempelmann-Mączyńska 1983), including 11 huts, 8 hearths and 34 pits and traces of postholes. The majority of features from the settlement on site 6, from which the richest palaeobotanical material was analysed, correspond with chronology of late stages of the cemetery in Opatów dated to the 4th century and the beginning of the 5th century AD.

The earliest materials from the first half of the 2nd century AD were provided by pit 3 with charred grain from a settlement in Wąsosz Górny, site 3 which is located outside the Liswarta region, at the upper Warta River (Gedl et al. 1970 pp. 170–171, Godłowski 1980 p. 148). Within this settlement a few deep pits of unknown function were discovered, which

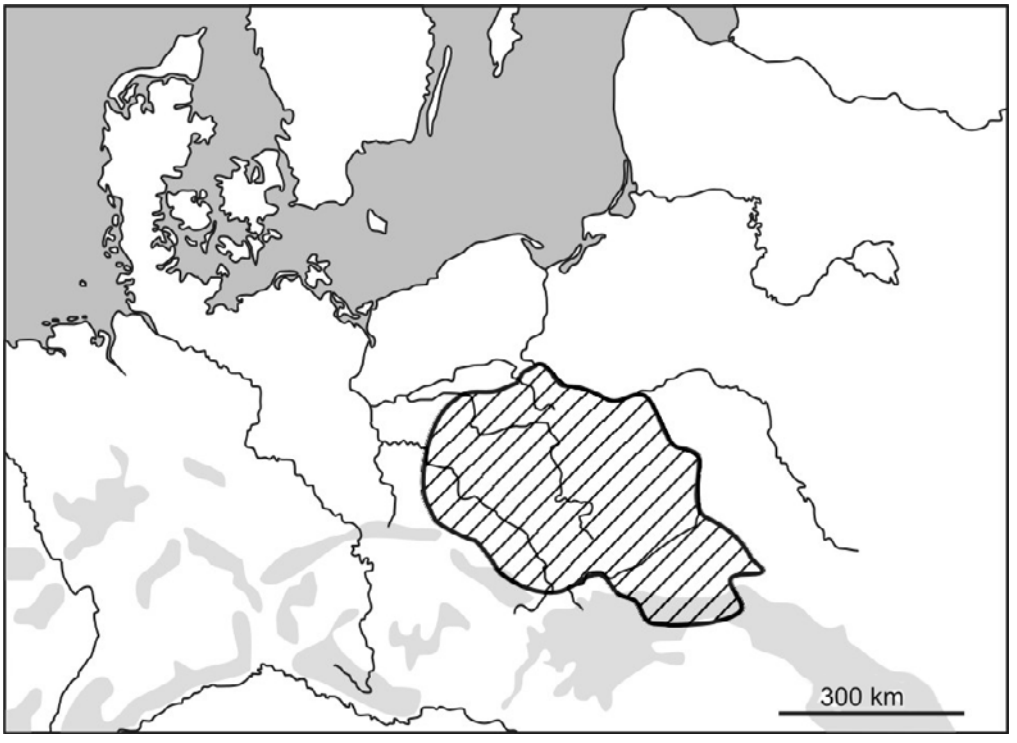

Fig. 2. The range of the Przeworsk culture in the Late Roman and Early Migration Periods

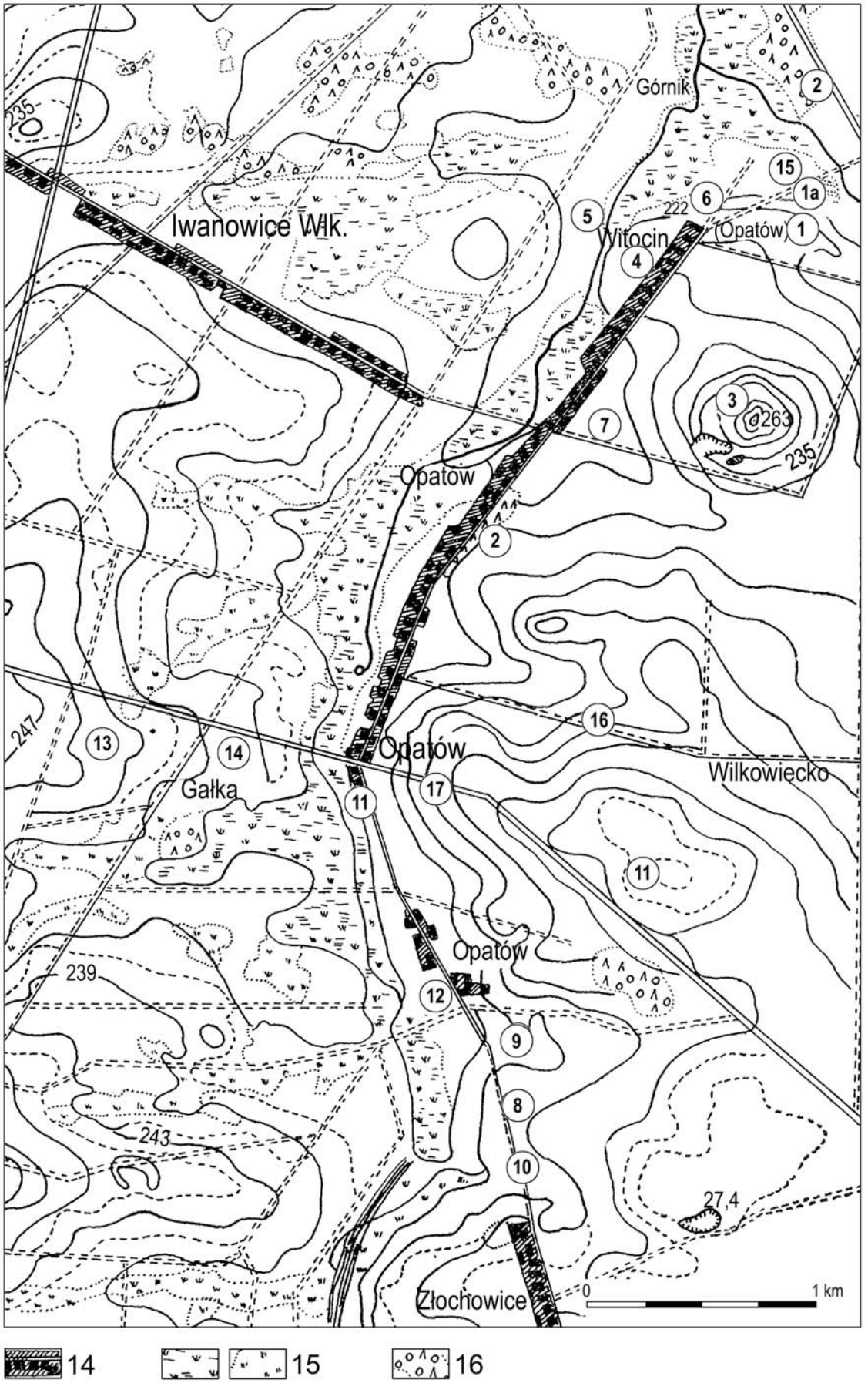

Fig. 3. The settlement complex of the Roman Period at Opatów, distr. Kłobuck. **1** – cemetery**; 2, 4, 6**, **11, 12, 15** – settlements; **3, 5, 7–10, 13** – sites of the other cultures; **14** – buildings, **15** – moist meadows, **16** – forests

contained large amounts of burnt grain. Suggestions based on plant material and concerning the purpose for which pits could have been used (Bieniek 1999) are presented below. A little later, at the second half of the 2nd century and the beginning of the 3rd dates a settlement in Danków located at a distance of 6 km to the north of Opatów. There, an area of 2400 m² was excavated. The findings included: a few pithouses, a row of pits and a zone of several hearths (Borowska 1960, 1961). At the same time two small necropolis were founded in Rybno and Waleńczów, to the south of the concentration of Opatów (Godłowski 1980, pp. 145–156; 1985, pp. 86–87, map 5; 6). A little later, at the beginning of the 3rd century, the next big cemetery was created in Mokra. It had 476 graves and was located 8 km to the northeast of Opatów. It lasted longer than a necropolis in Opatów because its youngest graves date back to the middle of the 5th century (Biborski 2010). In the second half of the 3rd century a cemetery in Żabieniec was founded and in the 4th and at the beginning of the 5th century a cemetery in Olsztyn was in use (Godłowski 1985 pp. 118–119, map 9). Also not completely examined settlement at Skrzydłów dates to the same time period (Łaszczewska 1966).

A complex of settlements in the lower Liswarta River basin covered about 450–500 km² and corresponded, most probably, with the area of a small tribe (Gedl et al. 1971 p. 105, 115). Each cemetery was accompanied by a group of at least a few settlements whose dwellers dealt mainly with agriculture and cattle raising. At the settlements in Opatów, its dwellers were smelting iron from local ore.

THE METHOD

The reconstruction of vegetation presented in this article concerns only the time when the Przeworsk culture settlement developed in this area. It was carried out at two levels. At first, the taxonomic composition of plant material obtained from all sites was analysed in order to get information about the presumed anthropogenic and natural plant communities in the area enclosing all three localities. Next, the changes of these communities in time were traced in the section of the pollen diagram from Waleńczów correlated with the Roman Period. The exploitation of cultivated and wild plants is dealt with separately. Wild plant names follow Mirek et al. (2002).

In order to compare the results of pollen analysis with those obtained from the investigation of charred remains and impressions all taxa found in the investigated sites were put together in Tables 2–7. Syntaxonomic classification was used to indicate the phytocenoses, in which a given species occurs most frequently in modern times (according to Zarzycki et al. 2002). The phytosociological method was used to infer the community types that could have existed in the past, which however must not have been identical with the present-day strictly defined plant associations. In fact, we do not know when the modern associations came into being but there are indications that some of the weed and grassland associations might have existed already as early as the Roman Iron Age (Knörzer 1975, Trzcińska-Tacik & Lityńska-Zając 1999). Pollen studies have demonstrated that most of the present day forest communities probably also formed at the beginning of the Subatlantic – ca 2500 radiocarbon years BP (Ralska-Jasiewiczowa 2004). These assumptions, treated as working hypothesis, allow us to refer to modern associations as possible analogues of the former ones. In addition to phytosociological criteria the grouping proposed by Lityńska-Zając (2005) was used based on the contexts in which a species occurred in archaeobotanical material from Poland. In the study on weeds in prehistoric times this author distinguished 4 groups of species: group 1 included species that most probably were weeds in field and garden cultivations; to group 2 belonged species that are sometimes found in deposits of charred cereals but which probably did not belong to weeds; group 3 included species which could grow as field or ruderal weeds; group 4 included rare or not exactly identified species, the status of which could not be defined according to the criterion used by her.

As far as the correlation of plant material from different sites is concerned it should be kept in mind that all macroremains come from features of the Przeworsk culture, but they are not exactly of the same age. The population of this culture lived in this area for about 300 years but individual habitation centres and houses in these centres were of shorter duration. In the pollen diagram the radiocarbon date indicates that the section showing the strong human impact on vegetation at the depth of 45–35 cm belongs to the Roman Period but more precise correlation with phases of this period is not possible. Besides, the conclusions proposed concern an area of about 450 to 500 km² and are based on different types of materials coming from different localities. In effect, the proposed reconstruction of vegetation refers to the whole period of the existence of Przeworsk culture settlement in the Liswarta River basin and results in generalizations, which must ignore the specific conditions of individual sites, such as topography, soils, microclimate and settlement type.

DESCRIPTION OF SITES

OPATÓW SITE 1

A few plant remains, which were identified by Lityńska-Zając from a grave at site Opatów 1 (Fig. 3) included charcoals of *Pinus sylvestris*,

Quercus sp., and *Juniperus communis* (grave 742, Lityńska-Zając 2011, unpubl.).

OPATÓW SITE 4

The settlement discovered at site Opatów 4 (Fig. 3) during rescue excavations provided charcoal remains from 12 hearths and one hut. Most of the hearths contained only charcoal of oak *Quercus* sp., in single hearths alder *Alnus* sp. and pine *Pinus sylvestris* were found. Pine was also the only tree present in the hut (Koczwańska 1973).

OPATÓW SITE 6

The Przeworsk culture settlement at site Opatów 6 (Fig. 3) , existed from the second half of the 2nd to the beginning of the 5th century AD (during the younger and late Roman Period and the early phase of the Migration Period). From 37 features including huts, hearths, and objects of unknown function, 110 samples of daub were examined but determinable plant impressions were found only in 67 samples. They were represented by numerous cereal spikelet fragments, grains, and straw, and rare impressions of fruits and seeds of other plants. Besides, a few charred specimens were found. 39 samples contained only impressions of straw, and in 4 samples no plant remains were present. From 15 features wood charcoals were identified. The number of spikelet impressions of cereals was counted as follows: an impression composed of a few spikelets joined together or of 2 to 3 barley spikelets belonging to one triplet was counted as one specimen. All plants found in site 6 are listed in Table 1. Almost all plant remains were recovered from features dated between the 3rd and 5th century AD. The oldest feature (hut 1), dated to the 2nd–3rd century AD, contained only 1 impression of a rye spikelet and one impression of an undetermined cereal grain

The impressions belonged to 6 cereal species, 17 taxa of wild herbs, and 6 tree taxa. The most frequent were impressions of straw, which most probably originated from cereals, although the presence of some tall grasses cannot be excluded. Among the identified remains 84% belonged to cereals.

Barley *Hordeum vulgare* L. em. Lam. was preserved as impressions of ear fragments, individual spikelets, ear rachis fragments, and caryopses single or arranged in triplets. One ear rachis fragment was charred. The imprints of palaea and/or lemma venation indicate that

Table 1. Opatów, site 6. Number of plant remains found in all huts, hearths and other features. Abbreviations: **fr** – fragment, **impr** – impression, **char** – charred

Taxa	Kind of remain	Preservation	Huts	Hearths	Other features
CEREALS					
Hordeum vulgare	spike fr	impr	8	3	19
	spikelet fr	impr	1		3
	triplet fr	impr	3	1	8
	rachis fr	impr			5
	rachis fr	char		1	
	caryopsis	impr	17	5	24
Hordeum vulgare /*Secale cereale*	spike fr	impr	2		8
	spikelet fr	impr			6
	rachis fr	impr	2		1
	rachis fr	char	1		
Panicum miliaceum	lemma	impr			1
Secale cereale	spike fr	impr	7	2	23
	spikelet fr	impr	1		9
	lemma	impr	2		11
	rachis fr	impr			1
	rachis fr	char		15	1
	caryopsis	impr		1	3
	caryopsis	char	1	3	2
Secale cereale?	spike fr	impr	1		5
	spikelet fr	impr	1		
	lemma	impr			2

Table 1. Continued

Taxa	Kind of remain	Preservation	Huts	Hearths	Other features
Triticum dicoccon	spikelet	impr	1		1
	glume	impr			1
Triticum dicoccon?	caryopsis	impr			1
Triticum monococcum	spike fr	impr		1	
Triticum dicoccon/*monococcum*	spikelet	impr	1		1
	spikelet base	impr			1
	glume	impr	1		
	caryopsis	impr		1	
	caryopsis	char	2		
Triticum spelta	spikelet fr	impr	1		
	glume	impr	1		
Triticum spelta/*dicoccon*	spikelet base	char	1		
	glume	impr			1
	glume base	char	4	1	
Triticum sp.	glume	impr			1
	caryopsis	impr	1		
Triticum sp.?	caryopsis	impr			1
Cerealia indet.	spike fr	impr	3		16
	spikelet fr	impr	4		7
	caryopsis	impr	15	4	11
	caryopsis	char	2		
	glume	impr			1
	rachis fr	char	1		
Cerealia indet. (& Poaceae indet.?)	straw	impr	+	+	+
WILD HERBACEOUS PLANTS					
Agrostemma githago	seed	impr	1	1	1
Asteraceae	frucification	impr			
Asteraceae?	frucification	impr			1
Avena fatua	spikelet base	impr			1
Bromus hordeaceus	caryopsis	char	2		
Bromus cf. *secalinus*	spikelet	impr			1
Bromus sp.	caryopsis	char		1	
Digitaria sanguinalis	lemma	impr			1
Galium palustre	fruit	char		1	
Galium spurium	fruit	char	1		
cf. *Melandrium album*	seed	impr			1
Poaceae indet.	caryopsis	char	1		1
	lemma	impr			1
	spike fr	impr			1
Polygonum aviculare	fruit	char	1		
Polygonum lapathifolium s.l.	fruit	char	1		
Pteridium aquilinum	frond segments	impr	15	7	14
	frond fr	impr	2		
Rumex acetosella	fruit	char		2	3
Scleranthus sp.	fruit	impr			1
Setaria viridis/*verticillata*	lemma	impr	1		1
TREES & SHRUBS					
Abies alba	wood	char	120	1	
Acer sp.	wood	char	6		
Betula sp.	wood	char	4	1	
Pinus sylvestris	wood	char	81	>1210	>120
Populus sp.	wood	char	18		
Quercus sp.	wood	char	>1410	>284	>500

barley belong to the hulled variety and the equal size of all spikelets in a triplet suggests that it is a six-rowed form. It was not possible to recognize whether it has loose or dense ears. Barley impressions were found in all kinds of features with the greatest abundance (106 specimens, 33.9% of all impressions) and frequency (in 42 samples, 38% of all samples) in the whole material.

Rye *Secale cereal*e L. was represented by impressions of fragments of ears and spikelets, the detached lemmas with characteristic keels provided with spines (Lityńska-Zając & Wasylikowa 2005), segments of ear rachis, and caryopses (Figs. 4–6). Charred grains were also preserved. Rye was a little rarer than barley (26 samples, 24%) and less abundant, but its charred remains were more frequent. 76 rye impressions made 24.3% of all impressions, while 23 charred specimens constituted 50.9% of all charred items. Like barley, rye was present in all kinds of features.

The proportion of wheats was small with respect of quantity and frequency. They were represented by 15 impressions (4.9% of all impressions) and 9 charred specimens (17.6% of all charred items) found in 15 samples (14% of all samples). All remains belonged to hulled wheats but specific identification was possible only in a few cases. Emmer wheat *Triticum dicoccon* Schrank. was described on the basis of 2 spikelet impressions, one impression of a glume, and one uncertain grain impression. One impression of a spike composed of 3 spikelets arranged one above the other and joined by the ear rachis fragment was identified as einkorn wheat *T. monococcum* L. Spelt wheat *T. spelta* L. was represented by one glume impression, one impression of a spikelet fragment, and one questionable fragment of a charred grain. No precise determination was possible with respect of 9 fragmentary impressions of spikelets, glumes and caryopses as well as 8 charred spikelet bases, glume bases, and grains.

Millet *Panicum miliaceum* L. was identified on the basis of one impression of a lemma. Fairly abundant were impression of grains and various parts of cereal ears which could belong to rye, barley, wheat or oat (Cerealia indet., 17.3% of all impressions).

The only wild plant which occurred relatively frequently was bracken *Pteridium aquilinum* (L.) Kuhn. represented by 38 impressions

Fig. 4. Opatów 6. *Secale cereale*. The impression of ear fragment with three spikelets, hut 10. Phot. A. Walanus

Fig. 5. Opatów 6. *Secale cereale*. The impression of ear fragment with four spikelets, feature 56. Phot. A. Walanus

Fig. 6. Opatów 6. *Secale cereale*. The impression of lemma fragment with spines preserved at keel edge, hut 10/11. Phot. A. Walanus

of frond fragments (12.4% of all impressions) found in 17 samples (15.4% of all samples). Most of the impressions were small fragments of ultimate frond segments with characteristic venation and bent down outer edges (Fig. 7) . In 2 samples the impressions of larger frond fragments were found (Fig. 8). Other wild herbs were rare. They belonged to 13 species

Fig. 7. Opatów site 6. The impression of a fragment of *Pteridium aquilinum* frond viewed from upper side, feature 37. Phot. A. Walanus

Fig. 8. Opatów site 6. The impression of an ultimate frond segment of *Pteridium aquilinum* viewed from the lower side, feature 2 (pit). Phot. A. Walanus

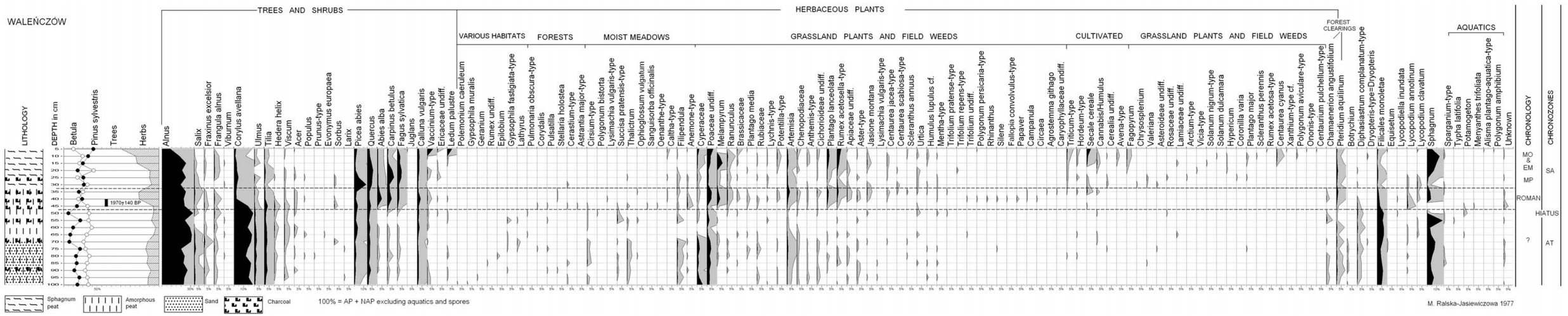

Fig. 9. The percentage pollen diagram from Waleńczów. **MP** – Migration Period, **EM** – Early Medieval Period, **MO** – Modern Times, **AT** – Atlantic, **SA** – Subatlantic

represented by 13 impressions (4.2% of all impressions) and 14 charred diaspores (27.4% of all charred specimens) found in 15 samples. Grasses were the most numerous among the wild plants. Charred grains and their impressions belonged to *Bromus hordeaceus*, *B.* cf. *secalinus*, *Digitaria sanguinalis*, *Setaria viridis* or *S. verticillata*, and *Avena fatua* and a few to unknown grass genera (Poaceae indet.). *Agrostemma githago*, cf. *Melandrium album*, *Scleranthus* sp., and fragments of fructifications of 2 species from the family Asteraceae were identified from impressions. A few charred fruits belonged to *Polygonum aviculare*, *P. lapathifolium* s.l., *Rumex acetosella*, *Galium spurium*, and *G. palustre*.

WĄSOSZ GÓRNY, SITE 3

Archaeological site 3 at the village Wąsosz Górny (Fig. 1) was located on an elevated terrace of the Warta River, near the mouth of the Liswarta River. In this site several pits and hearths of the Przeworsk culture were discovered. Three of the pits contained large number of charred plant material. Pit 3 was dated to the early and pits 2 and 17 to the late Roman Period (Gedl et al. 1970, 1971). Plant material was composed of cereal grains, fruits and seeds of wild herbaceous plants, and wood charcoals (Orlicz 1967, Bieniek 1999). Differences in plant assemblages present in these pits allowed some suggestions concerning the origin of plant material. Pit 3 contained large number of grains of three cereal species, millet *Panicum miliaceum*, rye *Secale cereal*, and spelt wheat *Triticum spelta* in similar proportions, which indicates that they probably represented a mixture of crops coming from different fields or different years. In pit 2 rye was the predominant cereal, the others being only small admixtures, which may means that this was the crop from a rye field. In both these pits weeds were very rare and it was concluded that they probably contained pure grain prepared for consumption or sowing. The content of pit 17 was a mixture of several crops (pea *Pisum sativum*, barley *Hordeum vulgare*, oat *Avena sativa*, spelt wheat, rye, millet, and flax *Linum usitatissimum*) together with the very numerous seeds and fruits of wild plants. The composition of the deposit indicated that it included uncleaned crops from several fields or harvests from several years (Bieniek 1999).

WALEŃCZÓW

A mire in the village Waleńczów (former Walenczów) is situated (Fig. 1) near a cemetery of the Lusatian culture from the late Bronze Age and a cemetery and settlement from the Roman period. The 1 m thick peat deposit was sampled for pollen analysis (Fig. 9) and one radiocarbon date was obtained from a peat sample taken at the depth of 40–45 cm. Its ^{14}C age was 1970 ± 140 BP (M-263), which allowed us to correlate this layer with the Roman Iron Age (Ralska-Jasiewiczowa 1977). The dated horizon divides the pollen diagram in two sections, which reflect distinctly different stages in the development of forest communities. During the older stage the main forest components were alder *Alnus*, birch *Betula*, hazel *Corylus avellana*, elm *Ulmus*, lime *Tilia*, and ash *Fraxinus excelsior*, while oak *Quercus*, pine *Pinus sylvestris*, and spruce *Picea abies* were of lesser significance. Hornbeam *Carpinus betulus*, beech *Fagus sylvatica*, and fir *Abies alba* were hardly present. *Hedera helix* and *Viscum* were well represented. During the younger stage the spread of hornbeam, beech, and fir took place, the role of elm, ash, lime, and hazel diminished. Birch and alder slightly lost their importance, pine percentages increased, *Hedera helix* and *Viscum* became distinctly reduced.

Against the background of forest cover changes three settlement phases can be seen separated by two episodes of forest recovery. In the oldest phase (below the depth of 65 cm) a few pollen grains of cereals appear together with the low curves of wild plants indicating the existence of arable land and pastures (e.g. *Rumex acetosella*, *Plantago lanceolata*, *Melampyrum*) as well as forest clearings (*Pteridium aquilinum*, *Chamaenerion angustifolium*). In general, however, the diagram shows a weak impact of human activity on forest communities (Ralska-Jasiewiczowa 1977). The correlation of this phase with a definite cultural event was not possible but on archaeological grounds its connection with the Lusatian culture settlement was suggested by Gedl et al. (1971 p. 68). In view of the new interpretation of the pollen diagram this opinion seems unsound. The second phase (45–30 cm) is characterized by a large number of human indicators and on the basis of ^{14}C dating may be correlated the Przeworsk culture settlement. In the following this phase will be discussed more in detail. The

subsequent decrease of human indicators and the signs of reforestation registered in the pollen diagram are probably connected with the Migration Period. The third phase of increased number of plants documenting the spread of farming and animal husbandry may correspond to the Middle Ages and modern times (Ralska-Jasiewiczowa 1977).

The rapid change of forest composition at the beginning of the second settlement phase was a matter of discussion concerning the cause of the late appearance of *Carpinus*, *Fagus*, and *Abies* in the pollen diagram (Ralska-Jasiewiczowa 1977, Latałowa 1976). Ralska-Jasiewiczowa suggested two possible explanations, both taking into account anthropogenic deforestation as the main cause. According to one hypothesis beech, hornbeam, and fir were already present in the area before this phase, somewhere on the hills surrounding the mire, but only the destruction of forests by the Przeworsk culture settlers allowed their pollen to reach the mire surface. According to the other hypothesis, which was considered by her a more reliable one, the thermophilous trees typical for the Atlantic Period survived here longer than in the other regions, until the Subatlantic, and only their destruction by the Przeworsk culture settlement made possible local expansion of beech, hornbeam, and fir. The third possibility, namely the occurrence of a hiatus in the deposit, was rejected because no indications of a cessation in peat growth were recognized in Waleńczów. However, a very similar pollen sequence was described from a peat-bog at Wolbrom, southern part of the Kraków-Częstochowa Upland, where apparent sudden spread of *Carpinus*, *Fagus*, and *Abies* was explained by the existence of a hiatus in the sediment, which included the whole Subboreal period (Latałowa 1976). This interpretation was later supported by radiocarbon dates indicating that the break or distinct slowing down in peat growth took place between 5850 ± 70 and 2420 ± 70 ^{14}C uncal. years BP (Latałowa & Nalepka 1987). Taking into account these datings and the new data about the spread of trees in Poland Ralska-Jasiewiczowa, while working on isopollen maps for Poland, came to the conclusion that also in Waleńczów diagram a hiatus covering of about 3000 years may exist (Nalepka & Walanus 2004, Polish Pollen Data Base 2004). It should be placed around the depth of 55 cm, just below the radiocarbon dated horizon. This means that the bottom section of the diagram represents the Atlantic period, and thus the lowest stage of human activities must belong to the settlement older than the Lusatian culture.

POLLEN ANALYSIS AND PLANT MACROFOSSILS IN THE RECONSTRUCTION OF PLANT COMMUNITIES

COMMUNITIES OF FIELD WEEDS

Wild plants, which probably infested cereals cultivated by the Przeworsk culture population in the Liswarta region are listed in Table 2, in which their phytosociological affiliation is

Table 2. Field weeds from the Przeworsk culture time in the Liswarta River basin. Macrofossils in Wąsosz Górny and Opatów, pollen and spores in Waleńczów. ( ) presumed but not identified species. Phytosociological affiliation according to Zarzycki et al.(2002). Archaeobtanical groups after Lityńska-Zając (2005)

Taxa	Wąsosz	Opatów	Waleńczów	Syntaxonomic affiliation		Arch
				Field weeds	Other communities	groups
Agrostemma githago	+	+	+	*Centauretalia*		1
Papaver sp. (*rhoeas*)			+	*Centauretalia*		1
Rhinanthus sp. (*serotinus*)			+	*Centauretalia*		1
Avena fatua	+	+		*Caucalidion*		1
Galium spurium	+	+		*Caucalidion*		1
Melampyrum sp. (*arvense*)			+	*Caucalidion*	*Festuco-Brometea*	1
Melandrium noctiflorum	+			*Caucalidion*		3
Neslia paniculata	+			*Caucalidion*		1
Stachys annua	+			*Caucalidion*		4
Bromus secalinus	+	+		*Aperion*		1

Table 2. Continued

Taxa	Wąsosz	Opatów	Waleńczów	Syntaxonomic affiliation		Arch
				Field weeds	Other communities	groups
Polycnemum arvense	+			*Aperion*		1
Rumex acetosella	+	+	+	*Aperion*, *Panico-Setarion*	*Corynephoretalia*, *Dicrano-Pinion*	1
Scleranthus annuus	+	+	+	*Aperion*, *Panico-Setarion*		1
Spergula arvensis	+			*Aperion*, *Panico-Setarion*		1
Chenopodium album	+			*Polygono-Chenopodietalia*		1
Echinochloa crus galli	+			*Polygono-Chenopodietalia*		1
Polygonum lapathifolium	+					
subsp. *pallidum*				*Polygono-Chenopodietalia*		1
Polygonum lapathifolium s.l.	+	+		*Polygono-Chenopodietalia*	*Bidentetea*	1
Chenopodium ficifolium	+			(*Polygono-Chenopodietalia*)	*Sisymbrietalia*	3
Solanum nigrum	+			*Polygono-Chenopodietalia*	*Sisymbrietalia*	1
Polygonum minus	+			*Panico-Setarion*	*Bidentetea*	1
Digitaria ischaemum	+			*Panico-Setarion*		1
Digitaria sanguinalis		+		*Panico-Setarion*		1
Setaria viridis/(*verticillata*)	+	+		*Panico-Setarion*		1
Setaria pumila	+			*Panico-Setarion*		1
Polygonum lapathifolium	+					
subsp. *lapathifolium*					*Bidentetea*	1
Anagallis arvensis	+			*Stellarietea*		1
Fallopia convolvulus	+		+	*Stellarietea*		3
Viola arvensis/*tricolor*	+			*Stellarietea*		1
Galeopsis speciosa	+			*Stellarietea*	*Atropetalia*	4
Galeopsis tetrahit type	+			*Stellarietea*	(*Atropetalia*)	4
Polygonum aviculare	+			*Stellarietea*	*Polygonion*	3
Thlaspi arvense	+			*Stellarietea*		1
Stellaria media	+			*Stellarietea*		3
Polygonum persicaria	+		+	*Stellarietea*	*Bidentetea*	1
Melandrium album	+			*Stellarietea*	*Artemisietea*	1
Convolvulus arvensis	+			*Stellarietea*	*Festuco-Brometea*, *Onopordetalia*	3
Artemisia sp. (*absinthium*, *vulgaris*)			+		*Artemisietea*, *Onopordion*	1
Cichorium intybus	+				*Artemisietea*	3
Malva sp.	+				*Onopordion*, *Arction*, *Sisymbrion*	3
Verbena officinalis	+				*Onopordion*, *Polygonion*	3
Urtica sp. (*dioica*)			+		*Artemisietea*, *Salicetea purp*, *Alno-Ulmion*	3
Bromus hordeaceus		+			*Arrhenatheretalia*	1
Rhinanthus sp. (*minor*, *alectorolophus*)			+		*Arrhenatheretalia*	1
Stellaria graminea	+				*Arrhenatheretalia*	1
Centaurea jacea type			+		*Molinio-Arrhentheretea*	1
Plantago lanceolata	+ cf.		+		*Molinio-Arrhentheretea*	1
Centaurea scabiosa type			+		*Festuco-Brometea*	1
Knautia arvensis	+				*Fest-Brom*, *Arrhenatheretalia*, *Quercetea*	1
Stachys cf. *recta*	+				*Fest-Brom*, *Quercetalia*	1
Galeopsis ladanum	+				*Thlaspietea*	1

indicated. The list includes species, which at present belong to weeds growing in cereal fields (communities of the order *Centauretalia cyani*, and the alliences *Caucalidion* and *Aperion* in Tab. 2) or root-crop and garden type cultivations (communities of *Polygono-Chenopodietalia* and *Panico-Setarion* in Tab. 2) as well as those occurring in both types of cultivations (*Stellarietea mediae* in Tab. 2). The set of typical weeds is enlarged by the addition of taxa, which nowadays grow mostly in the other communities but were often found together with cereals in archaeological sites and were classified to groups 1 or 3 by Lityńska-Zając (2005). At present they occur mostly in the following communities: moist and fresh meadows (*Molino-Arrhenatheretea*), fresh meadows (*Arrhenatheretalia*), xerothermic grasslands (*Festuco-Brometea*), waste-ground communities (*Artemisietea*, *Onopordetalia*, *Onopordion*, *Sisymbrion*, *Polygonion*), wet forests (*Alno-Ulmion*), and herbaceous communities of water shores (*Bidentetalia*). In three cases the classification proposed by Lityńska-Zając was corrected, namely *Stachys annua*, *Galeopsis speciosa*, and *G. tetrahit* type (assuming that it is *G. tetrahit*), the species of undefined status according to her classification (group 4), were considered here as weeds (group 1).

Most of the information about weeds derives from samples of charred grain from Wąsosz Górny, while the daub samples from Opatów and pollen samples from Waleńczów are much poorer in this respect (Tab. 2). The presence of about the same number of species growing in cereal fields and root-crops/gardens suggests that both autumn and spring sown crops were cultivated. The main winter crop was rye (although some barley and spelt could also be sown in autumn). In rye fields weeds of the order *Centauretalia cyani*, which require a longer vegetative period, could find best conditions for the development. Because no typical root-crop plants were known at that time, weeds which nowadays are characteristic for such cultivations (*Polygono-Chenopodietalia*) probably occurred among spring cereals and in gardens, where the vegetative period was shorter and possibly some weeding and hoeing was practised. Typical spring crops were millet, oat, and pea, but also barley and spelt wheat could have been sown in spring.

Some species indicate that different soils were taken in cultivation. The tillage of calcareous soils is indicated by the presence of species growing in communities of the alliance *Caucalidion* (*Avena fatua*, *Galium spurium*, *Melandrium noctiflorum*, *Neslia paniculata*, *Stachys annua*), alkaline or neutral soils are indicated by a few species of the alliance *Polygono-Chenopodion* (*Chenopodium ficifolium*, *Solanum nigrum*). The cultivation of acidic or slightly acidic soils is suggested by weeds of the alliances *Aperion* (*Bromus secalinus*, *Polycnemum arvense*, *Rumex acetosella*, *Scleranthus annuus*, *Spergula arvensis*) and *Panico-Setarion* (*Digitaria ischaemum*, *D. sanguinalis*, *Polygonum minus*, *Setaria pumila*). The use of different soils for farming was postulated also by Bieniek (1999) on the ground of the analysis of ecological requirements of individual species indicated by the ecological index numbers (Zarzycki 1984). She concluded that fields were located on three kinds of soils: rather fertile neutral to alkaline rendzinas and loams rich in calcium carbonate, acidic to moderately acidic poor sands or slightly loamy sands (probably sandy podsolic soils), and podsolic, more or less loamy soils with various degree of fertility.

Several species counted here among field weeds could also grow in other places, such as ruderal habitats (e.g. *Chenopodium ficifolium*, *Cichorium intybus*, *Melandrium album*, *Polygonum aviculare*, *Solanum nigrum*), meadows (for instance *Bromus hordeaceus*, *Plantago lanceolata*, *Stellaria graminea*), poor grasslands on sandy places (e.g. *Rumex acetosella*), and xerothermic grasslands (*Convolvulus arvensis*, *Knautia arvensis*). Certain weeds like *Polygonum lapathifolium* subsp. *lapathifolium*, *P. minus*, and *P. persicaria* could have their natural habitats on the drying up shores of water reservoirs in nitrophilous communities of the order *Bidentetalia*. Their occurrence in prehistoric charred cereal grain may be explained by the penetration of crop stands from the nearby patches of different natural and anthropogenic phytocenoses. Several of these species are perennials (for instance *Knautia arvensis*, *Plantago lanceolata*, *Stellaria graminea*), which might survive from the preceding year when the field was left fallow. Much discussed in literature was the indicative value of *Plantago lanceolata* (Behre 1981), a very important anthropogenic indicator in pollen diagrams. According to Behre it is an indicator, in the first place, of wet meadows and pastures and to some degree of fallow land,

which means that it may be an indirect evidence of rotational farming. It may occur also in dry pastures, grazed forest, along footpaths and in ruderal communities. Makohonienko et al. (1998) have shown that in Poland it may be an indicator of mowed or ploughed meadows and weak grazing.

The comparison of pollen spectra with the sets of plants from archaeological features shows that some taxa are present in both fossil records and some are not. *Plantago lanceolata*, *Rumex acetosella*, *Scleranthus annuus*, *Polygonum persicaria*, *Fallopia convolvulus*, and *Agrostemma githago* appear in pollen samples and among macrofossils. Some changes in pollen curves can be connected with the occurrence of certain species in cereal samples. For instance a slight rise of the Chenopodiaceae pollen curve together with the rise of that of *Secale* may reflect the abundance of *Chenopodium* seeds (first of all *Ch. album*) in the samples from Wąsosz, which contain also rye grain. The low curve of Brassicaceae pollen may (partly) correspond to the presence of *Neslia paniculata* (abundant fruits) and *Thlaspi arvense* (a few seeds). Different species of the family Lamiaceae found in cereal samples, such as *Galeopsis ladanum*, *G. speciosa*, *G. tetrahit* type, *Stachys annua*, *S.* cf. *recta* and Lamiaceae indet., may be recorded by the curve of *Mentha* type pollen. The increase of Poaceae indet. pollen curve may reflect the occurrence of weedy species *Bromus secalinus*, *Digitaria ischaemum*, *Echinochloa crus-galli*, and *Setaria viridis/verticillata* (Bieniek 1999) as well as the spread of grasses in meadows, grasslands and pastures. The evaluation of the role of *Artemisia* is difficult because the specific identification of its pollen is not possible. The *Artemisia* curve parallels that of *Plantago lanceolata* showing a small peak in the same sample as rye, *Agrostemma githago*, and *Scleranthus annuus*. This could suggest the occurrence of *Artemisia vulgaris*, a ruderal weed, which also occurs in fallows and seldom in fields (Lityńska-Zając 2005, p. 84). If so, this would be another species, besides *Plantago lanceolata*, indicating the practice of land rotation.

Several taxa present in charred cereal samples find no counterparts in the pollen diagram. Numerous species of the Caryophyllaceae family, such as *Melandrium album*, *M. noctiflorum*, *Spergula arvensis*, *Dianthus armeria*, *Stellaria graminea*, and *S. media* are weakly reflected in pollen of *Cerastium* type, *Silene*, and Caryophyllaceae undiff. Very abundant fruits of several *Polygonum* species (*P. aviculare*, *P. lapathifolium*, *P. minus*, *P. persicaria*), are represented only by one pollen grain of *P. persicaria* type. Likewise the large number of *Galium spurium* fruits (2455 in pit 17) finds weak expression in the Rubiaceae pollen curve. On the other hand in macrofossil samples there are no representatives (or only a very few) of several taxa that form rather high pollen curves and could include weeds. The examples are *Anthemis* type, Apiaceae, *Artemisia*, *Aster* type, *Campanula*, Cichorioideae undiff., *Cirsium* type, *Melampyrum*, *Papaver*, *Potentilla* type, *Ranunculus*, and *Rhinanthus*.

GRASSLAND COMMUNITIES

The qualification "grasslands" is used here for various non-forest communities, such as meadows, pastures, and sandy and xerothermic grasslands, in which grasses play an important role. Information about herbaceous plants that could grow in grasslands comes mostly from the pollen diagram (Fig. 9). Much less can be deduced from the macrofossils (Tab. 3). That is why the information about grasslands is less accurate compared to weeds, because the identifications based on pollen are often limited to the genus or family level or pollen type. This notwithstanding, there is evidence of the existence of a few grassland communities. A large group of taxa indicates the occurrence of phytocenoses similar to the present day semi-natural or anthropogenic fresh and moist meadows. Fresh meadows (*Arrhenatheretalia* in Tab. 3), which develop on well watered but not marshy soils are represented by *Bromus hordeaceus*, *Stellaria graminea*, and possibly also *Knautia arvensis*, *Plantago media*, *Rhinanthus*, and *Trifolium arvense/dubium* (if *dubium*). More species are connected with moist meadows (*Molinietalia* and *Calthion* in Tab. 3). To this group belong *Sanguisorba officinalis*, *Ophioglossum vulgatum*, *Caltha* sp., and probably *Filipendula* (if *ulmaria*), *Cirsium* type, *Lysimachia vulgaris* type, *Succisa pratensis* type, and *Thalictrum*. Three characteristic species of the class *Molinio-Arrhenatheretea*, *Plantago lanceolata*, *Centaurea jacea* type, and *Trifolium pratense* type, could occur in both types of meadows.

Table 3. Plants of fresh and moist meadows, pastures and sandy and xerothermic grasslands from the Przeworsk culture time in the Liswarta River basin. Explanations in Tab. 2

Taxa	Wąsosz	Opatów	Waleńczów	Syntaxonomic affiliation		Arch
				Grasslands	Other communities	groups
Centaurea jacea type			+	*Molinio-Arrhenatheretea*		1
Plantago lanceolata	+		+	*Molinio-Arrhenatheretea*		1
Trifolium pratense type			+	*Molinio-Arrhenatheretea*		2
Rhinanthus sp. (*minor*, *alectorolophus*)			+	*Arrhenatheretalia*		1
Bromus hordeaceus		+		*Arrhenatheretalia*		1
Knautia arvensis	+			*Arrhenatheretalia*, *Festuco-Brometea*	*Quercetea*	1
Plantago media			+	*Arrhenatheretalia*, *Festuco-Brometea*		4
Stellaria graminea	+			*Arrhenatheretalia*		1
Cirsium type			+	*Molinietalia*		
Filipendula sp. (*ulmaria*/*vulgaris*)			+	*Molinietalia*, *Festuco-Brometea*	*Alno-Ulmion*, *Alnetea*	
Lysimachia vulgaris type			+	*Molinietalia*	*Alno-Ulmion*, *Alnetea*	
Sanguisorba officinalis			+	*Molinietalia*		
Ophioglossum vulgatum			+	*Molinietalia*		
Succisa pratensis type			+	*Molinietalia*		
Thalictrum sp.			+	*Molinietalia*, *Festuco-Brometea*	*Alnetea*	
Caltha sp.			+	*Calthion*		
Trifolium arvense/*dubium*	+			*Corynephoretalia*, *Arrhenatheretalia*		
Jasione montana			+	*Corynephoretalia*	*Dicrano-Pinion*	
Rumex acetosella	+	+	+	*Corynephoretalia*	*Aperion*, *Dicrano-Pinion*, *Panico-Setarion*	1
Lycopodium clavatum			+	*Nardo-Callunetea*	*Dicrano-Pinion*	
Calluna vulgaris			+	*Nardetalia*, *Calluno-Ulicetea*	*Vaccinio-Piceetea*	
Artemisia sp. (*campestris*)			+	*Festuco-Brometea*	*Arction*	
Centaurea scabiosa type			+	*Festuco-Brometea*		1
Centaurea phrygia/stoebe	+			*Festuco-Brometea*, *Nardetalia*	*Nardetalia*	
Convolvulus arvensis	+			*Festuco-Brometea*	(*Onopordion*), *Stellarietea*	3
Pulsatilla sp. (*pratensis*)			+	*Festuco-Brometea*	*Dicrano-Pinion*	
Stachys cf. *recta*	+			*Festuco-Brometea*	*Quercetalia*	1
Galeopsis ladanum	+			*Thlaspietea*		1
Anemone type			+	grasslands		
Apiaceae			+	grasslands		
Aster type			+	grasslands		
Brassicaceae			+	grasslands		
Campanula sp.			+	grasslands		
Cerastium type			+	grasslands		
Lychnis type			+	grasslands		
Mentha type			+	grasslands		
Potentilla type			+	grasslands		
Ranunculus sp.			+	grasslands		
Rubiaceae			+	grasslands		
Silene sp.			+	grasslands		

A relatively large number of species may come from the xerothermic grasslands (*Festuco-Brometea* in Tab. 3), which occupy dry calcareous soils. Four taxa of this group were found in grain samples from Wąsosz, *Knautia arvensis*, *Convolvulus arvensis*, *Stachys* cf. *recta*, and possibly *Centaurea phrygia* or *C. stoebe*, and six are represented in the pollen diagram, *Plantago media*, *Centaurea scabiosa* type, perhaps also *Artemisia* (if *campestris*), *Filipendula* (if *vulgaris*), *Pulsatilla* sp., and *Thalictrum* sp.

From poor, sandy, non-calcareous habitats a few species may originate, which today grow in grasslands from the order *Corynephoretalia*. They include *Trifolium arvense/dubium* (if *arvense*) found in Wąsosz, *Jasione montana* recorded in the pollen diagram, and *Rumex acetosella* present in all three sites. *R. acetosella* probably was a field weed because it is often found together with charred cereal grains and in our case its pollen curve culminates in the same sample as rye. Some poor acidic habitats could have been occupied by grazed grasslands (Nardetalia in Tab. 3) indicated by the occurrence of *Lycopodium clavatum* spores and *Centaurea phrygia/ stoebe* (if *phrygia*) fruits. A small culmination of the *Calluna vulgaris* curve together with the increase of the curves of meadow plants and the decline of trees suggests that an anthropogenic heath developed. In all types of grasslands grasses must have played an important role but they were present also in other communities and thus the shape of Poaceae curve may be the combined effect of changes in mutual relations between grasslands, fields, and forests.

In addition to the above mentioned species, the pollen record includes several taxa identified only to the level of a genus or family, the origin of which cannot be indicated with certainty. The majority of them appear sporadically in the diagram but their total percentage increases together with grasses at the depth of 40 cm suggesting that they may originate from grasslands (grasslands in Tab. 3).

In archaeological sites from Poland several meadow species connected with drier habitats, appear often together with cereals. Five such species were found in macrofossil samples from Wąsosz and Opatów (*Plantago lanceolata*, *Knautia arvensis*, *Stellaria graminea*, *Rumex acetosella*, and *Bromus hordeaceus*), while plants growing in moist meadows appeared only in pollen diagram from Waleńczów. This may suggest that fields were located on fresh and not moist soils. It seems that the area of moist meadows was reduced in this region already in the early phase of the Przeworsk culture settlement because pollen curves of *Filipendula*, *Thalictrum*, *Succisa pratensis* type, and *Cirsium* type, which represent moist meadows, decrease or disappear in the section corresponding to the Roman Period. It is not clear if it was a result of human husbandry or the opposite, namely the occupation of low terraces by Przeworsk culture people, which is well documented by archaeological data (Gedl et al. 1971 p. 102), was enabled by the lowering of the water table.

RUDERAL WEEDS

Vegetation of ruderal habitats, such as farmyards, paths, road sides and other places rich in nitrogen compounds is weakly recorded in our material (Tab. 4). There are a few characteristic or differential species of the thermophilous communities of tall perennials from the order *Onopordetalia*, which develop on dry soils (*Cichorium intybus*, *Convolvulus arvensis*, *Melandrium album*, *Verbena officinalis*). This group might include also some species of *Artemisia* and *Malva*. A few species indicate the existence of communities belonging to the order *Sisymbrietalia*, which are the first colonizers of ruderal places (*Chenopodium ficifolium*, *Setaria viridis/verticillata* if *verticillata*, *Solanum nigrum*, some species of *Malva*). *Polygonum aviculare* could spread in strongly trodden places. Most of ruderal species were found in grain samples from Wąsosz and it seems possible that they were actually growing in cereal fields, the more so as they often appear together with cereals in other archaeological sites.

FOREST COMMUNITIES

Forest plants are represented by trees, shrubs, and herbaceous plants growing in herb layer. The information about trees comes from pollen and anthracological analyses, whereas species of the herb layer, except those of forest mantles, are recorded only in the pollen diagram (Tab. 5). A large number of taxa could grow in pine or pine-oak forests (*Dicrano-Pinion*, *Pino-Quercion*, *Vaccinio-Piceetea* in Tab. 5). Deciduous forests are represented by species which could form different forest

Table 4. Ruderal weeds and water shore plants from the Przeworsk culture time in the Liswarta River basin. Explanations in Tab. 2

Taxa	Wąsosz	Opatów	Waleńczów	Syntaxonomic affiliation		Arch
				Ruderals, water shores	Other communities	groups
Artemisia sp. (*absinthium*, *vulgaris*)			+	*Artemisietea*, *Onopordion*		1
Convolvulus arvensis	+			(*Onopordion*)	*Festuco-Brometea*, *Stellarietea*	3
Cichorium intybus	+			*Onopordion*		3
Verbena officinalis	+			*Onopordion*, *Polygonion*		3
Malva sp.	+			*Onopordion*, *Arction*, *Sisymbrion*		2
Polygonum aviculare	+			*Polygonion*	*Stellarietea*	3
Artemisia sp. (*campestris*)			+	*Arction*	*Festuco-Brometea*	
Urtica sp. (*dioica*)			+	*Artemisietea*	*Salicetea purp*, *Alno-Ulmion*	3
Melandrium album	+			*Artemisietea*	(*Stellarietea*)	1
Chenopodium ficifolium	+			*Sisymbrietalia*	(*Polygono-Chenopodietalia*)	3
Setaria (*viridis*)/*verticillata*	+	+		*Sisymbrietalia*		2
Solanum nigrum	+			*Sisymbrietalia*	*Polygono-Chenopodietalia*	1
Polygonum lapathifolium subsp. *lapathifolium*	+			*Bidentetea*		1
Polygonum minus	+			*Bidention*	*Panico-Setarion*	1
Oenanthe sp.			+	*Bidentetea*	*Phragmitetalia*, *Magnocaricion*	
Galium palustre		+		*Magnocaricion*	*Caricetalia nigr*, *Alnetea*	
Menyanthes trifoliata			+	*Scheuchzerio-Caricetea*		
Lycopodiella inundata			+	*Scheuchzerietalia*		
Sparganium type			+	*Phragmitetalia*		
Eleocharis sp.	+			*Phragmitetalia*		
Potamogeton sp.			+	*Potamion*		

communities depending on soil fertility and humidity. These could have been oak-hornbeam forests growing on fertile, fresh soils (*Carpinion* in Tab. 5), meso- or eutrophic beech and fir forests (*Fagion*), and eutrophic hygrophilous forests with alder, ash, and elm (*Alno-Ulmio*n) or willow shrubs and forests (*Salicetea purpureae*) growing in river valleys (Matuszkiewicz 2001, Zarzycki et al. 2002).

The history of forests is discussed below, here only some comments on species indicating exploitation of forests are presented. One group includes species characteristic of the class *Epilobietea*, which grow particularly abundantly in forest patches cleared by fire or tree felling, such as *Chamaenerion angustifolium*, *Fragaria vesca*, and *Rubus idaeus.* Such places are also invaded by *Pteridium aquilinum*. The other group is made of plants that grow in forest mantles, in thinned forests, and in the margin of forests in contact with grasslands and communities of tall herbs. Here belong *Origanum vulgare*, *Coronilla varia*, and *Dianthus armeria*, nowadays occurring most frequently in communities of the class *Trifolio-Geranietea*. *Chamaenerion angustifolium* was identified only in pollen spectra, *Pteridium aquilinum* was represented by spores and frond impressions, the remaining species were found only in grain samples from Wąsosz in small numbers suggesting their accidental penetration of crops.

The curve of *Melampyrum* needs comments. In Poland one species of this genus, *M. arvense*, grows in cereal fields and xerothermic grasslands and a few are forest species, among them *M. pratense* (*Dicrano-Pinion*, *Quercetalia* in Tab. 5). Fruits of this genus were not found in Wąsosz and in general they are rare in archaeological sites. Fruits of *M. arvense* appear in Poland as late as the early medieval time (Szydłowski & Wasylikowa 1973, Latałowa 1999, Lityńska-Zając 2005 p. 129, Lityńska-Zając 2011), therefore there are no convincing

Table 5. Plants of forests, forest clearings and forest mantles from the Przeworsk culture time in the Liswarta River basin. Explanations in Tab. 2.

Taxa	Wąsosz	Opatów	Waleńczów	Syntaxonomic affiliation	
				Forests	Other communities
Abies alba		+	+	*Vaccinio-Piceetea*, *Fagetalia*	
Lycopodium annotinum			+	*Vaccinio-Piceetea*	
Calluna vulgaris			+	*Vaccinio-Piceetea*	*Calluno-Ulicetea*, *Nardetalia*
Picea abies			+	*Vaccinio-Piceetea*	
Sorbus sp. (*aucuparia*)			+	*Vaccinio-Piceetea*, *Quercetalia*	
Vaccinium type			+	*Dicrano-Pinion*, *Pino-Quercion*, *Quercetalia*	*Oxycocco-Sphagnetea*
Melampyrum sp. (*pratense*)			+	*Dicrano-Pinion*, *Quercetalia*	
Pinus sylvestris	+	+	+	*Dicrano-Pinion*	*Oxycocco-Sphagnetea*
Viscum sp. (*album*)			+	*Dicrano-Pinion*	
Lycopodium clavatum			+	*Dicrano-Pinion*	*Nardo-Callunetea*
Juniperus communis		+		*Dicrano-Pinion*	*Nardetalia*, *Sedo-Scleranthetea*
Jasione montana			+	*Dicrano-Pinion*	*Corynephoretalia*
Diphasiastrum complanatum			+	*Dicrano-Pinion*	
Ledum palustre			+	*Piceo-Vaccinienion*	*Oxycocco-Sphagnetea*
Betula sp.	+	+	+	*Quercetalia*, *Vaccinio-Piceetea*	*Oxycocco-Sphagnetea*
Pteridium aquilinum		+	+	*Quercetalia*, *Pino-Quercion*	
Acer sp.	+	+	+	*Querco-Fagetea*, *Fagetalia*, *Tilio-Acerion*	
Astrantia maior type			+	*Fagetalia*	*Adenostylion*
Hedera helix			+	*Fagetalia*	
Corydalis sp.			+	*Fagetalia*, *Carpinion*	
Tilia sp.	+		+	*Fagetalia*, *Carpinion*	
Quercus sp.	+	+	+	*Quercetalia*, *Querco-Fagetea*, *Carpinion*	
Carpinus betulus			+	*Carpinion*	
Stellaria holostea			+	*Carpinion*	
Fagus sylvatica			+	*Quercetalia*, *Fagetalia*, *Fagion*	
Fraxinus excelsior			+	*Fagetalia*, *Alno-Ulmion*	
Corylus avellana			+	*Querco-Fagetea*	
Ulmus sp.			+	*Fagetalia*, *Alno-Ulmion*	
Circea sp.			+	*Alno-Ulmion*	
Alnus sp. (*glutinosa*)	+		+	*Alnetea*, *Alno-Ulmion*	
Frangula alnus			+	*Alnetea*, *Quercetalia*, *Pino-Quercion*	
Humulus lupulus			+	*Alnetea*, *Salicetea purpureae*, *Alno-Ulmion*	
Filipendula sp. (*ulmaria*)			+	*Alnetea*, *Alno-Ulmion*	*Molinietalia*
Lysimachia vulgaris type			+	*Alnetea*, *Alno-Ulmion*	*Molinietalia*
Salix sp.			+	*Salicetea purpureae*	
Populus sp.		+	+	*Salicetea purp*, *Quercetalia*, *Pino-Quercion*	
Urtica sp. (*dioica*)			+	*Salicetea purpureae*, *Alno-Ulmion*	*Artemisietea*
Viburnum sp. (*opulus*)			+	*Rhamno-Prunetea*, *Querco-Fagetea*, *Alnetea*	
Origanum vulgare	+			*Quercetalia*, *Trifolio-Geranietea*	
Coronilla varia	+			*Trifolio-Geranietea*	
Dianthus armeria	+			*Trifolio-Geranietea*	
Chamaenerion angustifolium			+	*Epilobietea*	
Fragaria vesca	+			*Epilobietea*	
Rubus idaeus	+			*Epilobietea*	*Adenostylion*

grounds to refer pollen curve of *Melampyrum* to this species. More likely is the occurrence of *M. pratense*, which according to Behre (1981) often grows in forest mantle communities and spreads particularly in forests disturbed by clearing, coppicing, or grazing. It seems thus that *Melampyrum* pollen curve at Waleńczów may represent *M. pratense* and reflect the exploitation of forests, particularly clearings with the use of fire, which are independently indicated by the simultaneous increase of *Chamaenerion angustifolium* and *Pteridium aquilinum* pollen/spore curves.

CULTIVATED AND GATHERED PLANTS

An important, if not the basic, source of vegetable food was plant cultivation. The most complete evidence concerning cultivated plants is provided by the samples of charred grain from Wąsosz Górny, slightly less information is obtained from impressions found in Opatów, and still less from the pollen diagram (Tab. 6). The content of pit 3 from Wąsosz Górny indicates that in the early Roman Period millet, rye, spelt wheat and flax were cultivated. No barley was present in this pit (Bieniek 1999). Plants cultivated in the late Roman Period included barley, rye, spelt wheat, oat, millet, pea, and flax. Barley found in Wąsosz and Opatów belonged to the hulled variety with loose ears (at least in Wąsosz, in Opatów ear density could not be recognized). The cultivation of wheats other than spelt is uncertain. In the first publication about plants found in Wąsosz Górny emmer *Triticum dicoccon* and einkorn *T. monococcum* were mentioned (Orlicz 1967), but later revision of the same material by Bieniek (1999) did not confirm these identifications. Among the impressions from Opatów a few imprints of emmer and einkorn were found, but they were probably only admixtures in the other cereals. Plant deposits from the other sites of the Przeworsk culture in Poland indicate, however, that emmer wheat was cultivated at that time, while einkorn probably was not (Lityńska-Zając 1997, Lityńska-Zając & Wasylikowa 2005). The identification of *Humulus lupulus* or *Cannabis sativa* pollen suggests that hemp was probably cultivated in the Liswarta River basin. The cultivation of hemp in the Roman Period is confirmed by the increase of *Cannabis* or *Humulus*/*Cannabis* pollen curves in several diagrams from Poland and the recovery of *Cannabis* fruits from two sites from the early and one from the late Roman Period. The other cultivated plants recorded from the Przeworsk culture localities in Poland include lentil *Lens culinaris* and bean *Vicia faba* var. *minor*, not found in the sites discussed in the present paper (Lityńska-Zając 2011 unpubl.).

The list of cereals found in the sites discussed is typical for the Przeworsk culture agriculture. The difference between the deposits from the early and late Roman Period in Wąsosz is probably accidental, because millet was recorded from the other late Roman sites and oat and barley from the other early Roman sites of this culture.

Edible plants collected from wild stands are usually underrepresented in archaeobotanical samples due to unfavourable conditions for their preservation in archaeological sites. They were usually collected for every-day use and not for storage, besides very often only vegetative parts susceptible to quick decay were gathered.

Table 6. The evidence of plants cultivated by the Przeworsk Culture people in the Liswarta River basin

Species	Wąsosz charred	Opatów impressions	Opatów charred	Waleńczów pollen
Avena sativa	+			
Cerealia indet.	+	+	+	
Hordeum vulgare	+	+	+	
Panicum miliaceum	+	+		
Secale cereale	+	+	+	+
Triticum dicoccon		+		
Triticum monococcum		+		
Triticum spelta	+	+		
Triticum sp.	+	+		+
Pisum sativum	+			
Linum usitatissimum	+			
Humulus/Cannabis				+

Table 7. Charcoals found in features of the Przeworsk culture sites at Opatów and Wąsosz Górny

Feature	*Quercus* sp.	*Betula* sp.	*Populus* sp.	*Acer* sp.	*Abies alba*	*Pinus sylvestris*	*Juniperus communis*	*Alnus* sp.	*Tilia* sp.
Opatów 1									
Grave 742	+					+	+		
Opatów 4									
Hearths 1–6 and 9–11	+								
Hearth 7						+			
Hearth 12								+	
Opatów 6									
Huts	>1266	4	18	6	120	81			
Hearths	>284	1			1	>1210			
Other features	>500					>120			
Wąsosz Górny									
Pit 17	+	+		+		+		+	+
Pit 3	10					667			

Several useful plants were present in the studied materials but in so small quantities that their purposeful accumulation, although very probable, cannot be considered certain. Rare remains of *Fragaria vesca*, *Rubus idaeus*, and *Vaccinium* indicate that these juicy fruits were consumed. Pollen diagram shows that hazel nuts *Corylus avellana* were available in the forests. Several herbaceous plants having edible fruits/seeds or green parts are among the weeds from Wąsosz. A few of them were rather numerous in pit 17 from Wąsosz, for instance *Chenopodium album*, *Fallopia convolvulus*, *Polygonum lapathifolium*, and *Polygonum* sp., but this is not an unquestionable evidence of their purposeful gathering (for more on this subject see Bieniek 1999).

The direct evidence of the use of wild plants is available only with respect to timber, straw, and bracken *Pteridium* leaves. The analysis of the rich wood charcoal material from Opatów and a smaller one from Wąsosz indicate that oak wood was most often used, followed by pine (Tab. 7). Other trees, birch *Betula* sp., fir *Abies alba*, maple *Acer* sp., poplar *Populus* sp., lime *Tilia* sp., and alder *Alnus* sp., as well as juniper *Juniperus* sp. were probably used on a smaller scale. Straw of cereals and probably of some other grasses was added to clay in quite large quantities and its impressions were observed in almost every piece of daub.

The presence of a fairly large number of frond impressions of *Pteridium aquilinum* in samples from Opatów is interesting. Spores of this fern species are often recorded in pollen diagrams, but its macrofossils are rare. In Poland uncharred fronds were found in the early medieval sites at Wolin (Latałowa 1999), Międzyrzecz (Klichowska 1959), Wawel (Wasylikowa 1978, Wasylikowa 2007 unpubl.), in medieval Kołobrzeg (Latałowa & Badura 1996) and Kraków (Mueller-Bieniek in press), and in a barrel from the 16th century AD from Kraków (Tomczyńska & Wasylikowa 1999). Impressions were never discovered. The relatively high frequency of impressions at Opatów suggests that fronds of this plant were gathered and used for some purpose. We do not know whether only fronds were collected or also rhizomes, and if fronds were deliberately added to clay. Several kinds of usage are mentioned in literature. For consumption and medicinal purposes rhizomes and young fronds were used, fronds served as bedding for cattle and for covering roofs, for making ropes and for protection of food against decay (Göransson 1988, Madeja et al. 2009, Makohonienko 2000, Pawlik & Schweingruber 1976).

THE VEGETATION AT THE TIME OF THE DEVELOPMENT OF THE PRZEWORSK CULTURE SETTLEMENT ACCORDING TO THE POLLEN DIAGRAM

Archaeological data from the Liswarta River catchment area indicate that this area was almost completely depopulated from the 5th-6th century BC to the middle of the 2nd century AD

(Gedl et al. 1971, Godłowski 1983). The existence of a hiatus in the pollen diagram at the depth of ca 55 cm, caused either by the cessation of peat growth or destruction of the deposit (charcoals in the sediment), is responsible for the lack of a complete record of vegetation that existed just before the arrival of the Przeworsk culture people. Some information about the vegetation at the very beginning of the Przeworsk culture settlement phase is provided only by the pollen spectrum from the depth of 45 cm. The deciduous forests composed of lime *Tilia*, oak *Quercus*, and maple *Acer* with some elm *Ulmus* could develop on fresh, fertile and moderately mesotrophic soils. They probably resembled the modern lime-hornbeam association *Tilio-Carpinetum*, which according to the map of the potential natural vegetation (Fig. 10) would occupy large areas around Waleńczów and Opatów (Matuszkiewicz et al. 1995, Matuszkiewicz 2008). Hazel *Corylus avellana* could grow in the shrub layer of these forests, while *Corydalis*, *Astrantia maior*, and *Stellaria holostea* were among the plants of the herb layer. *Hedera helix* and *Viscum* were quite common. These forests differed, however, distinctly from the modern ones by the lack of hornbeam *Carpinus betulus*. Sandy and sandy-clayey soils could be covered with acidophilous oak forest with oak as the dominating tree and the admixture of pine, spruce *Picea abies*, and birch *Betula*. Species of *Vaccinium*, *Melampyrum* (probably *pratense*), and *Pteridium aquilinum* could occur in these forests. They could be similar to the modern association of the middle-European acidophilous oak forest *Calamagrostio-Quercetum petraeae*, indicated east of Waleńczów and Opatów on the map of the potential natural vegetation. Near Wąsosz large areas could be occupied by forests resembling modern xerothermic oak woods known today as the association *Potentillo albae-Quercetum* (Matuszkiewicz 2008). The main tree was oak, accompanied by pine, birch, and lime, with hazel in the scrub layer. Here *Vaccinium* species and *Pteridium aquilinum* could also grow. Small areas on sands and sandy loams were covered with oak-pine and pine woods,

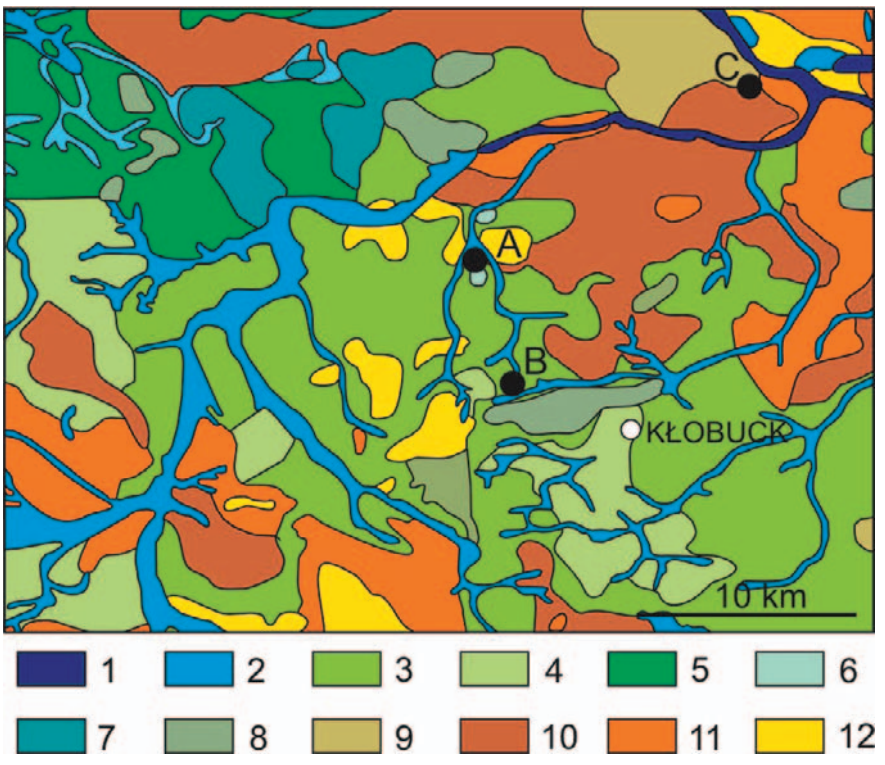

Fig. 10. The potential natural vegetation of the Liswarta River catchment (Matuszkiewicz 2008). Localities: **A** – Opatów, **B** – Waleńczów, **C** – Wąsosz Górny. Forest communities: **4** – *Salici-Populetum* (lowland willow-poplar forest), **5** – *Fraxino-Alnetum* (lowland alder and ash-alder forest), **6** – *Tilio-Carpinetum* (subcontinental lime-oak-hornbeam forest, poor), **7** – *Tilio-Carpinetum* (subcontinental lime-oak-hornbeam forest, rich), **8** – *Tilio-Carpinetum* with *Abies* (forb-rich fir forest with hornbeam and oak), **9** – *Dentario enneaphyllidis-Fagetum* (rich submontane beech forest), **10** – *Luzulo pilosae-Pinetum* (lowland acidophilous beech forest), **11** – *Potentillo albae-Quercetum typicum* (well-lighted lowland oak forest), **12** – *Potentillo albae-Quercetum rosetosum gallicae* (well-lighted upland oak forest), **13** – *Calamgrostio-Quercetum* (middle European acidophilous oak forest), **14** – *Querco-Pinetum* (continental mesotrophic oak-pine mixed forest), **15** – *Leucobryo-Pinetum* (suboceanic middle European pine forest complex)

now counted in the alliance *Dicrano-Pinion*. Herb layer of these forests would include some of the plants found in the pollen diagram, such as *Vaccinium*, *Diphasiastrum complanatum*, *Pulsatilla*, *Lycopodium annotinum*, and *Pteridium aquilinum*. Carrs with alder, ash, elm, and poplar, as well as willow thickets developed in river valleys. Some of the herbaceous plants recorded in pollen diagram, such as *Filipendula* (if *ulmaria*), *Thalictrum*, *Cirsium* type, *Succisa pratensis* type, and *Urtica* (if *dioica*), could have occurred in these forests or in patches of moist meadows in valley bottoms. The low sum of the herbaceous plants pollen (NAP 7%) suggests that forest cover was dense, but nonetheless a few agriculture indicators appeared. The most significant among them are one pollen grain of rye *Secale cereale* and the beginning of continuous curves of *Rumex acetosella* and *Plantago lanceolata* but cereal cultivation and pasturage must have been carried out on a small scale or at a considerable distance from the mire.

The increase of the NAP pollen curve (up to 22%) in the next sample (at 40 cm) and the presence of numerous indicators of land occupation give evidence of deforestation, which was caused by people. Not only the forested area diminished but also the composition of deciduous forests was changed. The significance of lime, elm, oak, birch, spruce, hazel, *Hedera*, and *Viscum* decreased, while that of hornbeam, beech, and fir increased. The proportions of ash and maple did not change. Forests of such composition were probably maintained during the whole period of the existence of the Przeworsk culture settlement. The decrease of the *Filipendula* curve and the disappearance of *Succisa pratensis* type, *Thalictrum*, and *Cirsium* type indicate that the area covered by moist meadows diminished. Cereal pollen is absent but pollen of typical weeds, such as *Fallopia convolvulus* and *Polygonum persicaria* type appear, together with possibly weedy species of *Rhinanthus* (if *serotinus*) and *Papaver* (if *rhoeas*). In the same sample pollen curves of plants representing grasslands, pastures, and grazed forests (*Ranunculus*, *Plantago media*, *Melampyrum*) show peaks. In the next sample (35 cm) continuous pollen curves of cereals *Secale* and *Triticum* begin and typical field weeds *Agrostemma githago* and *Scleranthus annuus* appear. An increase of pollen curves of species that can be connected with plant cultivation and animal grazing (e.g. *Plantago lanceolata*, *Rumex acetosella*) is recorded in the same sample. Forest clearings with the use of fire are evidenced by increased curves of *Chamaenerion angustifolium* and *Pteridium aquilinum*. The enlargement of cultivated areas and more intensified grazing probably caused the destruction of some forests with hornbeam and fir and hampered the spread of beech.

The sequence of events recorded in the three samples correlated with the Roman period can be interpreted as follows. The lowest spectrum (at 45 cm) corresponds to the initial stage of the occupation in the Liswarta River basin, when forests were little effected by agricultural activity, which was limited to relatively small areas. The middle spectrum (at 40 cm) reflects first of all the spread of meadows and pastures in the vicinity of the mire, and fields at a greater distance. At that time intensive grazing and cereal cultivation, connected with land rotation, reduced forest stands. The uppermost spectrum documents the expansion of cereal fields, probably not only near the mire but in the whole region. However, the changing proportions between grassland and cereal field indicators presumably reflect rather changes in the arial distribution of fields and grazed areas than the successive stages, in which one or the other branch of agriculture prevailed.

CONCLUSIONS

The vegetation in the Liswarta River basin during the time of the Przeworsk culture settlement was described on the basis of a pollen diagram from the mire in Waleńczów and the results of the analysis of plant macrofossils (charred fruits, seeds, charcoals and impressions) from archaeological sites at Wąsosz and Opatów. The first population of this culture settled in a well forested area. Mesophilous deciduous forests with lime, oak and maple were growing on more fertile soils and drier sandy places were covered by oak-pine and pine forests. River valleys were occupied by carrs, willow thickets and moist meadows. The spread of settlement, plant cultivation and animal husbandry caused the reduction of forest stands with elm, oak, lime, spruce, and hazel. The area covered by moist meadows probably diminished, while on drier soils grasslands expanded. At first forests with

hornbeam, beech, and fir expanded, but further development of agriculture caused their reduction. Cultivated plants included cereals (barley, rye, spelt wheat, oat, millet), pea and flax. Possibly emmer wheat and hemp were also cultivated, but their documentation is less reliable. The presence of plants that can grow on fallows suggests that some kind of field rotation was practised. Edaphic requirements of weeds indicate that fields were located mainly on fresh, fertile or moderately fertile soils of neutral reaction, rarely on poorer acidic or moderately acidic soils. Animals were grazed in meadows, fallows and forests. The exploitation of forests included procurement of timber, mostly oak and pine, clearing of forests with the use of fire, forest grazing, and gathering useful plants for food and for other uses.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. hab. Maria Lityńska-Zając, prof. PAN, for rendering accessible her unpublished plant identifications from the site Opatów 1 and unpublished Data Base of Archaeobotanical Plant Remains. We thank Dr hab. Dorota Nalepka, prof. PAN, for supplying the Waleńczów pollen data from the Polish pollen data base. Thanks are due Dr. hab. Adam Walanus, prof. AGH, for taking photographs of plant fossils. We greatly appreciate the most helpful comments of the referees Prof. Dr. Hilary Birks and Dr hab. Dorota Nalepka, prof. PAN.

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