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Useful plants from the site Lutomiersk–Koziówki near Łódź (central Poland) with special reference to the earliest find of *Xanthium strumarium* L. seeds in Europe

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ABSTRACT

Archaeological features at the multi-culture site of Lutomiersk–Koziówki 3a-c in central Poland contained preserved charred plant macro-remains. The site is located within the "Central European sand belt" characterised by sandy terraces and dunes, nowadays covered mainly by podzols and anthropogenically changed soils. The samples come from pits dated to the Middle Bronze Age (MBA, ca. 18th–14th centuries BC), the Late Bronze Age (LBA, ca. 10th–8th centuries BC), and the Roman Iron Age (RIA). The most intensive occupation was connected with the development of the LBA settlement of Lusatian culture. During that time mostly peas (*Pisum sativum*) and millet (*Panicum miliaceum*) were cultivated while remains of large-grained crops like einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), spelt (*Triticum spelta*), and barley (*Hordeum vulgare*) were not common. In that time goosefoot (*Chenopodium album*) and wild buckwheat (*Fallopia convolvulus*) were probably used as a source of food. In the Roman Iron Age, the presence of those plants decreased and rye (*Secale cereale*) appeared, becoming the most common cultivated plant besides barley. The unique find of cocklebur (*Xanthium strumarium*) seeds in the LBA samples was possibly connected with their useful properties, primarily as medicinal plants and secondarily as a source of oil. The cocklebur remains were probably processed, but no by-products and no whole fruits were noted. The context of these finds is exceptional compared with the other samples from the site, possibly reflecting medicinal activities of the people. Taking into account the history and migration of the cocklebur in Europe during the Holocene, it must be emphasized that the charred seeds from Lutomiersk–Koziówki are currently the oldest radiocarbon-dated finds in Europe (2745 ± 30 BP, ca. 975–818 cal. BC) and can reflect distant contacts of the settlers mostly with south-eastern Europe although eastern routes cannot be excluded as well.

1. Introduction

In the studied region little archaeobotanical research has been done until now, mostly connected with rescue excavations performed during the last two decades at archaeological sites from various periods, except for the Neolithic (Wasylikowa et al., 2003; Lityńska-Zając, 2005; Mueller-Bieniek, 2011; Kittel et al., 2011, 2014). The area is situated within the "Central European sand belt" (Zeeberg, 1998) characterised by extensive distribution of sandy areas, mainly river terraces and dunes. Palaeoenvironmental studies reflect intensification of human activity starting from the Early Bronze Age, with some decline in the Iron Age (Balwierz et al., 2005; Forysiak et al., 2010; Kittel et al., 2011).

The aim of the study is a presentation of plant macro-remains from the site of Lutomiersk–Koziówki and their exceptional character not only in this poorly studied region but also in a broader European context. The description of plant remains from all periods represented at the site reflects the degree of intensity of human occupation while the comparison of data from the two best-represented periods permits the tracing of changes in plant use.

1.1. Site description

The site of Lutomiersk–Koziówki is situated in Central Poland about 13 km west of Łódź (51°45′N; 19°13′E, 153.5 m a.s.l.) in the valley of the Ner river (a tributary of the Warta), near the mouth of the Zalewka (Wrząca) river (Fig. 1), in the belt of lowlands known as the *Nizina Południowowielkopolska*, directly on the Łask Plateau (Wysoczyzna Łaska, Kondracki, 2002). The studied area is located close to a drainage

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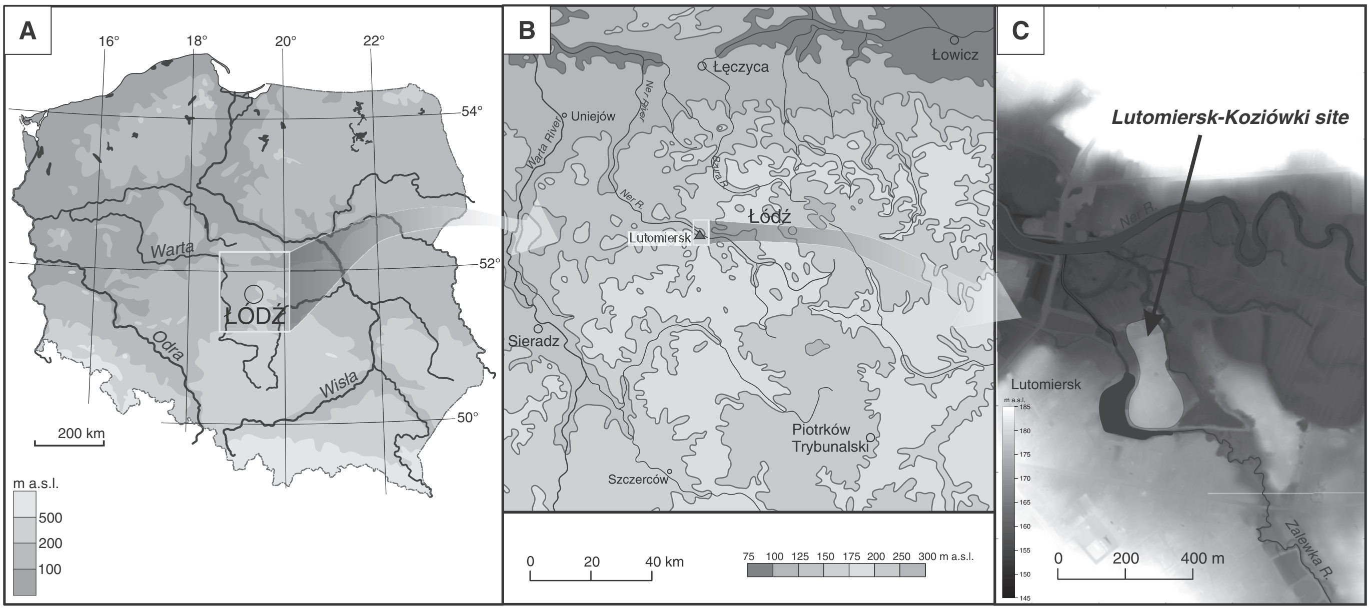

Fig. 1. Situation of the site: A — on the Polish territory; B — in the Lodz region; C — on the digital terrain model of the Ner River valley in the Lutomiersk vicinity.

divide separating the Wisła and Odra basins. Today the area is covered mainly by anthropogenic soils and podzols (Bednarek and Prusinkiewicz, 1999). The archaeological site is situated on a slightly inclined slope, on a surface of the Ner river terrace composed of medium- and coarse-grained sands (Kittel, 2012a, 2014). This fragment of terrace accumulated as an alluvial fan of the Zalewka river during the pleniglacial of the Weichselian (Plenivistulian). Today the terrace is preserved as a residual hillock delimited by the Zalewka valley floor on the eastern side and by modern artificial channels and ponds on the western and the southern sides (Kittel, 2012b; Kittel et al., 2014).

Without human influence the potential natural vegetation of the area () would consist mainly of regularly-flooded lowland willow-poplar floodplain forest (Salici-Populetum) and subcontinental lowland lime-oak-hornbeam forest (Tilio-Carpinetum). Additionally, at some distance from the site, lowland ash-alder forest (Fraxino-Alnetum) would also be found, as well as subxero-thermophilous Sarmatian oak and pine-oak forest (*Potentillo albae–Quercetum typicum*) and other plant communities of lesser importance (Matuszkiewicz, 2008).

1.2. Archaeology

The site of Lutomiersk–Koziówki 3 a-c was discovered in 1945 and investigated intermittently between 1946 and 2010 (Gardawski, 1959; Muzolf, 2012a). A total area of 2300 m^2 has been excavated. Numerous archaeological remains have been recognized from several cultural–chronological horizons: Late Palaeolithic and Mesolithic campsites, traces of the Neolithic Funnel Beaker and Corded Ware cultures (4th millennium BC), Late Neolithic remains of the Linin group of the Neman culture (the turn of 3rd and 2nd millennia BC), Trzciniec culture of the Middle Bronze Age, Lusatian culture of the Late Bronze Age, Pomeranian culture of the Early Pre-Roman Iron Age, Przeworsk culture of the Pre-Roman and the Roman Iron Age, and Early Medieval settlements, as well as the modern occupation remains (Kittel et al., 2014). Most of the features and artefacts found at the site date to the Middle Bronze Age, the Late Bronze Age, and the Iron Age (Muzolf, 2012a). The traces of the Stone Age and medieval occupation phases are not significant.

An important increase of human activity and human impact is reflected in density of artefacts and archaeological structures (Muzolf, 2012a), and in the initiation of slope processes at Lutomiersk–Koziówki 3a-c at the beginning of the Bronze Age (from ca. 1950 BC) (Kittel, 2014). In the remains of the Trzciniec culture (the Middle Bronze Age — MBA; ca. 18th–14th centuries BC), strong connections to southern regions and Trans-Carpathian influences were noticed (Muzolf, 2012b: 279; Muzolf, 2012e). The occupation by Lusatian culture communities (the Late Bronze Age — LBA; BA IV and BA V, 10th–8th centuries BC) left the most numerous artefacts and features. Remnants of metallurgy from this phase indicate that the site was a significant production centre during the Late Bronze Age (Muzolf, 2012c). In the Iron Age, the earlier phase of occupation (Pomeranian culture) seems to be ephemeral and represented only by scarce finds scattered in the cultural layers. Nevertheless, a foot of Celtic bronze fibula ornamented in the plastic style indicates contacts to the southern territories of the Celtic La Tène culture (Muzolf, 2012d). Later in the Iron Age, during the Przeworsk culture, the occupation of the site intensified and contact with the north – the Jastorf culture – is also documented (Siciński, 2012). According the medieval written sources, an important route linking Małopolska (Little Poland) in the south-east with Wielkopolska (Great Poland) in the north-west probably went through Lutomiersk (Zajączkowski, 1964, 1966). It was an important place for crossing the Ner river in the medieval times and probably also in earlier periods. Intense slope wash processes at the site area, active during the Middle and Late Bronze Age as well as in the Pre-Roman and Roman Iron Age as a result of human impact, have been recorded and described (Kittel, 2012c, 2014).

2. Material and methods

In total 51 samples from archaeological features (utility/storage pits) and three from cultural layers were studied botanically. Samples have been collected separately from each layer and above all from the lowest parts of features. All prehistoric archaeological features are situated above the ground water level.

Soil samples of known volume were processed at the site with the use of a mechanical 'water-separation' machine. Floating macro-remains were collected on a 0.5 mm sieve. A net with about 1 mm mesh size was placed inside the machine. After drying the plant material was sorted using a stereoscopic microscope.

The samples come mainly from features dated by archaeological context to the Bronze Age, mostly to the younger phase — the Lusatian culture (Late Bronze Age: IV–V EB, T1Suppl.). The volume of samples varied from 2 to 52 dm^3, with 724 dm^3 of sediment studied in total. Twelve selected subsamples of charred diaspores were radiocarbon

Table 1
AMS radiocarbon dates.

Feature no.	Sample no.	Items dated	Nr lab	Date uncalibrated	Date calibrated prob. 68.2%	Date calibrated prob. 95.4%
26	X/10	Cerealia cf. *Triticum* — 6 fragments of grains	Poz-43495	3185 ± 30 BP	1497–1431 BC	1508–1411 BC
76	IX/5	*Fallopia convolvulus* — 1 fruit, *Polygonum* cf. *lapathifolium* — 1 fruit, *Rumex acetosella* — 1 fruit	Poz-43491	2870 ± 70 BP	1154–932 BC	1259–851 BC
65	X/22	*Panicum miliaceum* — 4 grains	Poz-43504	2810 ± 35 BP	1004–919 BC	1054–847 BC
23	X/9	cf. *Pisum sativum* — 3 fragments of seeds	Poz-43505	2790 ± 35 BP	996–903 BC	1018–839 BC
141	IX/11	*Pisum sativum* — 10 large fragments of seeds	Poz-43492	2755 ± 30 BP	923–844 BC	978–827 BC
65	X/21	*Panicum miliaceum* — 3 grains	Poz-43498	2755 ± 30 BP	923–844 BC	978–827 BC
66	X/20	*Xanthium* sp. — 1 seed	Poz-43578	2745 ± 30 BP	912–842 BC	974–819 BC
layer 8	X/30	*Pisum sativum* —1 seed, *Panicum miliaceum* — 3 grains	Poz-43506	2720 ± 35 BP	898–831 BC	930–806 BC
59	X/18	*Pisum sativum* — 3 fragments of seeds, *Panicum miliaceum* — 1 grain	Poz-43499	2715 ± 35 BP	896–828 BC	924–806 BC
154	IX/14	*Pisum sativum* — 10 seeds or large fragments	Poz-43494	2675 ± 35 BP	891–802 BC	899–799 BC
47B	X/17	*Pisum sativum* — 4 large fragments of seeds	Poz-43496	2660 ± 35 BP	839–798 BC	896–794 BC
88	X/25	*Secale cereale* — 5 grains	Poz-43503	1685 ± 35 BP	267–403 AD	255–422 AD

Calibrated with the use of the OxCal 4.2 (Bronk Ramsey, 2009) and IntCal13 (Reimer et al. 2013).

dated (Table 1). In one case the dated plant material was older than the archaeological chronology of the feature (feature 26 in Table 1 and T1Suppl., explanation in Muzolf, 2012e: 75–76) which is most probably connected with destruction of an older feature by intensive LBA occupation and recycling of the older fill. In several samples, uncharred diaspores were noticed, suggesting modern contamination of the studied features and layers as the site was located above the ground water level. In such sites uncharred plant remains could only have survived for a short period in an oxidising circumstance whereas the charred plant remains are unaffected. Those samples were collected from shallow features and shall be treated with caution due to their uncertain origin; some samples contained little or no botanical remains (T1Suppl.). The uncharred plant remains are only given as a source of information about post-depositional processes in the archaeological layers. At a dryland site, they should be interpreted as recent contamination (Lityńska-Zając and Wasylikowa, 2005: 50–51). On this basis, samples dated to the Pre-Roman Iron Age can be excluded from the discussion as having been strongly disturbed and contaminated.

The total number of plant macro-remains found in the studied samples is given in Table 2, (with detailed data in T2Suppl., T3Suppl. and T4Suppl. in Supplementary data). For some specimens belonging to *Chenopodium* sp. and *Polycnemum arvense*, plants which produce black seeds, it was not possible to determine if they are charred without destroying them. In such cases they were treated as uncharred and then excluded from the interpretation. The use of fluorescence microscopy is planned to study the taphonomy of such remains (Edwards et al., 2015). Several specimens are strongly damaged or fragmented. In such cases, a minimal reconstructed number (after W. Kuijper, personal comm.) of diaspores is given. Apart from fruits, seeds, chaff and wood charcoal fragments, some tubers, stem fragments, and fungal sclerotia were also found (Mueller-Bieniek and Cywa, 2012). Plant names follow Mirek et al. (2002).

3. Results and discussion

3.1. Chronological list of useful plants

Samples dated to the Middle Bronze Age (the Trzciniec culture) are not rich in plant remains. Only in three samples grains of cereals were found, while wheat chaff remains were found in one sample. Diaspores of other plants were also scarce (Table 2).

In samples dated to the Late Bronze Age (31 in total), most of the plant remains were found in 10 of the samples, while six samples contained no charred diaspores. The composition of plant remains in LBA features is more complex than in other chronological periods, probably partly as a result of the larger number of samples. Cultivated plants are represented mostly by peas (*Pisum sativum*), millet (*Panicum miliaceum*), and cereals like wheats and barley (Table 2, Fig. 2). Wheats are represented mostly by glume wheats (einkorn — *Triticum monococcum*, emmer — *Triticum dicoccum* and spelt — *Triticum spelta*). The only grain of naked bread wheat (*Triticum aestivum* type) was found in a sample strongly contaminated by recent uncharred seeds (T3Suppl.), thus it might also be younger contamination. In the LBA material remains of *Chenopodium album* type (fat hen) and *Fallopia convolvulus* (wild buckwheat) are very abundant and are the most frequent among non-cultivars in that period (Figs. 3 and 4). The presence of many inner parts (embryos of *Chenopodium* or seeds of *Fallopia*) of those plants lacking fragments of characteristic outer layers can be interpreted as remains of their processing for food. The other potentially useful plants found only in the features dated to LBA are: *Bromus* sp. (bromes), *Polygonum* spp., *Rumex acetosella*, *Physalis alkekengi* (strawberry tomato), *Urtica dioica* (nettle), *Valeriana officinalis* (common valerian), *Hypericum* sp. (St John's wort), *Heracleum sphondylium* type (common hogweed) and *Xanthium strumarium* (cocklebur) as well as *Claviceps purpurea* (ergot).

In the three samples dated to the Przeworsk culture of the Roman Iron Age, remains of rye (*Secale cereale*) and hulled barley (*Hordeum vulgare*) are significant, while wheats (*T. spelta*, *T. aestivum* type) are noted. Rye is completely absent in the Bronze Age features and wheat chaff remains are visibly scarcer in the Roman Iron Age than before. Peas and millet, which were abundant in the Bronze Age features, are relatively scarce in the Iron Age as are nutlets of wild buckwheat and seeds of fat hen (Figs. 2 and 3). In the samples a seed of corncockle (*Agrostemma githago*) was also noted, suggesting winter cultivation of some crops. In general, samples of the Roman Iron Age (the Przeworsk culture) contained significantly more large-seeded cereal remains than the Bronze Age features that contained mainly peas and millet, but this difference can be connected with the special type of RIA archaeological feature (no 88, probably a storage pit with quern stones preserved, details in T4Suppl.).

The single sample dated to the Medieval period is not distinct from the other palaeobotanical samples at Lutomiersk–Koziówki. It contains millet, peas, and the wild plants commonly found in earlier periods. The plant composition is similar to that noted in the Bronze Age samples which could be caused by the infilling of the feature by residual material from the BA occupation layers or it could reflect the settlement hiatus between the Roman (almost from the end of 4th cent. AD — Siciński, 2012) and the Early Medieval Periods (lasted at least to the 7th cent AD — Trojan, 2012) noted also in palynological studies from the region (Balwierz et al., 2005) and in the scarcity of Medieval occupation in contrast to well represented Bronze Age and Roman Iron Age settlements (Wasylikowa et al., 2003; Kittel et al., 2011). Archaeobotanical analysis of features dated to the Medieval period was done for site 5 at Pęcławice situated ca. 40 km north of Lutomiersk–Koziówki. Cultivated plants

Table 2
Summarised list of plant remains; abbreviations: MBA — Middle Bronze Age (II–III EB), the Trzciniec culture; LBA — Late Bronze Age (IV–V EB), the Lusatian culture; PRIA — Pre-Roman Iron Age, the Przeworsk culture; RIA — Roman Iron Age, the Przeworsk culture; EM — the Early Medieval period; fr — frequency; s/f — seed/fruit; gb — glume basis, sb — spikelet basis; Em — inner part of seed/fruit (embryo or seed); scler — sclerotia; Rhi — underground vegetative parts (tubers).

Plant name	Type	Chronological period								
		MBA		LBA		PRIA		RIA		EM
		sum	fr	sum	fr	sum	fr	sum	fr	sum
Remains of cultivated plants										
Hordeum vulgare (naked)	s/f			2	1					
Hordeum vulgare (hulled)	s/f			6	4			41	2	
cf. *Hordeum* sp.	s/f			2	1					
Secale cereale	s/f							46	2	
Secale cereale/*Triticum* sp.	s/f							11	1	1
Triticum aestivum type	s/f			1	1			2	1	
Triticum dicoccum type	s/f			6	1					
Triticum cf. *dicoccum*	gb			1	1					
Triticum cf. *monococcum*	sb			1	1					
Triticum cf. *spelta*	gb			3	2					
Triticum spelta	sb							1	1	
Triticum sp.	s/f			19	3			3	1	
Triticum sp. (hulled)	sb			2	1					
Triticum sp. (hulled)	gb	35	1	5	3					
cf. *Triticum* sp.	s/f							6	2	
Cerealia indet.	s/f	4	3	52	12	2	2	181	3	2
Panicum miliaceum	s/f			80	15	1	1	4	3	1
Pisum sativum	s/f			106	12			1	1	1
cf. *Vicia faba*	s/f			1	1					
Other plant macroremains										
Agrostemma githago	s/f							1	1	
Asteraceae indet.	s/f			10	2					
Avena sp.	s/f			1	1					
Brassicaceae indet.	s/f			1	1			2	2	
Bromus sp.	s/f			28	3					
Carex sp.	s/f			1	1					
Centaurea sp.	s/f			25	4					
Chenopodium album type	s/f			186	12			17	1	2
Chenopodium album type	Em			69	3					
cf. *Chenopodium* sp.	s/f	1	1					4	1	
cf. *Chenopodium* sp.	Em			1	1			1	1	1
Cyperaceae indet.	s/f							8	2	
cf. *Digitaria* sp.	s/f			1	1					
Echinochloa crus-galli	s/f			2	1					
Euphrasia sp./*Odontites* sp.	s/f			2	1					
Fabaceae indet.	s/f			5	3			1	1	
Fallopia convolvulus	s/f	5	4	407	12	2	1	6	3	5
Fallopia convolvulus	Em			31	4					
Fragaria sp./*Potentilla* sp.	s/f			1	1					
Galium cf. *aparine*	s/f			6	2					
Galium cf. *mollugo*	s/f			22	4					
Heracleum sphondylium	s/f			1	1					
Hyoscyamus niger	s/f			4	3					
Hypericum sp.	s/f			1	1					
cf. Lamiaceae indet.	s/f			1	1					
cf. *Lamium* sp.	s/f			4	1					
cf. *Luzula* sp.	s/f			1	1					
Malva sp.	s/f			1	1					
Melandrium cf. *album*	s/f	1	1	16	2					
cf. *Melilotus* sp.	s/f							1	1	
cf. *Myosotis* sp.	s/f			1	1					
Panicoideae indet.	s/f			4	4					
Physalis alkekengi	s/f			1	1					
Plantago lanceolata	s/f			8	4					
Poaceae Bromus/Festuca-Typ	s/f			14	2			15	2	
Poaceae Phleum type	s/f	1	1	2	2			4	1	1
Poaceae indet.	s/f			19	6			7	1	1
Poaceae indet.	Em							3	1	
Polycnemum arvense	s/f	1	1							
Polygonum aviculare	s/f			4	3					
Polygonum lapathifolium	s/f			1	1					
Polygonum lapathifolium/persicaria	s/f	2	2	3	2			19	2	
Polygonum minus/persicaria	s/f	3	2	46	5	1	1			2
Polygonum sp.	s/f			2	1					
Polygonum sp.	Em			1	1					
Polygonaceae indet.	s/f							2	1	
cf. *Potentilla* sp.	s/f			2	2					
Prunus sp./*Cerasus* sp.	s/f			1	1					
Prunella cf. *vulgaris*	s/f			4	2			4	2	
Rhinanthus sp.	s/f			8	2					
cf. Rosaceae indet.	s/f	1	1							
Rubiaceae indet.	s/f			1	1			1	1	
Rumex acetosella	s/f	4	2	48	8			33	3	
Rumex sp.	s/f			3	2			1	1	
Schoenoplectus tabernaemontani	s/f	1	1	2	2					
Setaria verticillata/viridis	s/f			3	2					
Solanum nigrum	s/f			2	1			1	1	
Spergula arvensis	s/f							2	2	
Stachys sp.	s/f							3	2	
Trifolium type	s/f			33	8			9	2	1
Urtica dioica	s/f			1	1					
cf. *Valerianella* sp.	s/f			2	2					
cf. *Valeriana officinalis*	s/f			15	3					
Veronica sp.	s/f			5	3					
cf. *Vicia* sp.	s/f	1	1	5	2					
Viscum album	s/f			1	1					
Xanthium strumarium	s/f			4	2					
cf. *Claviceps purpurea*	scler			2	1					
Indeterminata	s/f	22	6	271	18	7	2	24	3	10
Indeterminata	Rhi			1	1					
Indeterminata	Others			19	2			8	2	30
Cenococcum	scler	13	4	13	5					

were dominated by charred grains of hulled barley, oats and millet as well as charred seeds of lentils. Millet finds were the most frequent while lentils were found in a single sample (Mueller-Bieniek, 2011). The large number and frequency of peas (*P. sativum*) in the LBA samples from Lutomiersk–Koziówki are significant taking into account their common underrepresentation in archaeobotanical assemblages. In medieval central Europe, when we are able to compare archaeobotanical data and written sources, peas are extremely underrepresented both in charred and waterlogged samples (e.g. Mueller-Bieniek, 2012; Mueller-Bieniek et al., 2015).

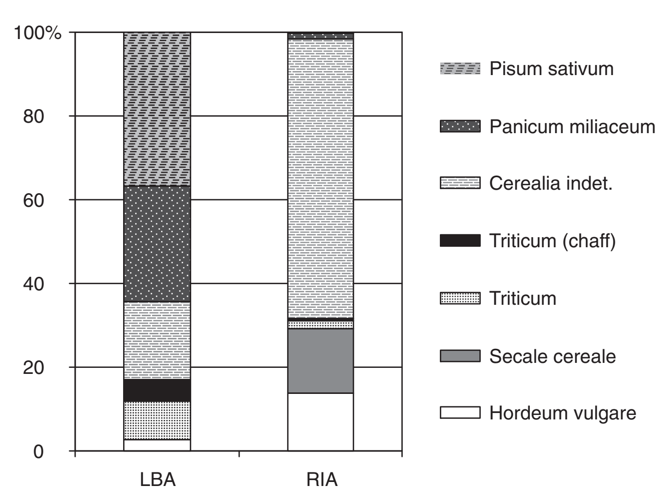

Fig. 2. Proportions of cultivated fruits and seeds in LBA and RIA, based on the number of finds. Total number of cultivated plants remains: LBA — 289, RIA — 297.

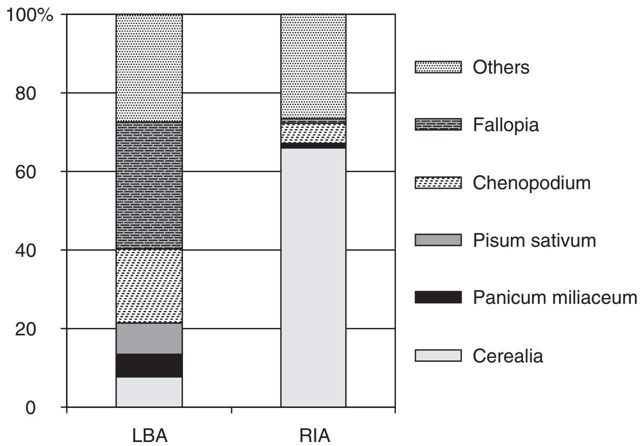

Fig. 3. Proportions of groups of plant remains in LBA and RIA, based on number of finds. Total number of plant remains: LBA – 1352, RIA - 442.

3.2. Selected potentially useful plants in their archaeological and botanical context

On the basis of plant macro-remains we can only suggest usefulness of the plant. The appearance of the plant remains in charred assemblages seems to bemore important than their number (Mueller-Bieniek and Walanus, 2012; Mueller-Bieniek et al., 2015). Carbonized (charred) plant remains represent a small part of the plant remains originally present and discarded at any one site (Van der Veen, 2007), their selection is usually strongly influenced by husbandry practices.

3.2.1. Goosefoot (*C. album type*) and wild buckwheat (*F. convolvulus*)

These plants produce edible diaspores, resistant to destruction, that are frequent and usually abundant in archaeological samples. Their useful character and gathering have been demonstrated several times in archaeological (e.g. Helbaek, 1958, 1960; Behre, 2008) and ethnographical (Twarowska, 1983; Łuczaj, 2004; Łuczaj and Szymański, 2007) sources. The inner parts of goosefoot seeds and wild buckwheat fruits (nutlets) were found mostly in one LBA sample (feature 47B) in which diaspores of millet, peas, *Polygonum* spp., *R. acetosella*, and *Solanum nigrum* (black nightshade) were also noted. The largest find of *F. convolvulus* nutlets is connected with LBA feature 154 (Table 3, T3Suppl.). In this sample, seeds of *C. album* were also found, but no inner parts of those diaspores were noted. Large-seeded cereal grains (barley and wheats) and pea seeds were the most numerous among cultivars, while millet and chaff remains were scarce. Other plants were represented in this feature mainly by large-seeded grasses (including *Bromus* sp.), *Polygonum minus*/*persicaria*, *R. acetosella*, *Melandrium* cf. *album* and *Trifolium* type as well as other less numerous but palaeoeconomically important plants such as *Plantago lanceolata* (narrowleaf plantain). In this sample possible pod fragments were also noted ('Indeterminata — others' in T3Suppl.).

In LBA feature 141, the plant composition is similar to that described for feature 154 with different proportions of the plant remains. In the sample, one seed of mistletoe (*Viscum album*) was also found. Other plants from Polygonaceae family (mainly *Polygonum lapathifolium* and *R. acetosella*) as well as large seeded grasses like *Bromus* sp. which are relatively frequent in the material are also known from archaeobotanical studies to be probably useful edible plants (among others: Gluza, 1977, 1984; Behre, 2008).

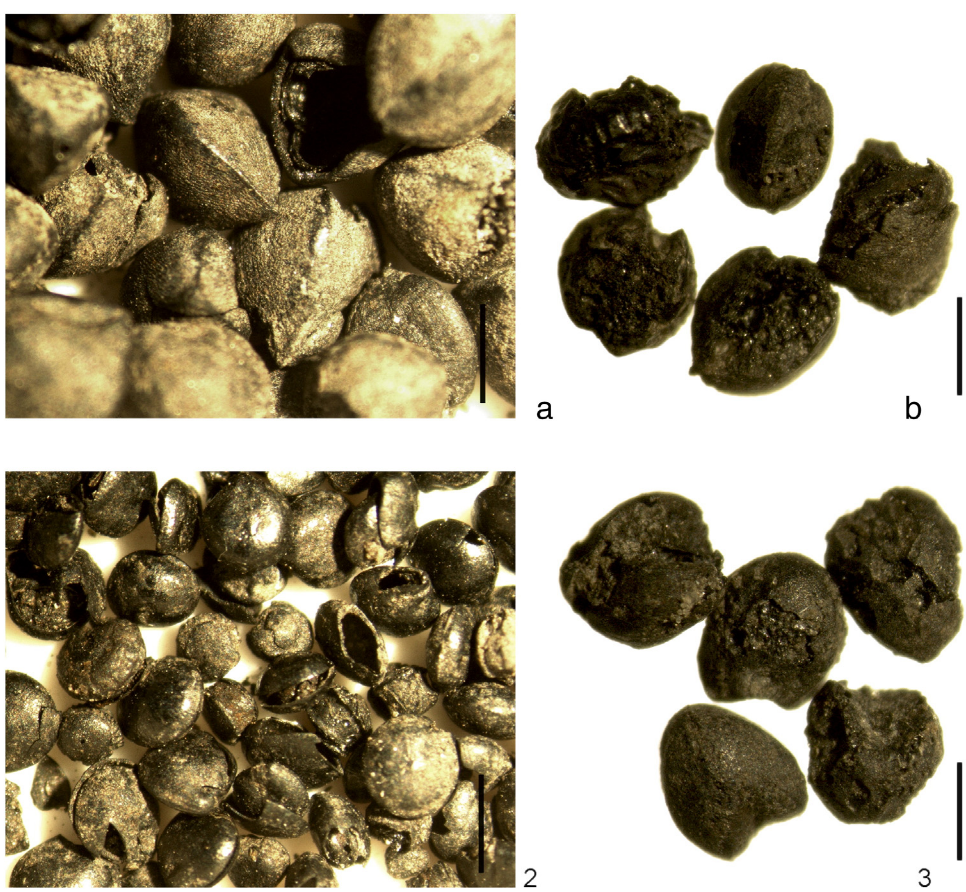

Fig. 4. Charred fruits and seeds from the same feature (no. 47B) dated to LBA. *1*, black-bindweed (*Fallopia convolvulus*), a — fruits, b — seeds (Em in T3Suppl.); *2*, fat hen (*Chenopodium album* type), seeds and embryos; *3*, common millet (*Panicum miliaceum*), grains. Seeds of black-bindweed and grains of common millet are intentionally presented next to each other in the same scale to reveal their surface similarity, *scale bar* 1 mm.

Table 3
Plant remains from selected samples dated to the Late Bronze Age, abbreviations as in Table 2, details in T3Suppl.

Plant name	Type	Sample					
		IX/11	IX/14	X/17	X/20	X/21	X/22
		Feature					
		141	154	47B	66	65	65
Cerealia indet.	s/f		11	1		1	3
Hordeum vulgare	s/f	2	5				
Panicum miliaceum	s/f	5	3	24	11	4	5
Pisum sativum	s/f	35	48	4	2		1
Triticum sp.	s/f		13				
Triticum sp.	Chaff		1	1			4
Bromus sp.	s/f		25	1			
Centaurea sp.	s/f		1		12	9	3
Chenopodium cf. *album*	s/f	2	35	100	8	1	15
Chenopodium cf. *album*	Em			50	18	1	
Claviceps purpurea	scler					2	
Euphrasia sp./*Odontites* sp.	s/f						2
Fallopia convolvulus	s/f	6	308	53	4	1	7
Fallopia convolvulus	Em	3		26			
Galium cf. *mollugo*	s/f				12	7	
Heracleum sphondylium	s/f				1		
Hyoscyamus niger	s/f						2
Hypericum sp.	s/f				1		
Malva sp.	s/f						1
Plantago lanceolata	s/f	1	5		1	1	
Polygonum minus/persicaria	s/f	1	36	5			
Prunella cf. *vulgaris*	s/f		2		2		
Rhinanthus sp.	s/f					5	3
Rumex acetosella	s/f	2	28	10	3	2	
Schoenoplectus tabernaemontani	s/f						1
Solanum nigrum	s/f			2			
Trifolium type	s/f	4	10	4	11		
Urtica dioica	s/f					1	
Valeriana officinalis	s/f				5	9	1
Veronica sp.	s/f				2	2	1
Viscum album	s/f	1					
Xanthium strumarium	s/f				3	1	
Other identified macroremains		7	47	10	26	15	5

3.2.2. Common cocklebur (X. strumarium)

Two archaeological features (65 and 66) dated to the Late Bronze Age (Table 3, T3Suppl.) contained very diverse charred plant remains. In pit 65, a stone grinder was uncovered. In two samples (X/20 — feature no. 66 and X/21 — feature no. 65), seeds of *Xanthium* sp. were found. One was radiocarbon dated to 2745 ± 30 BP (912–842 BC, prob. 68.2%; 975–818 BC, prob. 95.4%). Almost no traces of large-grained cereals were noted, and remains of other cultivated plants were scarce. In these samples, several grassland species were found including: *Centaurea* sp. (not *C. cyanus*), *P. lanceolata*, *Prunella* cf. *vulgaris*, *R. acetosella*, *Trifolium* type, *Veronica* sp., cf. *V. officinalis*, and *Hypericum* sp., as well as other plants that are rarely noted in charred archaeobotanical samples such as *H. sphondylium* type, *U. dioica*, and ergot (*C. purpurea*) (Fig. 5). The composition of the plants (Table 3, T3Suppl.) can indicate that animal fodder was stored in the studied features, but it must be noted that most of the plants also have some medicinal properties.

In the two samples, charred seeds of cocklebur (*Xanthium* sp.) were found. *Xanthium* sp. is an annual plant from Asteraceae family, monoecious and wind-pollinated, which is an uncommon feature in that family and important for palaeoecological studies. Pollen of *Xanthium* sp. is rather characteristic and differs from other Asteraceae of the same geographical distribution. It is usually well represented in palynological records (Makohonienko, 2009: 57). The pollen could have been transported by wind over great distances. The taxonomy of the genus *Xanthium* is complicated. In Poland, three taxa are noted: *Xanthium albinum* (Widder) H. Schulz (= *Xanthium riparium* Itzigs. & Hertsch), *Xanthium spinosum* L., and *X. strumarium* L. (Mirek et al., 2002), with several varieties and subspecies differing mainly in their fruit morphology (Tacik, 1971; Rutkowski, 1998). The fruits are ellipsoid with two thorns at the apex and numerous spines on the surface, clearly adapted to epizoochory or the dispersal of seeds by animals (Makohonienko, 2009: 55) and additionally to hydrochory because of the considerable buoyancy connected with aerated tissue of the achenes (Brinkkemper and Kuijper, 1993; Marinova pers. comm.). Now it seems that the genus can be separated to two species: *X. strumarium* L. covering most of the former taxa, including *Xanthium italicum*, *X. riparium*, *X. albinum*, *Xanthium sibiricum*, and *X. spinosum* L. (Hanelt, 2001; Kew Royal Botanic Gardens). In Poland, *X. spinosum* is described as an American alien plant (Sowa and Warcholińska, 1992; Rutkowski, 1998), growing mostly in SE Poland (Tacik, 1971) in warmer regions (Rutkowski, 1998). The recent fruits of *X. spinosum* in the reference collection of the Palaeobotanical Department of the Institute of Botany PAS in Kraków contain mostly unripe seeds (no well-developed seeds were found). In all studied recent specimens of burs belonging to *X. strumarium*, *X. italicum*, and *X. spinosum* no significant traces of aerial tissue were noted, but more detailed taxonomical studies are necessary. It must be emphasized that extraction of seeds from the thorny burs stored in the reference collection is very difficult because of hardness of the pericarp and probably could have been connected with some special process (soaking and/or roasting) when done purposefully in the past. In the studied archaeological samples, only charred seeds with no traces of outer parts of fruits were noted.

The charred *Xanthium* seeds from Lutomiersk–Koziówki are elongated and dorsi-ventrally flattened with one side visibly convex having characteristic sculpture and the other side most probably concave before charring. The seeds are up to 4.6 mm long and 2.3 mm broad, much smaller than recent specimens in the reference collection of the Institute of Botany PAS. Such a difference between ancient charred and recent material is not uncommon. *R. acetosella* charred ancient nutlets are usually much smaller that recent ones (e.g. Bieniek, 1999: 149). Experimental studies also often show a decrease of dimensions as a result of charring (e.g. Kislev and Rosenzweig, 1991). Additionally in *X. strumarium* s.l., significant variation in fruit size among and within populations can occur (Hare, 1980; Zimmerman and Weis, 1983). Until now, mainly remains of fruits (achenes, burs) were noted in European archaeological sites. The oldest are dated to the end of the Bronze Age (Opravil, 1983), to the Iron Age (Brinkkemper and Kuijper, 1993; Dálnoki and Jacomet, 2002; Jacomet and Brombacher, 2009; Šoštarić et al., 2009); most are connected with Medieval times (Wasylikowa, 1978; Opravil, 1983; CZAD Archaeobotanical database of Czech Republic). Finds of seeds are still rare, and those from site 3a-c at Lutomiersk–Koziówki seem to be the oldest radiocarbon-dated examples recorded in Europe. The date 2745 ± 30 BP, after calibration giving ca. 912–841 BC with 68.2% of probability (and 975–818 BC with 95,4% of probability) as well as the archaeological context demonstrate the Late Bronze Age date of the cocklebur finds (HaB1–HaB2, correlated with late part of the IV Bronze Age Period and early part of the V Bronze Age Period according to Gedl, 1982).

Xanthium sp. nowadays is a cosmopolitan plant, usually growing in disturbed sites, both anthropogenic ones and along water shores. Some species can be invasive plants. Pollen of *Xanthium* was recorded in glacial-age sediments in southern Europe, and the plant probably migrated during the Holocene from a refuge to northern forested areas of Europe thanks to disturbances caused by intensive human activities. After the recent glacial period, pollen of *Xanthium* sp. appeared in southern European profiles from the Bronze Age, 4000 BP, and became more frequent during the last two thousand years (Makohonienko, 2009). In Central Poland, pollen of *Xanthium* sp. was recorded in Lake Gościąż sediments dated to the Lusatian culture of the Hallstatt period of the Early Iron Age (Ralska-Jasiewiczowa and van Geel, 1998: profile G1/87). In pollen diagrams, depending on their geographical localisation, pollen of *Xanthium* can be interpreted as a

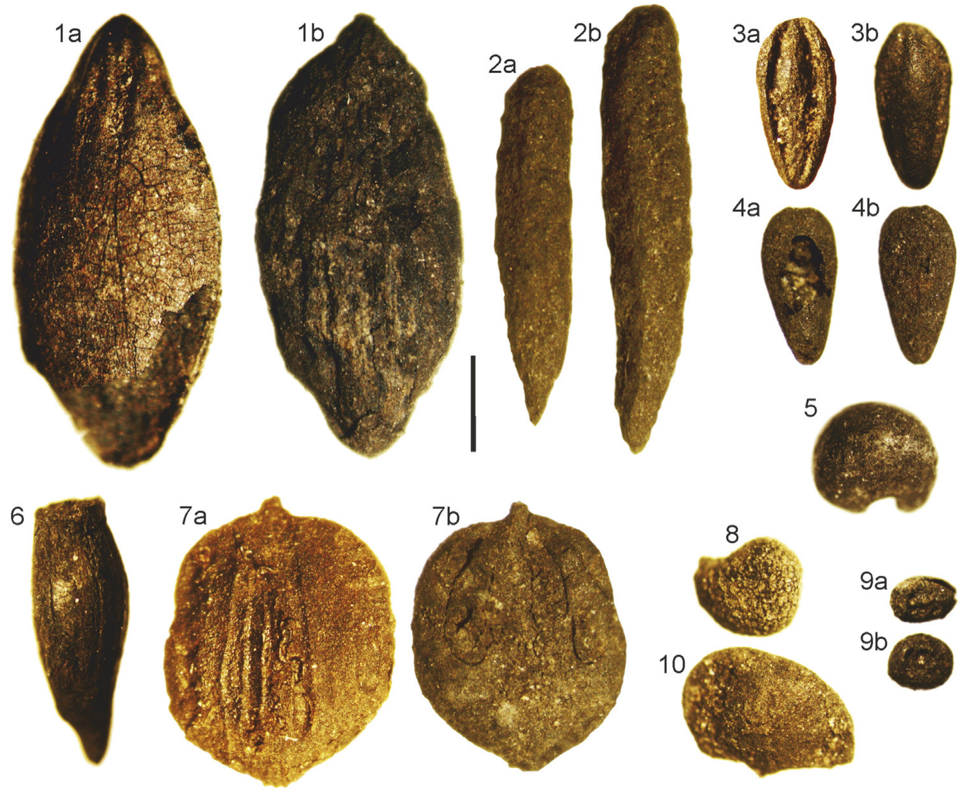

Fig. 5. Charred fruits and seeds from features with cocklebur (nos. 65 and 66) dated to LBA. 1, seeds of *Xanthium* sp.; 2, sclerotia of ergot (*Claviceps purpurea*); 3, seed of *Plantago lanceolata*; 4, fruit of probably *Valeriana officinalis*; 5, seed of *Malva* sp.; 6, fruit of *Centaurea* sp.; 7, fruit of *Heracleum sphondylium*; 8, seed of *Hyoscyamus niger*; 9, fruits of *Galium* cf. *mollugo*/*verum*; 10, seed of Rhinanthus sp. *scale bar* 1 mm.

ruderal plant (Ralska-Jasiewiczowa and van Geel, 1998) or can be treated as a secondary indicator of pasturage (Tonkov et al., 2008). Charred fruits of cocklebur (*X. strumarium*) from the La Tène settlement of Michelstetten in Lower Austria were interpreted as a ruderal plant as it comes from a purely ruderal context (Kohler-Schneider and Heiss, 2010). It seems that the ruderal "career" of *Xanthium* began at quite an early date. For north and northeast China, *X. sibiricum* Patrin ex Widder (= *X. strumarium* L.) is known as potential indicator of anthropogenic influence in palynological studies, characteristic of dry cultivated fields as well as ruderal sites (Makohonienko, 2009: 57, 64).

Cocklebur is interpreted as an archaeophyte in Europe (e.g. Opravil, 1983), but in its migration natural agents were also probably involved, as the plant could have been naturally dispersed along water courses (Brinkkemper and Kuijper, 1993). On the other hand in popular sources (like wikipedia) *X. strumarium* is described as a Neophyte probably originating from North America which is definitely wrong but well entrenched in non-specialist literature. Nevertheless the origin of the plant in central Europe is uncertain. It probably was present in refuges in south-eastern Europe or the Mediterranean zone or could also have migrated from the east. Its origin in Europaean prehistory as a steppe plant was also postulated (Brinkkemper and Kuijper, 1993). The plant was formerly cultivated as a vegetable in China, and after World War II it was experimentally cultivated in former USSR and Germany as an oil and fibre plant as its fruits contain 36% oil and 46% raw protein (Hanelt, 2001). In China archaeobotanical finds of cocklebur fruits date back to the Neolithic (Jiang et al., 2013). The plant contains iodine, tannins, alkaloids, and other chemicals and is poisonous to livestock. It was used in folk medicine against thyroid diseases (Broda and Mowszowicz, 2000) and is still popular in traditional Chinese medicine for nasal congestion and several other complaints (Jiang et al., 2013 and the literature cited there). In the Yuergou site, located in Xinjiang, China, dated to around 2300–2400 years BP broken burs of *X. strumarium* with missing seeds were interpreted as remains of intentional use of the seeds (Jiang et al., 2013).

3.2.3. Other useful plants

Hogweed (*H. sphondylium*) is known in Poland as "barszcz". Its leaves and stems were prepared as a lacto-fermented soup of the same name, but that custom completely disappeared from Polish cuisine in the 20th century AD (Łuczaj and Szymański, 2007; Łuczaj, 2010; Turner et al., 2011). The name "barszcz" is now used for a different type of soup. Hogweed is also known as medicinal plant (Broda and Mowszowicz, 2000). Hogweed fruits have been found in archaeobotanical samples as early as the Neolithic (Brombacher and Jacomet, 1997) but mostly preserved by waterlogging. The fruit from Lutomiersk–Koziówki is charred (Fig. 5) and accompanied by cocklebur.

Nettle (*U. dioica*) charred diaspores are also relatively rare in archaeobotanical materials, and the presence of charred nettle macroremains is usually taken as an indicator of its use, mostly as food and medicine but also as insulation or textile (Lityńska-Zając, 2012; Mueller-Bieniek, 2012: 101). In the past, diaspores of nettle could have been used as a source of edible oil and as addition to horse fodder (Kluk, 1788).

Sclerotia of ergot (*C. purpurea*) are usually connected with rye (*S. cereale*) grains (Wasylikowa, 1978), and both modern and archaeological specimens are much larger than the two specimens from Lutomiersk–Koziówki (the measurements of the studied specimens: 5.1 × 1 mm and 4.2 × 1 mm). The sclerotia were found in the sample dated to the LBA, when rye probably was not yet cultivated, and rye remains are absent generally in the relatively rich material from the studied site dated to that time (Table 2). In Central Europe rye was noted from the Neolithic onward as a tolerated weed but it was most probably cultivated as separate crop in the Iron Age (Zohary et al., 2012; Lityńska-Zając and Wasylikowa, 2005). The oldest mass finds of ergot come from Neolithic sites in Sachsen-Anhalt in Germany, where they were probably connected with wheat (Hellmund, 2008). Finds of ergot are scarce in the Neolithic and the Bronze Age, becoming much more frequent in the Middle Ages (Hellmund, 2008 and literature cited there). Ergot is a parasite of many grasses, particularly often on the genera *Molinia* and *Secale*. Sclerotia are poisonous because of alkaloids. It was cultivated (the form connected with rye) and used as an important pharmaceutical raw material for gynaecological purposes (Hanelt, 2001: 15). Ergot was found in the same sample as cocklebur.

In the material dated to the LBA also one seed of strawberry tomato (*P. alkekengi*) was found. The plant is very rarely noted in Polish archaeobotanical records (e.g. Bieniek, 2007). It was very common in Neolithic waterlogged samples from Zürich in Switzerland (Brombacher and Jacomet, 1997), while in the region of Basel it was absent until the Iron Age (Jacomet and Brombacher, 2009). The plant might have been used as a source of edible fruits and as medicine (Brombacher and Jacomet, 1997). In Poland, strawberry tomato is known as garden ornamental plant as well as a ruderal plant from Artemisietea vulgaris class (Zarzycki et al., 2002).

3.3. Interpretation of carpological remains

The composition of cultivated plants in the studied samples from Lutomiersk–Koziówki 3a-c fits the current state of knowledge on Central Europaen scope (Wasylikowa et al., 1991; Lityńska-Zając and Wasylikowa, 2005) although detailed archaeobotanical studies of the Łódź region are very scarce. At Lutomiersk–Koziówki 3a-c, a significant difference in the composition of useful plants between the Bronze Age and the Roman Iron Age settlement was noted. During the Bronze Age mostly peas and millet were harvested, but barley and hulled wheats were also known in that area covered mainly by poor sandy soils. Taking into account the frequent underrepresentation of peas remains and overrepresentation of millet in archaeobotanical samples it seems that peas were very important staple food in the studied area. The use of edible wild plants (*C. album* and *F. convolvulus*) was probably practised by the Bronze Age settlers. The Roman Iron Age agriculture was instead concentrated on large-seeded cereals, and rye and barley became significant. The composition of wild plant remains from two features dated to the Late Bronze Age, accompanying the extraordinary finds of cocklebur seeds (*X. strumarium*), probably reflects fodder remains or some medicinal or ritual activities. The recognition of fodder remains in charred carpological material is usually ambiguous (e.g. Wasylikowa, 1999; Bieniek, 2008; Tereso et al., 2013).

4. Conclusions

On the basis of fruit and seed remains we can conclude that in the most intense stage of human occupation at Lutomiersk–Koziówki 3a-c site (the Middle and Late Bronze Age), mostly peas and millet were cultivated while large-seeded cereals like einkorn, emmer, spelt, and barley were not common. The Bronze Age settlers probably intensively used plants known now as weeds like fat hen (*C. album* type) and wild buckwheat (*F. convolvulus*) that produced large quantity of edible and relatively resistant diaspores. In the Roman Iron Age, the presence of those abundant useful plants decreased and there was a visible increase in the role of rye (which had been absent in the Bronze Age), barley, and also wheats. The presence of cocklebur (*X. strumarium*) seeds was possibly connected with their useful properties, primarily as medicinal plants and secondarily as a source of oil. The context of these finds is exceptional compared with the other palaeobotanical samples from the site, probably reflecting medicinal activities or places where animals were kept, as the composition of charred plant macro-remains is not connected with crop storage or processing. Taking into account the equivocal history and possible migration of the cocklebur in Europe during the Holocene, it must be emphasized that the charred seeds from the site 3a-c at Lutomiersk Koziówki are currently the oldest radiocarbon-dated finds in Europe and can indicate the role of the plant in human economy and possibility of eastern cultural influences during the Bronze Age in central Poland.

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