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UTILISATION OF CULTIVATED AND WILD PLANTS IN THE ECONOMY OF THE LINEAR POTTERY CULTURE IN THE UPPER VISTULA BASIN

ABSTRACT

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The current recognition of plant materials obtained from archaeological sites of the Linear Pottery Culture in the Upper Vistula basin made it possible to indicate the species that were cultivated and utilised by the Early Neolithic human communities. The data presented in this paper, referring to the occurrence of macroscopic plant remains of various types, was collected from 23 sites (97 identified taxa). The analyses covered charred remains of plants, their imprints in daub and pottery, and fragments preserved within the mass of clay used for production of ceramic vessels. The results of these studies have delivered a great number of interpretative opportunities; apart from reconstructions of the environment and economic behaviours of first farmers, these opportunities included the versatile application of plants, and clearly indicated that an application of plants and organic materials was highly diversified and constituted the grounds on which human economy of the Early Neolithic was based.

Keywords: Neolithic, Linear Pottery Culture, cereals, plant utilisation, south-eastern Poland
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1. INTRODUCTION

The current recognition of plant materials encountered at archaeological sites of the Linear Pottery Culture (LBK) in the territory of Poland is relatively poor (comp. Lityńska-Zając, Wasylikowa 2005 and literature quoted there; Bieniek 2007 and literature quoted there; Lityńska-Zając 2007 and literature quoted there). Nevertheless, the data gathered so far, complemented with new, systematic studies conducted by, i.a. the Cracow Team for Archaeological Supervision of Motorway Construction (e.g. Czekaj-Zastawny 2014; Lityńska-Zając *et al.* 2014), made it possible to indicate plant species cultivated and utilised by the Early Neolithic human communities. This paper is partly based on both published and unpublished sources (the list of all sites including the relevant literature herewith), and it aimed to present archaeobotanical data collected in the area of the Upper Vistula basin, as well as to analyse and summarise the state-of-the-art referring to the utilisation of crop and wild plants by the LBK communities.

2. PRESENTATION OF RESULTS

The data confirming the occurrence of macroscopic plant remains of various sorts in south-eastern Poland came from 23 archaeological sites belonging to the Linear Pottery Culture (Table 1 – CD). These sites are mainly located on loess soils of the Lesser Poland Uplands (Fig. 1). Three of them are situated in the Sub-Carpathian region. At particular sites a varied number and kind of samples were examined, depending on the nature of archaeobotanical studies conducted there (systematic or occasional). A great part of plant materials was obtained from utility pits. Others came from construction pits and post-holes, as well as alleged ovens and graves. The latter two types of features were discovered at the site 17 in Brzezie (Czekaj-Zastawny 2014). In samples collected from the fillings of four graves charcoals and seeds were preserved which could have got into the sediments altogether with the dirt swept from the closest surroundings to cover the grave pits (Lityńska-Zając *et al.* 2014).

The plant materials under analysis included impressions in daub or pottery (one site), charred remains (most of the sites), and the both types of materials (six sites). At the particular archaeological sites under scrutiny the number and kind of identified remains varied. Most of the specimens ascribed to the culture in question were gathered in Brzezie, site 17, Gwoździec, site 2 and Targowisko, site 16, while the smallest number was encountered in Jurkowice and Kraków-Pleszów, site 20. The greatest taxonomic diversity was recorded, among others, in Brzezie, site 17, Olszanica and Gwoździec. For materials from Rzeszów and Zofipole, site 1 the number of excavated caryopses of cereals was not given in the original elaborations (Table 1). A separate category of sources enclosed plant remains preserved in the mass of clay used for production of vessels. Fragments of plants were commonly added to the mass of clay as an intentional temper.

These remains are visible on both, surfaces of vessels (thick-walled specimens in particular) and within cross-sections of their walls. They were subject to microscopic examinations using an optical and a scanning electron microscope. The research material came from a dozen or so archaeological sites (i.a. Kraków-Mogiła 62, Kraków-Pleszów 20, Modlnica 5, Modlniczka 2, Zagórze 2, Brzezie 17, Targowisko 10 and 11, Gwoździec 2, and Łoniowa 18; comp. Fig. 1).

Based on the plant material preserved at archaeological sites of the Linear Pottery Culture in south-eastern Poland 97 taxa were identified, including 63 units determined to the level of species, 28 to the level of genus, and six to the level of family. A part of caryopses and fragments of spikelets were counted to the group of undetermined cereals *Cerealia* indet., while another part to cereals and/or wild grasses *Cerealia* indet. vel Poaceae indet. Moreover, in table 1, among the cereal remains only common wheat *Triticum aestivum* was given, although in an original elaboration drawn for the site in Olszanica (Ford 1986), a few remains of naked wheat were described as club wheat *T. compactum*. The approach assumed in this paper was due to the current classification system combining both of these ancient subspecies of naked wheats into one species. With regard to their morphology they differ in terms of their spike compactness and caryopsis outline. However, presently they are both counted to one biological species, namely *Triticum aestivum* subsp. *aestivum* syn. *Triticum aestivum* (Hanelt 2001; Lityńska-Zając and Wasylikowa 2005, 226-227; comp. also Lityńska-Zając 2010).

Poorly preserved fragments of charcoals represented undetermined coniferous and deciduous tree species. Furthermore, at two sites an occurrence of sclerotia of the ectomycorrhizal fungus *Cenococcum geophilinum* was recorded.

As mentioned above, at archaeological sites of the Linear Pottery Culture plant remains are mostly preserved as charred specimens, rarely as impressions in daub or sporadically, in pottery. All of the cereals, and most of the woody and herbaceous plant materials were represented by charred remains or imprints. However, a certain part of diasporas of herbaceous plants were found uncharred. They occurred at few archaeological sites, usually in small numbers (excluding the site 17 in Brzezie, comp. Lityńska-Zając *et al.* 2014 and the site 2 in Zagórze, comp. Lityńska-Zając *et al.* 2015). Due to the type of a substrate in which archaeological features were established, in most cases not reaching the groundwater table and thus creating favourable conditions for the preservation of uncharred remains, it is very probable that these specimens were simply a contamination of younger or even modern chronology (Lityńska-Zając and Wasylikowa 2005, 47-50 and literature quoted there). Materials from the site 5 in Modlnica were exceptional in this respect (Lityńska-Zając *et al.* 2012b), where a part of the site enclosing the LBK settlement was located at a lower altitude. With certain limitations, uncharred dia-sporas preserved in features encountered at this site were considered to be of a similar age to the charred specimens. Amongst the uncharred remains from Modlnica there were identified: six fruits of silver birch *Betula pendula*, two fruits of European goldenrod *Solidago virga-urea* and

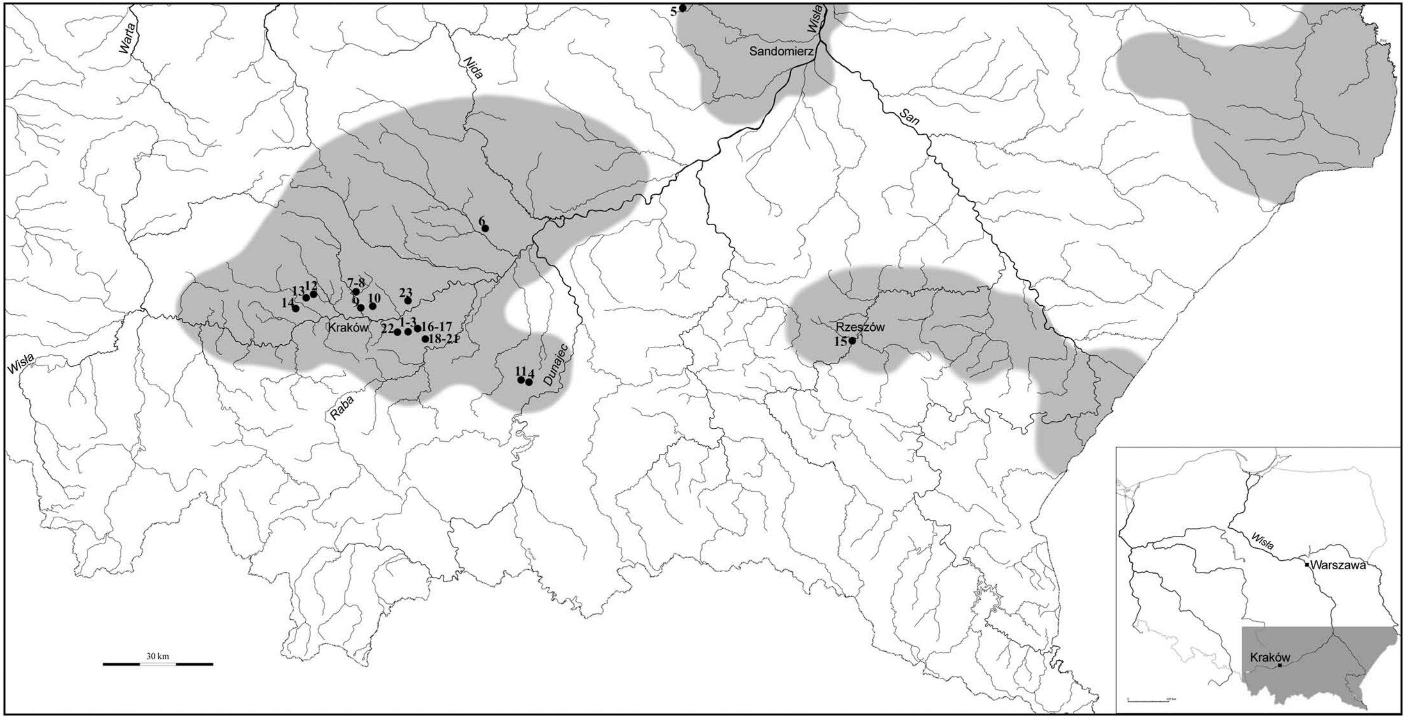

Fig. 1. Location of the Linear Pottery Culture sites from south-eastern Poland

List of the sites mentioned in the text: 1. Brzezie, site 17, Kłaj commune (Lityńska-Zając *et al.* 2014); 2. Brzezie, site 33, Kłaj commune (Lityńska-Zając *et al.* 2012, unpublished); 3. Brzezie, site 40, Kłaj commune (Lityńska-Zając *et al.* 2012a, unpublished); 4. Gwoździec, site 2, Zakliczyn commune (Bieniek and Lityńska-Zając 2001; Lityńska-Zając 2007); 5. Jurkowice, site 1, Opatów commune (Klichowska 1960); 6. Kazimierza Mała, site 1, Kazimierza Wielka commune (Lityńska-Zając 2007); 7. Kraków-Bieńczyce, site 12 (*det.* Z. Tomczyńska, In Gluza *et al.* 1988); 8. Kraków-Bieńczyce, site 15 (*det.* Z. Tomczyńska, In Gluza *et al.* 1988); 9. Kraków-Mogiła, site 62a (Gluza *et al.* 1988); 10. Kraków-Pleszów, site 20 (*det.* W. Giżbert, In Kulczycka-Leciejewiczowa 1969); 11. Łoniowa, site 18, Dębno commune (Lityńska-Zając *et al.*, in print); 12. Modlnica, site 5, Wielka Wieś commune (Lityńska-Zając *et al.* 2012b, unpublished); 13. Modlniczka, site 2, Wielka Wieś commune (Lityńska-Zając *et al.* 2011, unpublished); 14. Olszanica (at present inside of the administrative borders of Cracow) (*det.* Giżbert In Kozłowski and Kulczycka 1961; Ford 1986; Lityńska 1986a); 15. Rzeszów (*det.* Giżbert In Moskwa 1961); 16. Szarów, site 12, Kłaj commune (Lityńska-Zając *et al.* 2010, unpublished); 17. Szarów, site 21, Kłaj commune (Lityńska-Zając 2010, unpublished); 18. Targowisko, site 10, 11, Kłaj commune (Lityńska-Zając *et al.* 2014a); 19. Targowisko, site 12/13, Kłaj commune (Lityńska-Zając *et al.* 2012c); 20. Targowisko, site 14/15, Kłaj commune (Lityńska-Zając *et al.* 2012d); 21. Targowisko, site 16, Kłaj commune (Lityńska-Zając *et al.* 2012e; Lityńska-Zając 2013); 22. Zagórze, site 2, Niepołomice commune (Lityńska-Zając *et al.* 2015); 23. Zofipole, site 1, Igołomia-Wawrzeńczyce commune (*det.* ?, Burchardówna 1953)

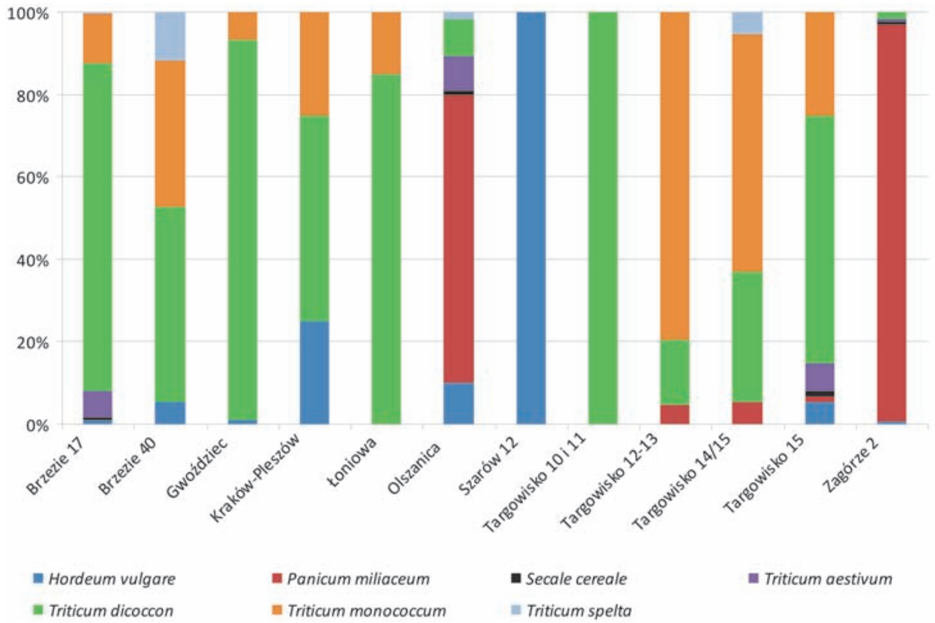

Fig. 2. Percentage number of cereal remains from individual sites of the Linear Pottery Culture

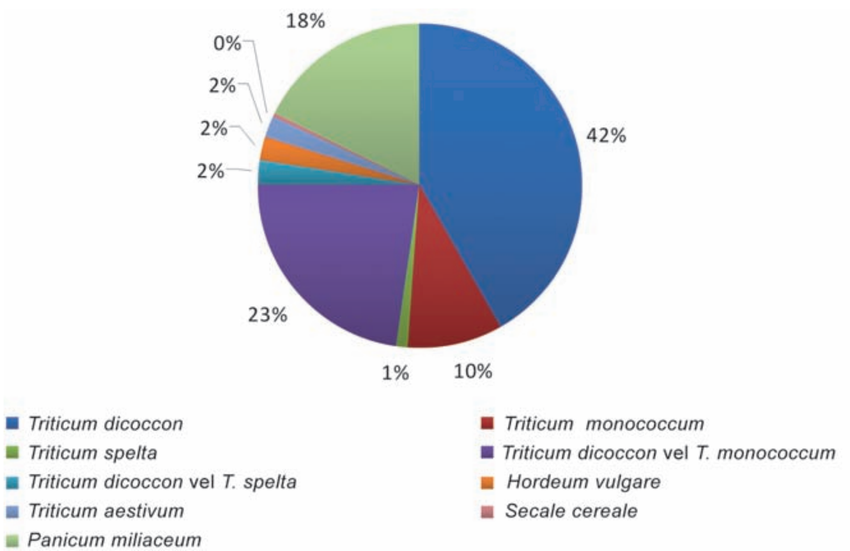

Fig. 3. Percentage number of total cereal remains from all archaeological sites of the Linear Pottery Culture

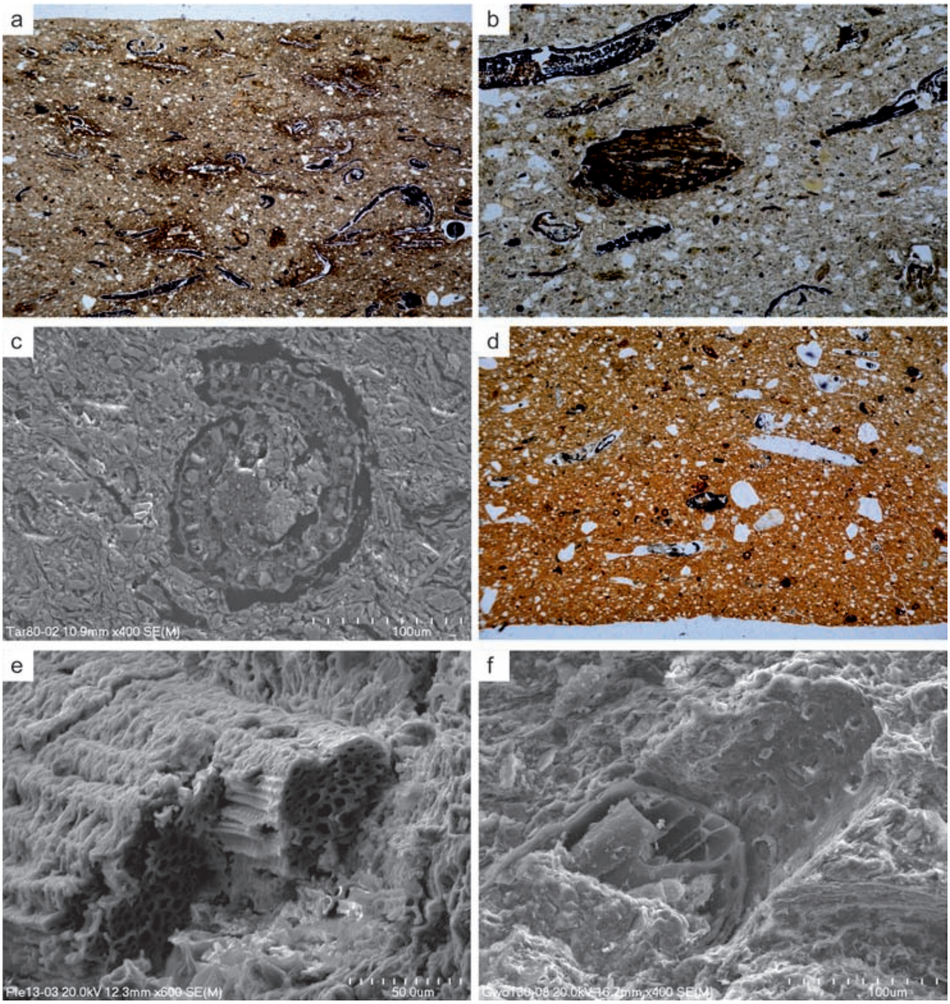

Fig. 6. Remains of plants found within the Neolithic pottery; a, b, d – micrographs based on thin sections; c, e, f – SEM micrographs; a – sample Zag108, numerous organic fragments (black objects) visible in ceramic fabric, reducing atmosphere of firing; b – sample Zag105, basal and longitudinal cross-section of the remains; c – sample Tar80, basal cross-section of the remain; d – sample Zag112, oxidising layer close to the external surface, voids after burning of plants tissue; e – sample Ple13, plant tissue visible on the fresh surface of the pottery; f – sample Ple17, plant tissue visible on the fresh surface of the pottery

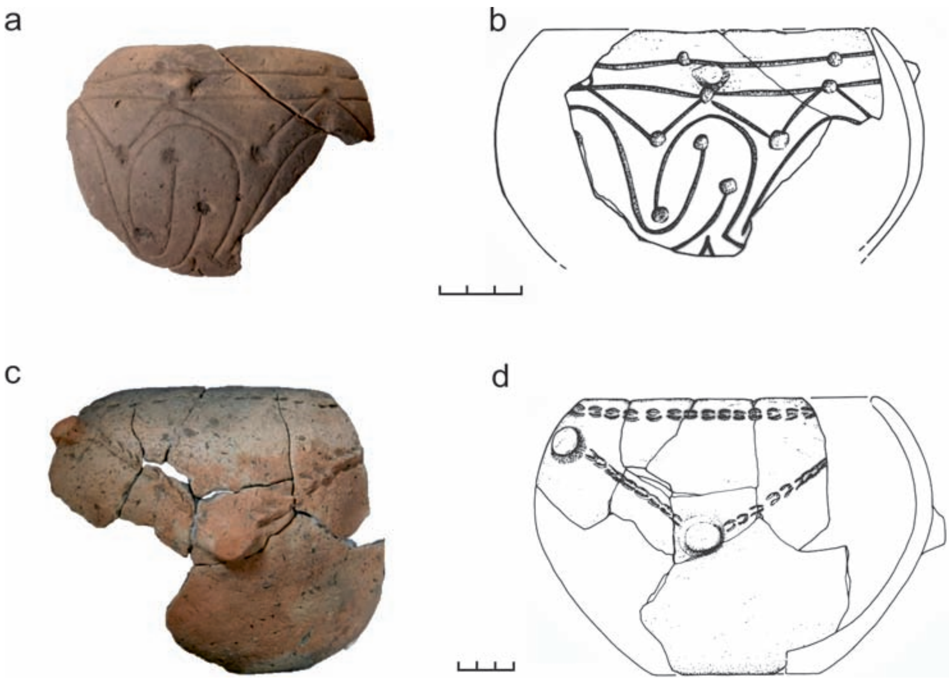

Fig. 7. LBK wares from the Lesser Poland; a, b – sample Wyc1, fine vessel ("table ware"); c, d – sample Mod168, medium thick-walled ware ("kitchen ware")

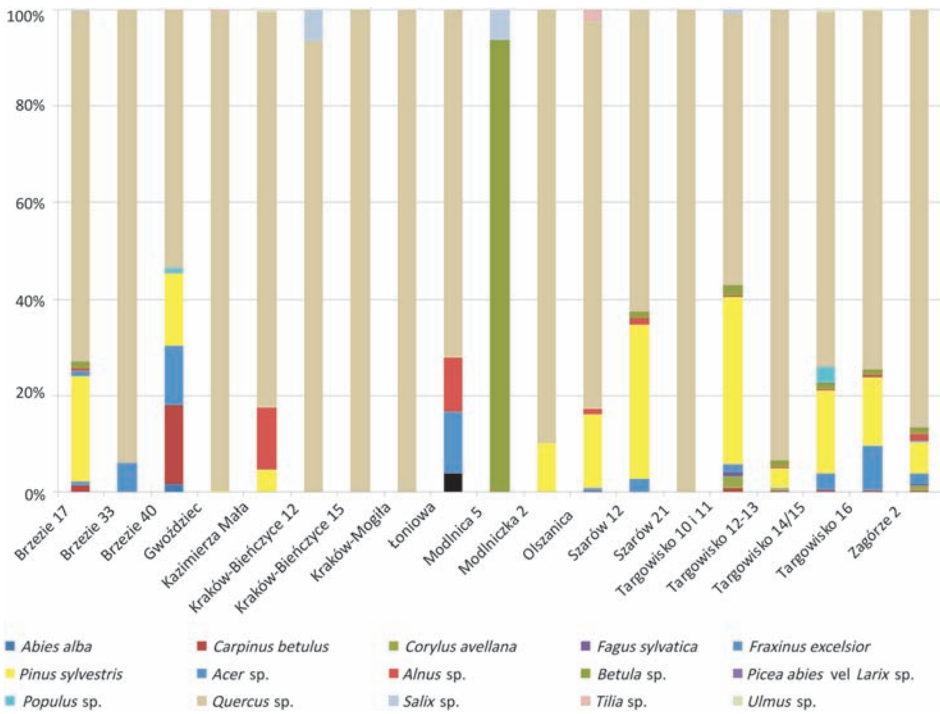

Fig. 8. Percentage number of charcoals from the Linear Pottery Culture sites

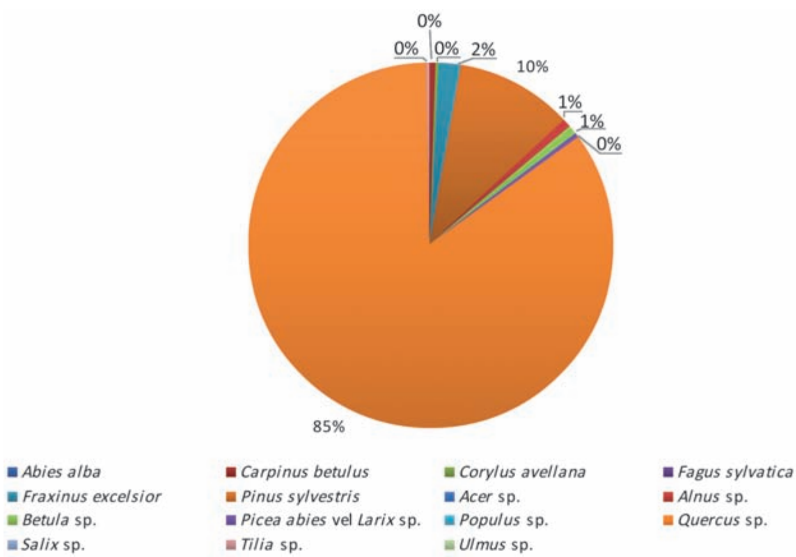

Fig. 9. Percentage number of charcoals in relation to the total number of specimens (N = 17799)

three seeds of goosefoot *Chenopodium* sp. In all other cases uncharred dia-sporas were neglected while interpreting the material.

In archaeological assemblages of the Linear Pottery Culture several species of cereals were recorded (Table 1). These were mostly remains of dehusked wheats, such as emmer *Triticum dicoccon* and einkorn *T. monococcum*, as well as spelt *T. spelta*. At these sites there also occurred plant remains in a worse state of preservation, identified as *T. dicoccon* vel *T. monococcum* and *T. dicoccon* vel *T. spelta*. The remains of wheat enclosed caryopses and fragments of spikelets. At eight sites specimens classified as remains of barley *Hordeum vulgare* were encountered. These were mostly individual specimens, while at the site in Olszanica seven caryopses and four imprints of spikelets of this species were found (Table 1). Remains of common millet *Panicum miliaceum* preserved at six sites, including a great number of millet caryopses encountered in Olszanica and Zagórze, site 2. Moreover, at several sites caryopses of common wheat *T. aestivum* were discovered, though they were not very numerous. Furthermore, in Olszanica an occurrence of imprints of caryopses and a spike of rye *Secale cereale* was recorded (Giżbert 1961), whereas at four other sites charred remains of this species were found.

Amongst other cultivated plants encountered at the sites Gwoździec 2, Brzezie 40 and Targowisko 16, one should name few seeds of common flax *Linum usitatissimum* (one, two and one specimen, respectively), while at the site 16 in Targowisko a single seed of the common pea *Pisum sativum* was found.

Wild herbaceous plants were represented by 43 species and 18 genera. They included remains of species commonly recorded in archaeological materials of various chronologies (Lityńska-Zając 2005), such as: white goosefoot *Chenopodium album*, black bindweed *Fallopia convolvulus*, rye brome *Bromus secalinus* or lady's thumb *Polygonum persicaria*. The most numerous were diasporas of white goosefoot, which also revealed the highest frequency of occurrence at archaeological sites. The great majority of the identified taxa were represented by only singular specimens (Table 1).

Within the material under scrutiny, 11 species and 11 genera of trees were identified (Table 1). In most cases the source material were charcoals. There also preserved fruits or seeds of apple *Malus* sp., including wild apple *M. sylvestris*, as well as European hornbeam *Carpinus betulus*, birch *Betula* sp. and oak *Quercus* sp. Based on the examinations of the charcoal, remains of black alder and two oak species, sessile oak *Quercus petraea* and pedunculate oak *Q. robur* were identified at the site in Olszanica (Ford 1986). Nevertheless, such precise identifications may raise certain doubts. Most botanists specialised in anthracology believe that, based on the properties of wood anatomy, subfossil remains of alders and oaks growing in Poland can only be identified to the level of genus (Schweingruber 1978, 74-76, 144-145), and this approach has been assumed for the interpretation of plant materials presented here.

3. CROP PLANTS IN THE ECONOMY OF THE LINEAR POTTERY CULTURE

3. 1. Cultivated plants

In order to reconstruct the structure of ancient crops, archaeobotanical data obtained from archaeological sites of the Linear Pottery Culture in south-eastern Poland was used. In general, it can be stated that examinations of fossil materials have delivered relatively reliable information about the species cultivated in the past. An occurrence of their remains at archaeological sites is usually considered to prove local cultivation of particular crop species by inhabitants of settlements located nearby. However, in some cases the possibility of importing these species from other territories should also be taken into consideration. Premises of this sort usually become readable upon examination of the remains of weeds co-occurring with cereal caryopses within individual samples (Latałowa 1999, 221, 1999a; Lityńska-Zając 2005, 84). Far more difficult is to reconstruct the quantitative relationships between particular species and determine their shares within ancient crops.

For the interpretation of the results various comparative methods were employed. One of these methods allowed the investigators to obtain a diagram reflecting percentage numbers of cereal remains (regardless of their types) for particular cereal species encountered at archaeological sites discussed in this paper (Fig. 2). Thanks to the second method, a total number of remains counted to this category of sources could be compared (Table 2; Fig. 3). Whereas, the third method revealed the frequency of occurrence of particular species at archaeological sites, regardless of their quantity (Table 2; Fig. 4).

The oldest Neolithic cultural layers revealed the greatest share of dehusked wheats, including emmer *Triticum dicoccon* and einkorn *T. monococum*, at particular sites (Fig. 2, 5).

Table 2. Total number of cereal remains and their frequency at Linear Pottery culture archaeological sites

taxa name	total of specimens	% (N=1720)	number of sites	% (N=23)
Triticum dicoccon	717	42	11	48
Triticum monococcum	164	9	8	35
Triticum spelta	16	0,9	4	17
Triticum dicoccon vel *T. monococcum*	394	23	9	39
Triticum dicoccon vel *T. spelta*	42	2	5	21
Hordeum vulgare	37	2	8	35
Triticum aestivum	39	2	4	17
Secale cereale	6	0,3	4	17
Panicum miliaceum	305	17	6	26

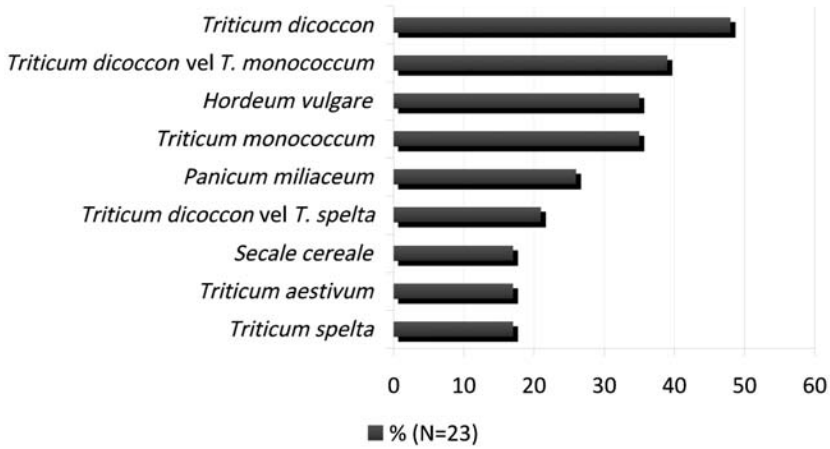

Fig. 4. Frequency of occurrence of cereal remains from the Linear Pottery Culture sites. Percentage is calculated from the total number of sites with cereals (N=23)

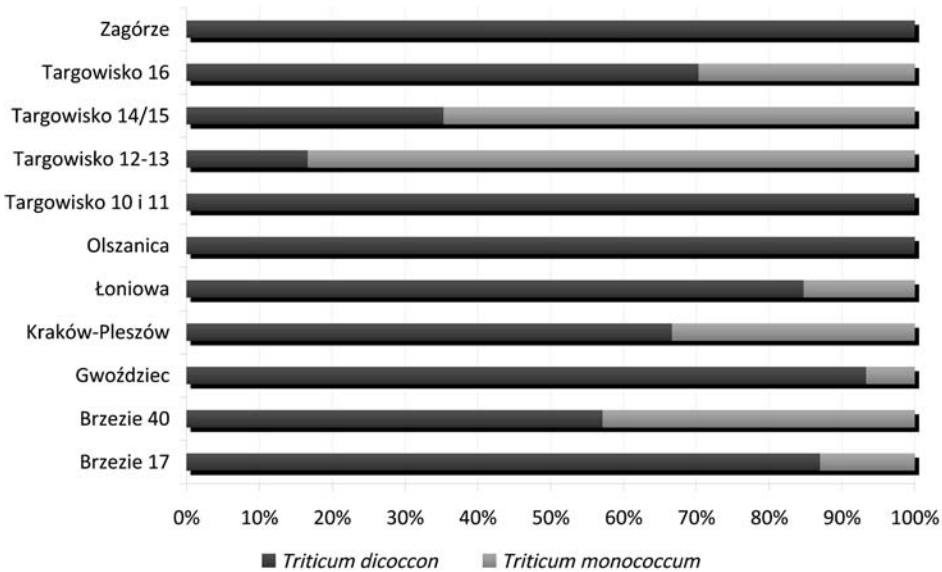

Fig. 5. Relative occurrence of einkorn *Triticum monococcum* and emmer wheat *T. dicoccon* from the Linear Pottery Culture sites

This picture was disturbed for the site 12 in Szarów, which was due to an occurrence of only one identified crop species, namely barley *Hordeum vulgare*. In Olszanica and Zagórze, site 2 remains of millet *Panicum miliaceum* prevailed overwhelmingly. While in Brzezie, site 17, Olszanica and Targowisko, site 15 there occurred remains of common wheat, the share of which was not very high, reaching up to 9%, at maximum.

With regard to the total quantitative summary (Table 2, Fig. 3) the remains of dehusked wheats, emmer and einkorn, were also predominant. Moreover, the former species was the most frequently recorded at the sites under scrutiny (Fig. 3). The both species of wheat were most likely the most common species of crops of that time. The share of emmer remains was significant at many sites, although in assemblages of two sites (Targowisko, site 12-13 and Targowisko, site 14/15) a greater quantity of einkorn remains was recorded (Fig. 4). The major role played by this group of wheats was also confirmed by numerous finds described as *T. dicoccon* vel *T. monococcum* and *T. dicoccon* vel *T. spelta* (Table 1, Fig. 3). The third species of dehusked wheats, spelt *T. spelta* emerged at four sites and was poorly represented. Remains of the latter species have never occurred frequently and abundantly in subfossil materials obtained from the territory of Poland and thus, presumably, this wheat was not particularly significant in ancient crops (Lityńska-Zając and Wasylikowa 2005, 493). Another species that was recorded relatively frequently, though in small numbers, was barley *Hordeum vulgare*. Its role in the structure of ancient crops has not been fully clarified. This cereal could have been cultivated on a small scale. According to some opinions expressed in the related literature, in the first phases of the Neolithic period barley was of little, if any at all, economic significance, and might have co-occurred with wheat on crop fields only as a weed (e.g. Bogaard 2004, 14; Kreuz *et al.* 2005). This assumption is based on the fact that it was usually poorly represented in assemblages coming from different regions of Europe (Conolly *et al.* 2008; Zohary *et al.* 2012). Finds of barley containing a slightly greater number of its remains obtained, among others, from features of the Linear Pottery Culture, were encountered in Piotrowice Wielkie (Klichowska 1969) and Sobociska (Klichowska 1969a). Having referred to the data presented above to other, thoroughly investigated region of Poland, particularly Kuyavia (Bieniek 2007) and Lower Silesia (Lityńska-Zając 2007), it can be concluded that the share of this species in the crop structure of that time was considerably smaller than that of primeval wheats. Barley gained its major role as a crop species no earlier than in the times of the Lusatian Culture development and later on, in the Roman period (Lityńska-Zając and Wasylikowa 2005, 492-493).

In terms of the quantity of identified plant remains (charred caryopses and their imprints) a considerable position was taken by common millet *Panicum miliacem*. Remains of this species were mainly encountered in Zagórze, site 2 and Olszanica, while the number of specimens recorded in the assemblage from Zofipole is unknown. Unfortunately, “plant remains preserved in features of the Linear Pottery Culture in Zagórze are difficult to interpret due to a taxonomic composition of species recorded there. A part of them indicates a secondary relocation of the materials” (Lityńska-Zając *et al.* 2015, 162). Millet remains have been reported in assemblages collected from European sites with a relatively early chronology, but the latest studies revealed that this species had spread on crop fields no sooner than in the 4th or 3rd mill. cal BC (Moreno-Larrazabal *et al.* 2015 and literature quoted there). Based on the above-mentioned remarks it should be assumed that the role played by millet was rather marginal.

Rye *Secale cereale* is a very interesting species with regard to the matters discussed here. Remains of this species were encountered at four sites, in the form of a few charred caryopses (Table 2, Fig. 3, 4). Moreover, in Olszanica, imprints of an unknown number of caryopses and a spike of rye were recorded (Giżbert 1961). Finding a spike with solid rachis internodes is very important from the perspective of the recognition of this species history. A great majority of archaeobotanical sources confirm its late introduction into cultivation, as the so-called secondary crop plant (Wasylikowa 1983; Behre 1992; Lityńska-Zając and Wasylikowa 2005, 99). Isopollen maps displaying pollen spectra of rye dated to the period between 5500 and 2500 BP revealed a small frequency of its occurrence in the territory of Poland during the Neolithic and Bronze Age. Its share significantly increased starting from the Roman period (Okuniewska-Nowaczyk *et al.* 2004, 349).

Since the earliest times the structure of crops grown in Poland have been dominated by cereals, most probably being the major source of plant-based food consumed by the Neolithic human communities. Grains of cereals, wheats in particular, were usually ground to make flour or hulled to obtain groats. Cereals are easily-assimilable food since they contain a considerable amount of carbohydrates, mostly in the form of starch, and smaller amounts of proteins and fats (Domańska *et al.* 1982, 255). Grains of barley *Hordeum vulgare* could have been designated mainly for animal feed (Domańska *et al.* 1982) while millet, usually consumed as millet groats, might have also been used to feed fowl (Strzelczyk 2003; Lityńska-Zając and Wasylikowa 2005, 106).

Moreover, ancient human communities utilised chaff that could have served as feed or bedding for bred animals, as well as raw material for covering roofs, stacks and clamps. One of the most commonly and directly confirmed manners of cereal utilisation, possibly as by-products, has left its traces impressed in daub. Such traces have been preserved at all of the sites where this type of prehistoric material was encountered. Cereal remains, depending on the state of preservation and plasticity of the material in which the imprints were left, could be identified precisely to the level of species or genus, or classified in general to the group of undetermined cereals *Cerealia* indet. These were mainly fragments of chaff, glumes and bracts, as well as fragments of caryopses preserved in a form of imprints. Their occurrence within daub was due to an intentional complementation of mass of clay with fresh residues of threshing, as the so-called temper. Construction clay was used for insulating buildings, coating floors, walls and pits.

Comminuted fragments of plants were also widely used in production of ceramic vessels, which is one of the identification marks of the Linear Pottery Culture (Moskal-del Hoyo *et al.* 2016). Adding this component to the mass of clay had a certain impact on physical properties of clay products, e.g. their porosity or weight. Plant temper was mostly used in production of thick-walled vessels. Their walls have provided a great opportunity to observe structures and cross-sections of plant tissues (Fig. 6 a, b, c). Thin-walled vessels also contain organic fragments, although they are usually more comminuted, thus undetectable with a naked eye on thoroughly smoothed surfaces of vessels (Fig. 7). Similar remains are also encountered within small clay figurines. Preservation of plant fragments within the mass of clay was possible thanks to reduction firing. The limited access of oxygen during pottery firing prevented the organic material from being burnt. The LBK vessels are often characterised by a specific tricolour fracture, which is due to oxygen supply at the end of firing process, or rapid oxidation firing with an insufficient penetration of oxygen leaving the fracture only partially oxidised. Within oxidised layers of vessel walls fragments of plants have not preserved, and only regular voids can be observed (Fig. 6 d). In the course of long-term studies (thin section and SEM-EDS analysis) several hundred examples of plant remains preserved within earthenware have been recorded. Plant remains within pottery can be observed on various cross-sections and in different state of preservation (Fig. 6 e, f). Nevertheless, repetitive structures of plant tissues are detectable. Their identification was not possible based on plant morphology, but it was carried out with the help of plant anatomy, especially by observing the microscopic features of plant epidermis. Plant fragments identifiable by macro-morphology were not found. Therefore, mainly microscopic features were used for taxonomic plant identifications (Moskal-del Hoyo *et al.* 2016). The study has demonstrated that plant temper added to pottery was different from that usually used in building materials, such as daub. Plant materials added to the mass of clay used for making pottery was chopped and crushed so that their remains are not easily perceptible with macroscopic methods, and therefore they can be identified only occasionally. The examination has shown that plant temper was also used in finer ware. Moreover, the use of remains of grasses was indicated, since the analysis of the micromorphology of the plant remains has confirmed that the material mixed into the clay could have come mainly from their inflorescence bracts. The phytoliths preserved in Neolithic pottery definitely represent inflorescences of C3 grasses and they may correspond to domesticated grasses, such as wheat or barley (Moskal-del Hoyo *et al.* 2016).

An attempt to establish the economic significance of other crop plants is far more difficult due to their poor representation in the fossil material under scrutiny. One of these plants is common pea *Pisum sativum* that can be grown to obtain seeds, green feed for domesticated animals or hay. Its seeds, containing from 25 to 50% plant-based proteins and 50% carbohydrates, and playing the role of fine alimentation product, are a major human nourishment whether consumed raw or after being cooked. Feed concentrates for livestock can be made from seeds, hay, chaff and silage (Dzieżyc 1967, 108; Podbielkowski 1985). Pea seeds can also be ground to make flour used as an additive in bread baking (Körber-Grohne 1988).

Another species, common flax *Linum usitatissimum* could have been used as oilseed and fibre crop. Flax seeds can be processed into edible oil, while flax pomace constitutes nutrient-rich feed for animals. Moreover, flax seeds have a healing significance (linseed), and are used mostly as a medicament that helps protect the digestive tract (Ożarowski, Jaroniewski 1989, 225-227). Long-stem forms provide fibres obtained from a cortical layer of the stem (Domańska *et al.* 1982; Podbielkowski 1985). Evidences of retting flax have not been found in materials older than these dated to the Early Middle Ages. At a site in Wrześnica, com. Sławno a bundle of flax consisting of *ca* 800 specimens was found (Latałowa 1998; Latałowa and Rączkowski 1999). Unfortunately, there is no certainty about the nature of its usage by the LBK communities. However, it seems that fibres obtained from flax stems could have been processed into yarn that served for production of fabrics. In Gwoździec, within a filling of a construction pit situated nearby a dwelling object, a concentration of clay loom weights (eight entirely preserved specimens and nume-rous fragments) and spindle whorls (six items) were encountered and interpreted as remnants of a loom (Kukułka 2001).

Summarising, the authors stated that a small number of cereal caryopses recorded at most of the archaeological sites of the Linear Pottery Culture, in contrast to other sites dated to the Neolithic period, e.g. of the Funnel Beaker Culture where they occurred in bulk and frequently within storage pits designated exclusively for storing cereal grains (Klichowska 1970; Jankowska 1997; Kruk *et al.* 2016), does not have to necessarily mean that their cultivation was of a small economic significance to human communities living in the oldest Neolithic period. Quite the contrary, plant remains constantly encountered in archaeological layers of that time reflect their common occurrence as crop plants, as well as wide-range economic application. Engaging taphonomy in studies of this sort can be of crucial importance.

3.2. Wild plants

At some of the archaeological sites (Table 1) crop species were accompanied by few remains of herbaceous plants growing spontaneously in habitats of various types (Matuszkiewicz 2001; Zarzycki *et al.* 2002), situated more or less closely to the settlements under analysis. These were mostly weeds usually occurring on crop fields among cereals, such as common corncockle *Agrostemma githago*, rye brome *Bromus secalinus* and field gromwell *Lithospermum arvense*, or in horticultural crops, e.g. barnyard grass *Echinochloa crus-galli* and yellow foxtail *Setaria pumila*. In ruderal habitats, fig-leaved goosefoot *Chenopodium ficifolium*, white goosefoot *C. album* and black bindweed *Fallopia convolvulus* might have appeared; the latter two species occurred on crop fields as well. In the fossil materials under analysis there were also recorded remains of plants growing in drylands, grasslands (e.g. thyme-leaved sandwort *Arenaria serpyllifolia*), wet meadows (e.g. ragged robin

Lychnis flos-cuculi), and other natural places such as those located nearby ponds, springs, forest roads and in wet alder forests (e.g. lady's thumb *Polygonum hydropiper*).

From the viewpoint of economic usefulness, some of these plants might have been picked for utilitarian purposes. A few of them could have been gathered easily due to their high capacity of seed production (Behre 2008), and consequently providing humans with abundant crops. The most prolific species amongst those represented by plant remains found within the cultural layers of the Linear Pottery Culture is white goosefoot with a capacity of *ca* 100,000 seeds produced by a single individual (Tymrakiewicz 1962, 31-32). This is one of this species, the seeds of which were very often recorded in the fossil materials of varied chronological units (Lityńska-Zając 2005, 87). According to the opinions expressed by many scholars (e.g. Helbæk 1960; Behre 2008) the gathering of plants by prehistoric humans was an important supplement to their plant-based diet, the major component of which since the Neolithic period were cereals. This form of economy was of a considerable significance, and the volume of products obtained through gathering reached the volumes of harvested crops (Helbæk 1960). Without any doubt we can assume that collecting edible plants has always accompanied human existence until the present (Łuczaj 2011). The best example to support this thesis that can be the easily observed contemporary practice in Poland of picking fruits of the bilberry *Vaccinium myrtillus*, or various mushroom species. Gathering wild plants, storing them and processing into different meals played a very significant role in humans' diet (Ayerdi *et al.* 2016). Unfortunately, it must be stressed that the fossil materials encountered at the LBK sites did not contain a large number of herbaceous plant remains that could directly indicate their utilisation. This may be due to the fact that many plant remains preserved in a charred form are not fully represented in archaeological sources, which can result from the manner of their utilisation (e.g. green parts of plants) (Collegde and Conolly 2014). Taking into account certain limitations (Lityńska-Zając 2008) in assessing the fossil material, the major criterion in such assessment is the manner of plant utilisation, described in ethnological sources as a "criterion of potential usefulness" (e.g. Zegarski 1985; Tylkowa 1989), and the knowledge of the chemical, physical and biological properties of particular species (Kuźniewski and Augustyn-Puziewicz 1986; Ożarowski and Jaroniewski 1989). However, in this case we must assume that these properties have been known to humans for ages. Moreover, it should be stressed that amongst plants presently growing in the surroundings of human activity zones, and commonly occurring in nature, most of them can reveal an economic application (comp. e.g. Maurizio 1926; Twarowska 1983; Łuczaj 2004). Therefore, the assessment of fossil materials is very difficult and ambiguous, which is even more obvious if we realise that in most cases charred plant remains encountered at archaeological sites do not contain green parts of plants and their underground organs that have also been gladly used by humans (Szymański 2008).

Seeds of goosefoot, including white goosefoot, are traditionally considered to be edible (Podbielkowski 1985). They might have been intentionally collected and stored by the LBK communities. Young individuals of white goosefoot *Chenopodium album* can be eaten raw or cooked as legumes (Łuczaj 2004, 101). This species was also used as feed for livestock (Szot-Radziszewska 2007). Its seeds could have served for making flour and groats, or as an additive in bread baking. However, one should keep in mind that an excessive content of white goosefoot seeds in bread may cause various pathological symptoms experienced by individuals who ate these products, such as skin swelling and diarrhoea (Bagiński and Mowszowicz 1963, 39). With regard to the LBK materials, the greatest number of diasporas of white goosefoot were recorded at the site 16 in Targowisko.

For producing flour and groats plant species with large and starch-rich fruits, namely grasses (Poaceae) were used. Their caryopses contain considerable amounts of starch, as well as carbohydrates, proteins and fats. Amongst the analysed materials representing this group of plants there were identified, among others, soft brome *Bromus hordeaceus*, rye brome *B. secalinus*, drooping brome *B. tectorum*, hairy crabgrass *Digitaria sanguinalis*, barnyard grass *Echinlochloa crus-galli*, yellow foxtail *Setaria pumila* and oat *Avena* sp. There was also a significant number of specimens identified only to the level of family Poaceae indet.

For making salads, spinach and pottages green sprouts and leaves of various species of goosefoot *Chenopodium*, sorrel *Rumex* and knotweed *Polygonum* could have been used.

An extremely interesting species in this respect is wild amaranth *Amaranthus lividus*, the remains of which have preserved at the site 16 in Targowisko. In Poland it became widespread no sooner than in the Middle Ages. Nevertheless, the nature of its finds is unknown. Seeds of this species might have been an accidental admixture in samples. On the other hand, this species could have been gathered as a wild plant or cultivated (Lityńska-Zając and Wasylikowa 2005, 147-148). It was not until the discovery of its remains preserved in cultural layers dated to the 10th-12th century uncovered in Cracow, at the Wawel Hill, when a cultivated variant of *Amaranthus lividus* convar. *lividus* was identified (Wasylikowa 1978).

Some of the gathered species containing biologically active compounds could have been occasionally used and administrated as medicaments. This group encloses, i.a. wild mint (described in the materials as *Mentha arvensis* vel *M. aquatica*), or common corncockle *Agrostemma githago* and black nightshade *Solanum nigrum*. Seeds and fruits of the latter species contain a toxic glycoalkaloid, solanine, the highest content of which is recorded in unripe fruits and causes poisoning in all domesticated animals (Bagiński and Mowszowicz 1963, 203 204). According to descriptions by Dioskorides and Theophrastus the species of nightshade that were consumed by ancient humans include *S. nigrum*, *S. humile* and *S. villosum* (Maurizio 1926, 64). In the Middle Ages, green sprouts of black nightshade were used for making salads, though the most appreciated parts of this plants were the black and red berries, considered to be an exquisite delicacy (Jaroń 1938, 14). Twarowska (1983, 226-227) mentioned this species describing it as a healing plant that could also be consumed “in spite of its toxic properties, i.a. in dumplings”. In healing treatments nightshade should be administrated with a great caution due its strong poisoning effects. A juice made from the leaves and berries of this species was said to cure ulcers, scurvy, cancer and flank pains (Kluk 1788, 89).

Having assumed that the above-mentioned hypothesis of including uncharred fruits of European goldenrod *Solidago virgaurea* preserved at the site 5 in Modlnica into the LBK context discussed in this paper is true, the authors concluded that this species was also utilised by humans of that time. Goldenrod is a perennial plant commonly occurring in the current flora of Poland, revealing certain healing properties. This species is used as herb named *Herba Solidaginis*, containing flavonoids, tannins, saponins, essential oils and mineral salts. Its biologically active compounds have a diuretic effect and they are usually applied in inflammatory conditions of urinary tracts and glomerular nephritis. Due to their significant content of tannins, goldenrod-based products can be administrated to cure gastroenteritis (Ożarowski and Jaroniewski 1989, 269-270).

Plants were also used for other economic purposes. Field gromwell *Lithospermum arvense* could have played a role of a dye plant. Root bark of this species provides red dye, named litospermina (Nowiński 1983, 128). Other plants that might have been used as dyes include, i.a. dwarf elder (*Sambucus ebulus*) and false cleavers (*Galium spurium*). The above-mentioned pigment could have also been obtained from bark of various species of oak *Quercus* sp. Whereas, the bark of wild apple *Malus sylvestris* provides yellow, green and black dyes due to a significant content of β-carotene.

Apart from herbaceous plants the Linear Pottery Culture materials under scrutiny also contained remains of fruits of trees that were most likely purposely gathered by humans. The most spectacular example of such finds was delivered by materials preserved at the site 2 in Gwoździec, where fragments of fruits of wild apple *Malus sylvestris* were found, accompanied by seeds identified to the level of genus *Malus* sp. (Bieniek and Lityńska--Zając 2001). In general, fruits of the above-mentioned species have been rather sporadically encountered in archaeological assemblages from the territory of Poland (Lityńska 1986). Apples could have been consumed directly after picking; however, most probably they were also dried and stored. They contain tannins, pectines and citric acid, and they were known to practitioners of folk medicine as an antidiarrheal remedy.

Another species of economic significance to ancient humans was common hazel *Corylus avellana*. A single charred fragment of a hazelnut shell was recorded at the site 2 in Zagórze (Lityńska-Zając *et al.* 2015). Hazelnuts contain fats, proteins and carbohydrates (Podbielkowski 1985, 192). They have a high calorific value amounting to 780 kcal in 100 grams of fresh mass (Byszewski 1972, 337), and can be eaten fresh, directly after picking, or dried and stored for a longer period of time (Maurizio 1926, 67; Łuczaj 2004, 118). Nowadays, hazelnuts are used for the production of sweet confectionery (e.g. halva). The fat obtained from these nuts is employed in the dyeing industry for the production of oil paints, fragrances and food industries, and for soap production. Hazelnut oil is also used as fuel and machine oil.

At the site 2 in Zagórze two fragments of acorn were preserved. Acorns of both species of oak have a very high caloric value since 100 grams of their dry mass provides 560 kcal (Collegde and Conolly 2014). They are also a great source of starch, the content of which amounts to 48-50%, while in dry fruits this value rises up to 60-70%. Moreover, acorns contain 2% protein and 2% fat. In dry fruits these values increase to 5-6% and *ca* 3%, respectively (Deforce *et al.* 2009). Due to the significant content of tannin, oak fruits are usually very bitter (Łuczaj 2004), therefore before consumption it is essential to remove this substance from acorns. Acorns after cooking and leaching gain a slightly distinctive flavour resembling the flavour of cooked cereals. However, they can be used as the base for the preparation of various meals or fed to swine, though for other animals they are toxic.

Remains of trees and more rarely shrubs are usually encountered at archaeological sites in the form of charcoals or wood fragments. Due to their fragility charcoals are very susceptible to fragmentation with varied resilience depending on certain properties of particular species. Consequently, one fragment of wood put into a fireplace can disintegrate into an unpredictable number of pieces which are subject to further fragmentation while lying within the sediments, exploration of archaeological features and processing of the material in the course of laboratory examinations. Therefore, an interpretation of quantitative data of this category of sources is troublesome and controversial (e.g. Gluza *et al.* 1988; Wasylikowa *et al.* 2003; Lityńska-Zając and Wasylikowa 2005, 274-276). In order to make the results more objective, apart from the presentation of the data obtained from the sites under scrutiny (Table 1, Fig. 8), two values were compared: a total number of charcoals ascribed to particular species or genera (Table 3, Fig. 9), and the frequency of their occurrence at archaeological sites (Table 3, Fig. 10).

At most of the LBK sites, the remains of oak *Quercus* sp. were predominant (Table 1, Fig. 8), and their shares ranged from 50 (Brzezie, site 40) to 100%; the latter value was recorded at the sites where only a few fragments of charred wood were preserved (e.g. Kraków-Bieńczyce, site 15 and Kraków-Mogiła, site 62a). A slightly different situation was encountered at site 5 in Modlnica, where a prevailing occurrence of charcoals of birch *Betula* sp. was revealed. All the remains of this species were preserved within a single utility pit (no. 908). At the site in question only two more charcoals were discovered, identified as remains of willow *Salix* sp. Remains of Scots pine *Pinus sylvestris* were relatively abundantly represented at the sites 10/11 in Targowisko and Szarów, site 12 (Fig. 8). Following oak, it was the second most frequent species identified in the assemblages under scrutiny (Table 3, Fig. 10). Remains of European ash *Fraxinus excelsior* and alder *Alnus* sp. were also quite frequently recorded (Table 1, 3, Fig. 10), although their share in the total number of fragments was rather low (Table 3, Fig. 9), which also concerns their shares at particular sites (Table 3, Fig. 8). Noteworthy is the occurrence of relatively few remains of beech *Fagus sylvatica*, hornbeam *Carpinus betulus* and fir *Abies alba* at the sites of the Linear Pottery Culture. *Carpinus betulus* was represented by 91 specimens (Table 3, Fig. 9) encountered at seven sites (Table 3, Fig. 10). The greatest number of its remains

Table 3. Total number of trees and shrubs remains and their frequency at Linear Pottery culture archaeological sites

taxa name	total of specimens	% (N=17799)	number of sites	% (N=23)
Abies alba	7	0	5	22
Carpinus betulus	91	0,5	7	30
Corylus avellana	32	0,2	5	22
Fagus sylvatica	15	0	6	26
Fraxinus excelsior	429	2	11	48
Pinus sylvestris	1767	10	12	52
Acer sp.	41	0,2	4	17
Alnus sp.	124	0,7	11	48
Betula sp.	239	1	8	35
Picea abies vel *Larix* sp.	3	0	1	4
Populus sp.	43	0,2	3	13
Quercus sp.	14968	84	18	78
Salix sp.	11	0	5	22
Tilia sp.	12	0	4	17
Ulmus sp.	17	0	4	17

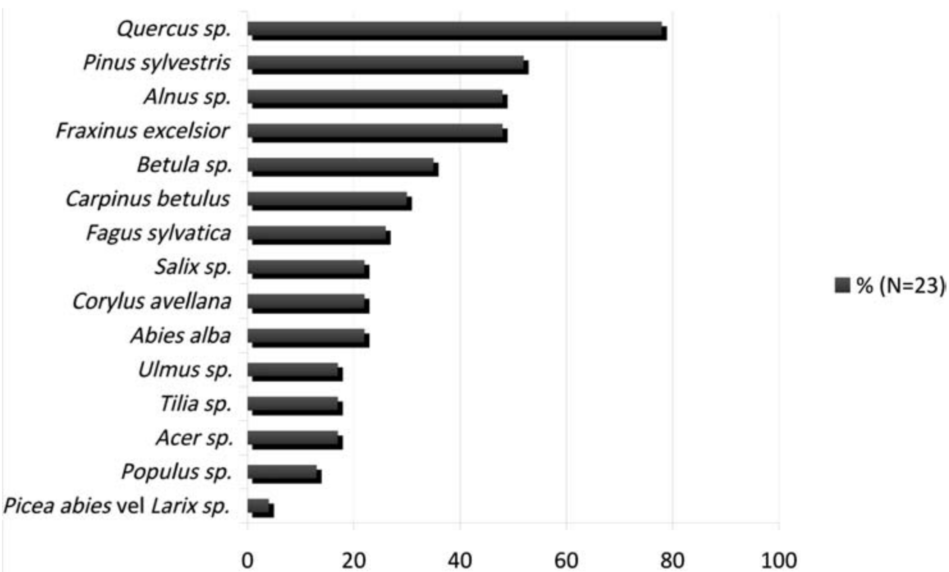

Fig. 10. Frequency of occurrence of charcoals. Percentage is calculated from the total number of sites with charcoals (N=23)

was recorded at site 17 in Brzezie (Table 1, Fig. 8). Presently, hornbeam is a species commonly found in the oak-hornbeam forests in Poland. According to palynological data, its origins in the Polish territories can be dated relatively late, to the end of the Atlantic Period., whereas the beginnings of its intensive expansion took place *ca* 3500 radiocarbon years BP (Ralska-Jasiewiczowa *et al.* 2004, 69). Charcoals of beech were recorded at six sites (Table 3, Fig. 10), represented by 15 fragments (Table 3, Fig. 9). Its share at the particular archaeological sites was low (Table 1, Fig. 8). The migration of *Fagus sylvatica*, which started in the south *ca* 5000 radiocarbon years BP, spread along a few routes. As a result the range of beech covered sub-mountain and upland areas, however it was no sooner than in *ca* 3000 radiocarbon years BP (Latałowa 2003, 290; Latałowa *et al.* 2004, 95). Hardly less interesting is an occurrence of fir, the remains of which were identified at five sites (Table 3, Fig. 10), in the number of seven specimens (Table 3, Fig. 9). An expansion of this species began in the foreland of the Carpathian Mountains *ca* 3500 BP (Obidowicz *et al.* 2004, 31). Nevertheless, the presence of the above-mentioned taxa is likely to constitute a younger contamination within the features of the Linear Pottery Culture, which was quite possible due to the multicultural nature of the sites under scrutiny. Certainly, it cannot be excluded that remains of the tree species quoted in this paper that emerged quite frequently, though not very numerously, within the archaeological macroscopic materials (e.g. Lityńska-Zając *et al.* 2014) should be given more attention, and require a brand new insight into their history, including verification of the existing information referring to their expansion in the territories of Poland. The authors believe that a factual connection of the above-mentioned tree species with the features of the Linear Pottery Culture could be proved indisputably by radiocarbon dating performed for the identified fragments of charred wood.

A common occurrence of tree remains at archaeological sites is a result of the considerable demand for wood. In the main these were the remnants of fuel material used in ancient households. Everyday demand for fuel was mainly satisfied by brushwood collected by humans in surrounding forests, which is supported by the great taxonomic variability recorded in samples gathered from hearths and fireplaces (Lityńska-Zając and Wasylikowa 2005, 47-51).

Plant materials were also used for erecting wooden constructions. Large-scale utilisation of wood for this purpose was also proven by numerous postholes preserved at almost all of the LBK sites excavated (Czekaj-Zastawny 2014), as well as traces of branches and laths impressed in daub like those encountered at the site 17 in Brzezie, among many others.

4. SUMMARY

The earliest cultural layers of the Neolithic period connected with the Linear Pottery Culture have delivered a large quantity of data referring to the remains of cereals that played a predominant role in the structure of ancient crops. The greatest number of the most diversified data was provided by studies conducted in the past decade in the area of the Wieliczka-Bochnia Piedmont. Hundreds of samples taken there were subject to botanical analyses (comp. the list of sites given in the caption of Fig. 1). Amongst the investigated materials obtained from large settlements of the Linear Pottery Culture with post frame houses, the greatest number of remains preserved in utility pits and construction pits accompanying dwelling objects. Such materials also occurred within postholes and hearths. With regard to particular archaeological sites, the results of analyses were similar and they clearly indicated an existence of certain regularities readable in the set of plants utilised by the LBK communities that consequently confirmed the composition of crop plant species recognised until present. The most popular crop species of that time were dehusked wheats, namely emmer and einkorn. They are the most commonly encountered cereal remains found in sediments ascribed to the cultural unit in question. They must have played a crucial role in the crop structure of that time. Cereals, mostly dehusked wheats such as emmer and einkorn, were most likely cultivated as food for humans. They provided the most valuable food source in a form of grains that were used for production of flour and groats. The role of other species, including barley, has not been indisputably determined and they might have been of marginal economic significance. Common wheat, millet and rye were most likely weeds growing among other cereal crops. A taxonomic identification of macroscopic plant remains obtained from the site in Gwoździec, Brzezie, site 40 and Targowisko, site 16 indicated a utilisation of common flax. At the site 16 in Targowisko a utilisation of common pea was also confirmed.

Ancient human communities supplemented their everyday cereal-based diet with wild gathered plants. Based on the occurrence of herbaceous plant remains, some important conclusions can be drawn. Firstly, these were plant species occurring in the fields amongst the crop plants intentionally grown, thus they confirm an existence of plant cultivation. Habitat conditions required by particular species of these plants prompt to a conclusion that agricultural and horticultural crops must have been purposely established and maintained by inhabitants of nearby settlements on fresh, fertile substrates with neutral pH indicator (comp. analysis, Lityńska-Zając *et al.* 2013) whereas the remains of the plant species of different requirements were most surely associated with other habitats. This indicates that the plant-based food management was conducted in various zones of the area surrounding the settlement (*op. cit.*). Remains of both cereals and herbaceous plants were mostly encountered within the fillings of utility pits, but they were also found in postholes and hearths. They got into utility pits altogether with harvested crops, thus they should be considered as remains of food reserves stored by ancient humans (Lityńska-Zając *et al.* 2013). Mixed plant materials were also found within postholes, and may be a result of the sweeping of plant residues into the hole from its closest surroundings. Moreover, these finds indicate that activities connected with food processing were performed in the closest surroundings of households (outside or in their interiors) whereas if found in hearths, plant remains could be interpreted as dispensable residues of threshing burnt in fire.

Another example of traces evidencing the important economic activities that are preserved in archaeological materials are the remains of wood utilised mainly as a source of fuel. Apart from small brushwood, fireplaces might have also been supplied with waste products left after house building. Based on the remains of trees preserved within construction pits, a find of a burnt down house no. XVIII at the site 17 in Brzezie (Czekaj-Zastawny 2014), or charcoals coming from wooden posts, some conclusions can be drawn referring to preferences in selecting construction material for house building. In this respect the prevailing number of materials was classified as oak *Quercus* sp., followed by ash *Fraxinus excelsior* and pine *Pinus sylvestris*. Thus, it can be stated that the major tree species used for erecting post frame constructions were oak and ash. From the fillings of postholes of the above-mentioned house no. XVIII found at site Brzezie 17, numerous fragments of bark were obtained. This fact can be linked with a few possible explanations, i.a. placing posts covered with bark, or using bark for coating floors or partition walls. Investigations carried out at a few archaeological sites provided the grounds for an explicit conclusion that inhabitants of settlements of the cultural unit in question enriched construction clay with temper. This temper consisted mostly of threshing residues.

A specific manner of plant utilisation was using them as temper in the production of ceramic vessels. For this purpose only selected parts of plants were employed. These were the fragments situated most closely to the grains. Having identified that the organic temper added to the mass of clay contained remains of domesticated cereals, an assumption can be made that they were of a particular significance to the Early Neolithic human communities. Applying comminuted fragments of cereals (mainly inflorescence bracts) was due to technological reasons (for achieving respective physical properties of vessels), but it might have also been a matter of tradition. The latter could have been particularly true with regard to the production of thin-walled vessels or movable objects made of clay (e.g. figurines). The practice of applying plant-based material as a temper to enrich the mass of clay evolved throughout the LBK development in the territories of the Lesser Poland. Statistical analyses proved that at the beginning of this culture development the organic temper was commonly used for production of all types of ceramics. In the last phase the technology based on adding fragments of cultivated plants to the mass of clay had legibly lost its popularity (Moskal-del Hoyo *et al.* 2016). In the times of post-linear cultures development and afterwards, the chamotte-based admixtures prevailed (consisting of fragments of crushed pottery).

The studies on identification and utilisation of plants have delivered a great number of interpretative opportunities besides the reconstruction of the environment and economic behaviour of ancient human communities. They have provided the grounds for concluding on the application of organic materials (e.g. in constructions), utilisation of plants (e.g. in medicine or consumption), structure of field crops and even their location. The results of the archaeobotanical studies presented in this paper have proved that an application of plants and organic materials was of an extremely wide range, and it constituted the very bases of human economy in the Early Neolithic.

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UTILISATION OF CULTIVATED AND WILD PLANTS IN THE ECONOMY OF THE LINEAR POTTERY CULTURE IN THE UPPER VISTULA BASIN

Table 1. List of plant remains from the Linear Pottery culture archaeological sites.
Explanation: kind of remain: z – caryopsis, n – seed, o – fruit, k – spike, kł – spikelet, p - glume, wkł – spikelet fork, sł – chaff, os – rachis, d – charcoal, ko – bark, sc – sclerocium, 0 – unknown number of specimens

Nazwa taksonu / taxa name	Stan zachowania / state of preservation	Typ szczątka / kind of remains	Brzezie	Brzezie	Brzezie	Gwoździec	Jurkowice	Kazimierza Mała	Kraków-Bieńczyce	Kraków-Bieńczyce	Kraków-Mogiła	Kraków-Pleszów	Łoniowa	Modlnica	Modlniczka	Olszanica	Rzeszów	Szarów	Szarów	Targowisko	Targowisko	Targowisko	Targowisko	Zagórze	Zofipole	Suma / total
			17	33	40	2	1	1	12	15	62A	20	18	5	2			12	21	10, 11	12-13	14/15	16	2	1	
Hordeum vulgare	s	z	3		5	3										7		1					4	1		24
Hordeum vulgare	od	kł														4										4
Hordeum vulgare	od	z										1				8										9
Panicum miliaceum	s	z														127					2	1	1	169	0	300
Panicum miliaceum	od	z														5										5
Secale cereale	s	z	2													1							1	1		5
Secale cereale	od	k														1										1
Secale cereale	od	z														0										0
Triticum aestivum	s	z	17													16	0						5	1		39
Triticum dicoccon	s	p	17		35	20							4								1	2		1		80
Triticum dicoccon	s	wkł	8		8	16							1									4		1		38
Triticum dicoccon	s	z	151		1	278							45			1	0			1	6		45	1		529
Triticum dicoccon	od	p				7																				7

Triticum dicoccon	od	wkł	12									1				1										14
Triticum dicoccon	od	z	30									1				15										46
Triticum dicoccon	wys	wkł	3																							3
Triticum monococcum	s	kł																					1			1
Triticum monococcum	s	p			2	1															13	3	1			20
Triticum monococcum	s	wkł	10			13							1								1	5	1			31
Triticum monococcum	s	z	23		31	9							8				0				21	3	16			111
Triticum monococcum	od	z										1														1
Triticum spelta	s	p	1																			1				2
Triticum spelta	s	wkł			11																					11
Triticum spelta	s	z														2										2
Triticum spelta	od	z														1										1
Triticum dicoccon vel *T. monococcum*	s	kł	2																							2
Triticum dicoccon vel *T. monococcum*	s	os				1																				1
Triticum dicoccon vel *T. monococcum*	s	p	8		4	26															4	4				46
Triticum dicoccon vel *T. monococcum*	s	wkł	3		2	13															8	3	2			31
Triticum dicoccon vel *T. monococcum*	s	z	153			50		4					2								4		4			217
Triticum dicoccon vel *T. monococcum*	od	kł				1																				1
Triticum dicoccon vel *T. monococcum*	od	p				4																				4
Triticum dicoccon vel *T. monococcum*	od	wkł	16			1										5										22
Triticum dicoccon vel *T. monococcum*	od	z	60																							60
Triticum dicoccon vel *T. monococcum*	wys	p	1																							1
Triticum dicoccon vel *T. monococcum*	wys	wkł	9																							9
Triticum dicoccon vel *T. spelta*	s	p																				1				1
Triticum dicoccon vel *T. spelta*	s	z	5																		24	4	7	1		41
Triticum sp.	od	kł														1										1
Triticum sp.	od	wkł										1				3										4

Triticum sp.	od	z					1					1				4										6
Triticum sp.	s	p																			4					4
Triticum sp.	s	wkł	1																		2	1	2			6
Triticum sp.	s	z	6		3	1			1							10					41	15	19	6		102
Cerealia indet.	od	kł														1										1
Cerealia indet.	od	pl														0										0
Cerealia indet.	od	sł	146			1							10													157
Cerealia indet.	od	z	55			0										9										64
Cerealia indet.	s	sł	68																							68
Cerealia indet.	s	kł																					2			2
Cerealia indet.	s	z	1869		63	173		14					79			1		3	43	13	122	198	142	33		2753
Cerealia indet.	wys	sł	13																							13
Cerealia indet. vel Poaceae indet.	s	sł	26																		1					27
Cerealia indet. vel Poaceae indet.	s	z			33															1		6				40
Cerealia indet. vel Poaceae indet.	od	z	1																							1
Cerealia indet. vel Poaceae indet.	od	sł	20			0																				20
Cerealia indet. vel Poaceae indet.	od	z				1																				1
Linum usitatissimum	s	n			2	1																	1			4
Pisum sativum	s	n																					1			1
Agrostemma githago	s	n	1																							1
Amaranthus lividus	s	n																					1			1
Arenaria serpyllifolia	s	n	1																							1
Bromus arvensis vel *B. racemosus*	s	z																					1			1
Bromus hordeaceus	s	z				4																				4
Bromus secalinus	od	z	1																							1
Bromus secalinus	s	z	14		1																6		8			29
Bromus sterilis vel *B. tectorum*	s	z																			1					1
Bromus tectorum	s	z				1																				1
Capsella bursa-pastoris	s	n				1																				1

Chenopodium album	s	n	26		20	85		3								4				3	15	4	280	25		465
Chenopodium ficifolium	s	n	4																		1		1			6
Chenopodium murale	s	n	3		1																		2			6
Chenopodium urbicum	s	n																					2			2
Digitaria sanguinalis	s	z																					1	1		2
Echinochloa crus-galli	s	z				3		5															1	1		10
Fallopia convolvulus	s	o	12		12	13										7			2		13	20	30	4		113
Galium aparine	s	o	1															1								2
Galium spurium	s	o	1													1					1	1				4
Lithospermum arvense	s	o																		1						1
Lychnis flos-cuculi	s	n				1																				1
Melandrium album	s	n																	1							1
Mentha arvensis vel *M. aqatica*	s	o				1																				1
Moehringia trinervia	s	o																					2			2
Myosotis sylvatica	s	o	1																							1
Nepeta pannonica	s	o																					1			1
Polygonum hydropiper	s	o	1																					1		2
Polygonum lapathifolium	s	o	1		1																		18			20
Polygonum minus	s	o	1			4																1	1	2		9
Polygonum mite	s	o																			1	1				2
Polygonum persicaria	s	o	1			1														2			22	2		28
Prunella vulgaris	s	o																						1		1
Rumex acetosa	s	o				4																				4
Rumex acetosella	s	o	1																			1	6			8
Rumex sanguineus	s	o																					1			1
Setaria pumila	s	z	1			1		1													1		3			7
Setaria viridis vel *S. verticallata*	s	z																			1			1		2
Solanum nigrum	s	n																					5	1		6
Spergula arvensis	s	n																					1			1
Stellaria media	s	n																						1		1

Trifolium repens	s	o																				1			1
Veronica chamaedrys	s	o																					1		1
Viola tricolor vel *V. arvensis*	s	o																		1					1
Avena sp.	od	z													8										8
Avena sp.	s	z																			1				1
Brassica sp.	s	n	1																						1
Bromus sp.	od	z	2												1										3
Bromus sp.	s	z	24		10	16							4			1			9	1	5	4	10	1		85
Chenopodium sp.	s	n	21			10																3	3	42		79
Digitaria sp.	od	z													1										1
Digitaria sp.	s	z	1																						1
Galium sp.	s	o																		1			4		5
Malva sp.	s	o																					1		1
Myosotis sp.	nn	n																		1					1
Pisum sp.	s	n																2				1			3
Polygonum sp.	od	o	1													1										2
Polygonum sp.	s	o	2		1	1														1	1	1	3			10
Potentilla sp.	s	o																			3				3
Ranuculus sp.	s	o																		1					1
Rumex sp.	s	o	1		2													1	2		1		1			8
Setaria sp.	s	z																			1		1		2
Stellaria sp.	s	n																					1		1
Trifolium sp.	s	n													1								3		4
Vicia sp.	s	n																			1	1			2
Asteraceae indet.	s	o				2																				2
Caryophyllaceae indet.	s	n				4										1								1		6
Cyperaceae indet.	s	o																				1			1
Fabaceae indet.	s	n	1		2											1					2		2	5		13
Panicoidaceae	od	z													2										2
Poaceae indet.	od	l																				0			0

Poaceae indet.	od	s	100																						100
Poaceae indet.	od	sł	273									1													274
Poaceae indet.	od	z	10													14									24
Poaceae indet.	s	sł	440																			1			441
Poaceae indet.	s	z	8		2								1			4		1	1	1	14	16	19	8	75
Poaceae indet.	wys	sł	10																						10
Abies alba	s	d	1		3																	1	1	1	7
Alnus glutinosa	s	d														3									3
Carpinus betulus	s	d	32		28															2	23	1	4	1	91
Carpinus betulus	s	o	1																						1
Corylus avellana	s	d																		6	10	2	3	11	32
Corylus avellana	s	o																						1	1
Fagus sylvatica	s	d	3													1				2		1	4	4	15
Fraxinus excelsior	s	d	16	1	21								2			1		2		4	28	41	291	22	429
Malus sylvestris	s	n				2																		1	3
Malus sylvestris	s	o				9																			9
Pinus sylvestris	s	d	539		26	2		19							6	39		23		83	292	203	462	67	1761
Quercus petraea	s	d														155									155
Quercus robur	s	d														4									4
Tilia cordata	s	d														7									7
Acer sp.	s	d	27										7								6			1	41
Alnus sp.	s	d	16			1		54					6					1		1	10	3	15	14	121
Betula sp.	s	d	33											30				1		5	106	14	35	15	239
Betula sp.	s	o																					8		8
Malus sp.	s	n				2																			2
Picea abies vel *Larix* sp.	s	d																					3		3
Pinus sp.	s	d	1													5									6
Populus sp.	s	d			2	2																39			43
Quercus sp.	s	o																						3	3
Quercus sp.	s	d	1794	16	92	1377		340	14	14	19		39		53	70		45	3	135	6673	865	2379	881	14809
Quercus sp.	s	ko																3							3

Salix sp.	s	d	4						1					2						2			2			11
Tilia sp.	s	d	2			1																2				5
Ulmus sp.	s	d				1		2														6	8			17
Rosaceae indet.	s	d				1										5							1			7
liściaste	s	d	77		23	8									10			5		18	27	97	82	41		388
Coniferae indet.	s	d	7		6	2										6						1	27	2		51
Cenococcum geophilinum	s	sc																					16	8		24
suma/ total			6258	17	453	2180	1	442	16	14	19	7	209	32	69	566	0	87	63	282	7496	1586	4025	1396	0	25218