

Plant remains from the Linear Pottery Culture settlement at sites Modlniczka 3 and 4, Kraków district. New sources for understanding agriculture in the Early Neolithic in southern Poland

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ABSTRACT. The aim of the archaeobotanical research of plant macro remains assemblage from the Early Neolithic settlement at Modlniczka in southern Poland is to study plants (fruit and seeds), cultivated and wild species used by the oldest farming groups during the early phase of occupation at the sites. The results were obtained from 62 samples from two archaeological sites, Modlniczka sites 3 and 4, likely forming one large settlement. Only charred plant remains were taken into account. Among cultivated plants, two species of hulled wheat, *Triticum dicoccon* and *Triticum monococum*, and common barley *Hordeum vulgare* were documented. Among wild plants, several taxa were found, including *Chenopodium t. album*, *Ch. polyspermum*, *Fallopia convolvulus*, *Bromus* sp. Numerous seeds of *Chenopodium t. album* indicates that this plant could have been used as part of a diet. In addition, hazelnut (*Corylus avellana*) shells were found.

KEYWORDS: Linear Pottery culture, macroscopic plant remains, hazelnut shells, Early Neolithic

INTRODUCTION

The presented materials come from two directly adjacent archaeological sites: Modlniczka 3 (AZP 101-55/58) and Modlniczka 4 (AZP 101-55/59), located in the Wielka Wieś commune. Their range was determined in the course of surface surveys conducted in 1987 (Ruszar, 1987a, b). Based on subsequent excavations, it can be concluded that these sites represent a single settlement of the Linear Pottery culture (LPC), located in the southern part of site No. 3 and across a large area of site No. 4. This is indicated by spatial organizations typical of such settlements, including traces of

so-called longhouses. Analogous settlements are known from various sites of this culture in southern Poland, including those in western Małopolska, such as Modlnica 5 (Czekaj-Zastawny and Przybyła, 2012: 47), Kraków-Olszanica 4 (Milisaukas, 1986), Brzezcie 17 (Czekaj-Zastawny, 2014) and Biskupice 18 (Moskal-del Hoyo et al., 2024).

Geographically, the sites are situated in the valley of the Wędonka, a small tributary of the Rudawa River, flowing in the eastern part of the Krzeszowice Graben (Fig. 1) (Woźniak and Bania, 2019). This area lies within the Kraków-Częstochowa Upland (Kondracki, 2002). In the northern part of the village of Modlniczka, the

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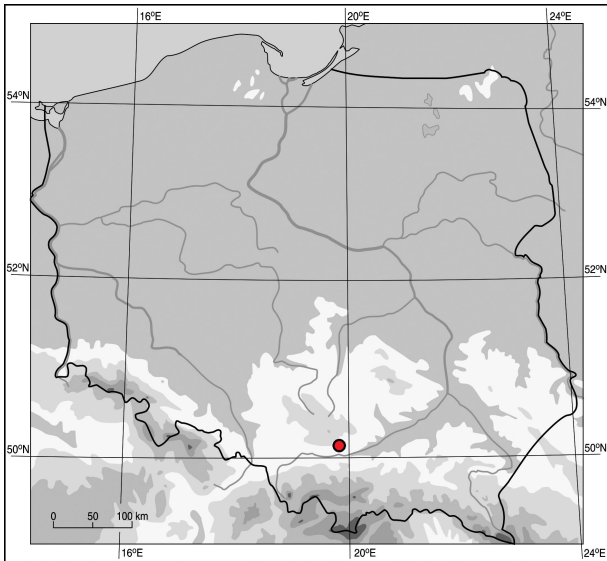


Figure 1. Location of sites 3 and 4 at Modlniczka, Kraków district, Poland. (Drawn by M. Wysocki and J. Wieser)

upper loess overlays Tertiary rocks, while to the south there are glacial sands and gravels (Czekaj-Zastawny and Przybyła, 2012).

The Linear Pottery culture (LPC) in Poland is estimated to have emerged ~5350–5000 BC (Czekaj-Zastawny et al., 2020). This cultural unit is divided into three principal phases: the early phase (Phase I or Pre-Music-Note), spanning ~5300–5250 BC; a subsequent classic phase (Phase II or Music-Note), lasting from ~5250 to 5100 BC; and a later phase (Phase III or *Żeliezowce* Phase), occurring between 5100 and 5000 BC (Czekaj-Zastawny and Oberc, 2021: 328, 329; Oberc et al., 2022; Moskal-del Hoyo et al., 2024: figs 5, 6).

Materials for research at the Modlniczka 3 were obtained from excavations conducted in 2018, which extended earlier work in this area. In the 2.1 × 100 m research trench, 11 features were identified. Among them, six were



Figure 2. Modlniczka site 4, Kraków district. Plan of the archaeological excavations. The layouts of the post-construction house (1, 2) and features Nos 4 and 20 (4a, b – elongated near-house pits) and cross-sections of post-holes Nos 10, 11 and 14 (3a–c). (Photo: M. Nowak, N. Gruda)

identified as elongated pits located in close proximity to houses (features Nos 67, 79, 83, 90 and 91) and utility/settlement pits (No. 86). The remaining features are post holes (features Nos 80–82, 84 and 85) associated with the construction of two different buildings. Based on pottery finds, these features can be dated to the middle phase of LPC development, specifically the note phase, and the late phase characterized by ornamentation in the *Żeliezovce* style.

In 2019, excavations were conducted at Modlniczka 4, with the research trench situated about 100 metres apart from the research area at Modlniczka 3. The work was carried out in a trench covering an area of 500 square metres. A series of LPC features were identified, including a longhouse (Fig. 2: 1, 2) with post holes (features Nos 6–11, 13–17, see Fig. 2: 3a–c) accompanied by elongated pits located near-house (Fig. 2: 4a, b). In the vicinity, there were settlement/utility pits (Nos 5 and 6), a clay extraction pit (No. 2) with features identified during its exploration (including No. 27), and in the northern part of the trench, a partially excavated elongated pit located near-house No. 1 (Fig. 3: 1–3). For features 1, 2 and 5, it was possible to determine relative chronology more precisely based on pottery finds. The finds from feature No. 1 represent phase Ib in LPC development with characteristic ornamentation in the form of straight, arched, and angular engraved linear patterns (Fig. 4: 1–6). Pottery from features Nos 2 and 5 are decorated with impressions called “notes”, typical of the middle phase of LPC development (Fig. 4: 7–9, 11, 13, 14). In feature No. 2, single fragments of ceramics decorated in the *Żeliezovce* style were also identified (Fig. 4: 10, 12)

MATERIAL AND METHODS

A total of 62 soil samples were collected from 28 features, with 37 samples originating from the Modlniczka 4 site and 25 samples from the Modlniczka 3 site. All samples were wet-sieved using 0.5 mm and 1 mm mesh sieves and then dry-sorted. Sample volumes ranged from 3.1 to 24 litres (Table 1). Following drying, the material appropriate for taxonomic identification was separated into seeds/fruits and charcoal. Plant remains, seeds and fruits were determined based on morphological features visible under a stereoscopic microscope with 10x and 40x magnification. Keys, atlases and other publications were used for identification (e.g. Cappiers et al., 2012; Kulpa,



Figure 3. Modlniczka site 4, Kraków district. The layout of feature No. 1 (1) and cross-sections (2, 3). (Photo: A. Głowacka)

1974), along with a reference collection of modern diaspores and fossil flora from the National Biodiversity Collection of Recent and Fossil Organisms of the IB PAS. The Latin names of taxa are given according to Mirek et al. (2020). The results of the archaeobotanical analyses are presented in Table 1. It also contains the type of remains and their state of preservation. The indeterminate category covers diaspores that could not be assigned to a taxon of any rank (species, genus, or family level) due to their poor condition.

RESULTS

At the Modlniczka 3 site, five taxa have been identified. Cultivated plants were represented by emmer wheat (*Triticum dicoccon*) and some damaged grain fragments which were included in the category of cereals (*Cerealia* indet.). Herbaceous wild plants were represented by two species: many-seed goosefoot (*Chenopodium polyspermum*) and fat hen (*Chenopodium t. album*). The remaining plant material consisted of caryopses from unidentified wild grasses (*Poaceae* indet.).

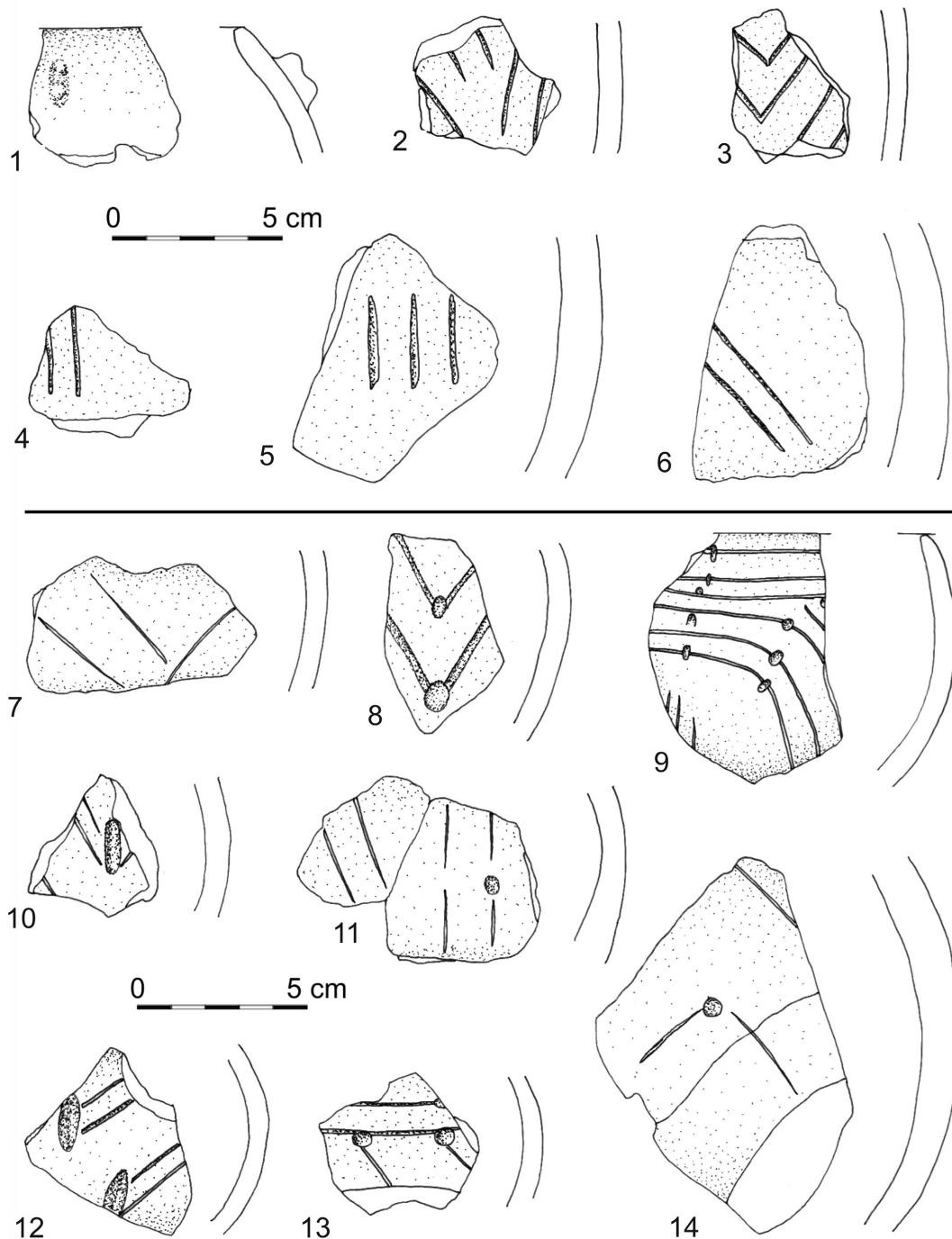


Figure 4. Modlniczka site 4, Kraków district. Selected pottery finds: 1–6. from feature No. 1, 7–14. feature No. 2. (Drawn by W. Rumian)

Plant material is richer in samples from Modlniczka 4, where 18 taxa were found (Table 1) identified to species level (*Agrostemma githago*, *Chenopodium t. album*, *Corylus avellana*, *Fallopia convolvulus*, cf. *Hordeum vulgare*, *Lens culinaris*, *Polygonum aviculare*, *P. minus*, *P. persicaria*, *Triticum dicoccon*, and *T. monococcum*), genus level (*Bromus* sp., *Oxalis* sp., *Polygonum* sp., and *Triticum* sp.) and family level (Fabaceae indet., and Poaceae indet.). A number of heavily damaged grain

fragments were classified within the category of cereals (*Cerealia* indet.). Due to poor preservation, several specimens were not identified (indeterminate).

The samples also contained fragments of grains, which due to their state of preservation were generally classified as unidentified cereals (*Cerealia* indet.).

At Modlniczka 4 site cultivated crops were represented by hulled wheats, such as emmer (*Triticum dicoccon*, see Fig. 5: 1a–c) and eincorn

Table 1. List of plant remains from sites 3 and 4 at Modlniczka. Abbreviations: type of remains: s – seed, f – fruit, c – caryopsis, gb – glume base

Site name	ID feature	Volume of samples [liter]	Quantity of sample	Depth	kind of remains	Modlniczka 3																			
						67	79	79	80	80	81	81	82	83	83	84	84	84	85	85	86	90	91	91	91
						60–80	90–100	100–110	40–50	40–50	40–40	40–50	40–50	50–60	60–80	40–50	40–50	40–50	40–50	80–90	90–100	50–60	90–100	90–100	
Taxa name						.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
cf. <i>Hordeum vulgare</i>	c					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum dicoccon</i>	c					.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
<i>Triticum dicoccon</i>	gb					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum monococcum</i>	c					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum monococcum</i>	glume					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum monococcum</i>	gb					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum</i> sp.	c					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum</i> sp.	glume					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum</i> sp.	gb					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerealia indet.	c					.	.	.	.	2	.	2	.	.	3	6	.	.	1	.	.	.	.
<i>Lens culinaris</i>	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Agrostemma githago</i>	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Chenopodium t. album</i>	s					.	.	2	2	8	10	2	.	2	1	2	.	.	2	1	2	1	2	1	8
<i>Chenopodium polyspermum</i>	s					2	.	1	.	.	.	1	.	.	.	.	.	.	.	2	.	.	.	.
<i>Fallopia convolvulus</i>	f					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Galeopsis cf. tetrachit</i>	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygonum aviculare</i>	f					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygonum minus</i>	f					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygonum persicaria</i>	f					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Bromus</i> sp.	c					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Oxalis</i> sp.	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygonum</i> sp.	f					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fabaceae indet.	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poaceae indet.	c					5	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.
<i>Corylus avellana</i>	nutshell					.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
indet	c					1	5	1	1	.	1	1	1	.	2	4	.	2	.	1	.	2	1	.	

(*T. monococcum*). The mentioned remains consisted of caryopses and glume bases of *T. dicoccon* (Fig. 5: 2a, b) and *T. monococcum* (Fig. 5: 3a, b). Probably the hulled wheat also includes the remains described as *Triticum* sp. barley (cf. *Hordeum vulgare*) and three fragments of lentil seeds (*Lens culinaris*, see Fig. 5: 4a, b) were also found.

Among the wild herbaceous plants appeared in material from Modlniczka 4 were common knotweed (*Polygonum aviculare*), small water pepper (*P. minus*), spotted lady's thumb (*P. persicaria*) knotweed (*Polygonum* sp., see Fig. 5: 7) black bindweed (*Fallopia convolvulus*, see Fig. 5: 6), common hemp-nettle (*Galeopsis cf. tetrachit*), wood sorrel (*Oxalis* sp.) and two caryopses are likely derived from brome grass (cf. *Bromus* sp.). The plant remains designated to the family level are represented by caryopses belonging to grasses (Poaceae) and a single seed of legumes (Fabaceae). The most

numerous were diaspores of fat hen (*Chenopodium t. album*, see Fig. 5: 5) that appeared as 46 specimens from Modlniczka 3 and 312 specimens from Modlniczka 4. The few specimens whose poor state of preservation prevented identification remain undetermined.

DISCUSSION

The plant material comes from archaeological features associated with the Neolithic house and its surroundings. Their fills, together with plant remains, may differ in nature, making interpretation difficult. However, it is evident that there were no accumulations of plant material; instead, all specimens were found dispersed within the fills of the features, suggesting that they likely represent settlement noise. The analyzed diaspores have survived in charred form, a key factor contributing to the survival of plant

Table 1. Continued

Site name	ID feature	Volume of samples [liter]	Quantity of sample	Depth	kind of remains	Modlniczka 4																										
						1	1	1	2	2	4	4	5	6	7	8	9	10	11	13	14	15	16	17	20	20	20	27				
						40-60	60-70	80-100	50-70	70-80	40-60	60-70	60-70	40-50	40-50	40-50	40-50	40-50	50-60	50-60	40-50	40-50	40-50	50-60	60-70	60-70	100-110					
Taxa name						.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>cf. Hordeum vulgare</i>	c					.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum dicoccon</i>	c					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum dicoccon</i>	gb					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum monococcum</i>	c					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum monococcum</i>	glume					.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
<i>Triticum monococcum</i>	gb					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Triticum</i> sp.	c					.	1	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Triticum</i> sp.	glume					.	.	.	2	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Triticum</i> sp.	gb					.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerealia indet.	c					1	9	1	10	7	.	1	1	.	.	.	.	1	.	.	.	.	.	7	.	.	.
<i>Lens culinaris</i>	s					.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Agrostemma githago</i>	s					.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Chenopodium t. album</i>	s					10	5	2	1	7	82	13	7	19	10	14	5	12	.	22	9	74	3	5	7	2	3	.				
<i>Chenopodium polyspermum</i>	s								
<i>Fallopia convolvulus</i>	f					.	4	1	1	1	.	.	.	.	1	.	.	.	.	.	1	.	.	1	.	.	.
<i>Galeopsis cf. tetrachit</i>	s					1				
<i>Polygonum aviculare</i>	f					1	.	.	1				
<i>Polygonum minus</i>	f					.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1				
<i>Polygonum persicaria</i>	f					1				
<i>Bromus</i> sp.	c					.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1					
<i>Oxalis</i> sp.	s					.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.
<i>Polygonum</i> sp.	f					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Fabaceae indet.	s					.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poaceae indet.	c					.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Corylus avellana</i>	nutshell					.	1	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
indet	c					.	4	3	2	1	.	1	.	3	.	.	.	.	1	.	1	.	.	3	.	.	2	

remains in dry environments in archaeological features. However, it limits the preservation of soft parts (e.g. leaves) of plants (Lityńska-Zajac and Wasylkowa, 2005: 42).

The collected data allows us to conclude that the basic cereals cultivated in the LPC settlement in Modlniczka were two species of wheat: emmer and einkorn. Most cereal remains from Modlniczka 4 (caryopsis and glumes) were obtained from the elongated pit 1 and clay extraction pit 2. Fragments of wheat described to the genus or species level were found in only four features from Modlniczka 4 (Nos 1, 2, 11, 14) and one from feature No. 86 from Modlniczka 3. These species have similar life cycles and habitat conditions, thus they may have been cultivated in the same fields (Lityńska-Zajac and Moskal-del Hoyo, 2021: 239).

The third cereal was barley (*Hordeum vulgare*). It was represented by a single grain, therefore, it is difficult to say whether it was

cultivated. The presence of barley in archaeological finds from LPC is scarce (Conolly et al., 2008; Zohary et al., 2012). Until recently, it was believed that during the Early Neolithic period, barley was considered a weed in wheat fields (Bogaard, 2004: 14; Kreuz et al., 2005). In Poland, the presence of barley in nine LPC sites is confirmed (Lityńska-Zajac et al., 2017; Czekał-Zastawny and Oberc, 2021; Kapcia et al., 2024). Predominantly, the findings consisted of individual specimens, however, at the Olszanica site, a total of seven caryopses and four imprints of spikelets attributed to this species were documented. This indicates that the crop was cultivated, albeit on a smaller scale compared to wheat, and was sown separately (Lityńska-Zajac and Wasylkowa, 2005: 490). Recently one of the barley grains, from Biskupice site 18, has been radiocarbon dated which confirmed its Early Neolithic origin (Kapcia et al., 2024).

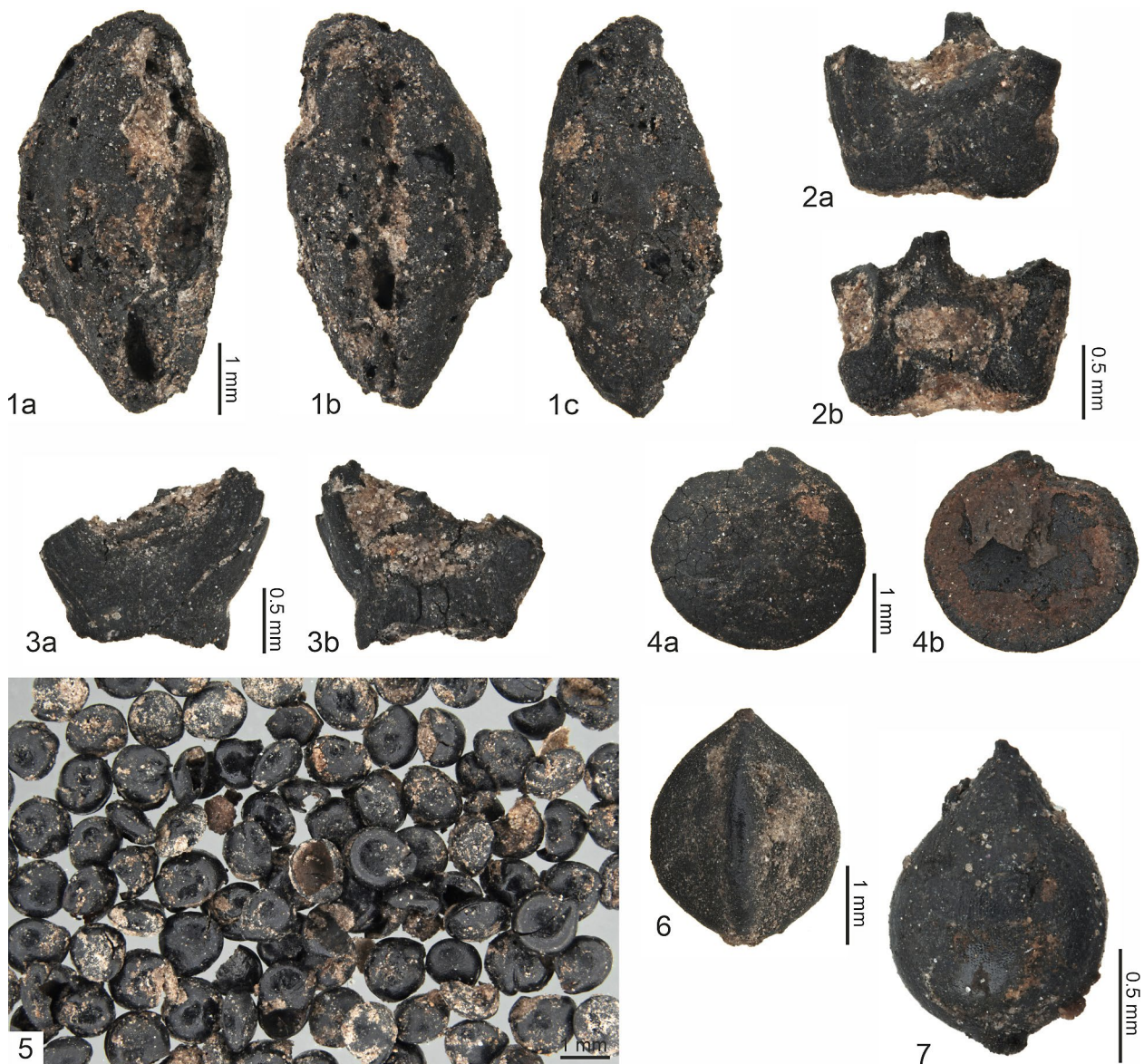


Figure 5. Plant remains from Modlniczka 4 site. **1.** *Triticum dicoccon*, caryopsis, dorsal view (a) ventral view (b) and lateral view (c); **2.** *Triticum dicoccon*, glume base from adaxial view (a) and abaxial view (b); **3.** *Triticum monococcum*, glume base, adaxial view (a) and abaxial view (b); **4.** *Lens culinaris*, dorsal view (a) and ventral view (b); **5.** *Chenopodium t. album*, seeds; **6.** *Fallopia convolvulus*, **7.** *Polygonum cf. minus*. (Photo: K. Stachowicz)

Lentils (*Lens culinaris*) were also found at Modlniczka 4. The genus *Lens* contains 6 taxa, with a wild ancestor identified as *Lens culinaris* ssp. *orientalis* (Lityńska-Zajęc and Wasylkowa, 2005, 117; Sonnate et al., 2009). Lentils are one of the oldest crops cultivated and domesticated by man. Lentil seeds have been found in several archaeological sites since the Neolithic times in south-eastern Europe (Zohary et al., 2012). It is widely believed that cultivation occurred before domestication, but the duration of this period remains an open question (Sonnate et al., 2009). It is now well-accepted that the domestication of lentils was accomplished in the Near East.

Among wild herbaceous plants, the most abundant taxa were fat hen (*Chenopodium*

t. album). Its seeds are rich in proteins and carbohydrates (Lityńska-Zajęc and Makowicz-Poliszot, 2019: 38; Łuczaj, 2004: 101; Podbielkowski, 1985: 166), which is likely why they may have been collected for consumption (Behre, 2008; Mueller-Bieniek et al., 2018b; Lityńska-Zajęc and Makowicz-Poliszot, 2019). At the Modlniczka 4 site, black bindweed (*Fallopia convolvulus*) was recorded in seven samples. It is an annual plant, characteristic of ruderal habitats and also a weed of cereal crops (Lityńska-Zajęc, 2005: 58). It is widespread at sites of the LPC in Europe (Bogaard, 2004) and has been often recorded at several sites in Poland (Brzezcie, Gwoździec, Olszanica, Targowisko, and Zagórze) (Lityńska-Zajęc

et al., 2017) Miechów 3 (Mueller-Bieniek et al., 2018a) Biskupice 18 (Kapcia et al., 2024), Ludwinowo 7 (Mueller-Bieniek et al., 2019) and Łańcut 3 (Kapcia unpubl.). There are other edible species such as fat hen (Bogaard, 2004).

Nut shells of common hazel (*Corylus avellana*), associated with gathering activities, were also observed in the assemblage. Hazel nut shells are found less frequently than hazel charcoals on LPC archaeological sites in Poland. Mostly there are single specimens like in Ludwinowo 7 (Mueller-Bieniek et al., 2019), Biskupice 18 (Kapcia et al., 2024), Gwoździec 2 (Czekaj-Zastawny et al., 2020), Łańcut 3 and 23 (Kapcia unpubl.). Hazelnuts are important food that were widely consumed throughout prehistory, mainly thanks to being an excellent source of energy (high-fat content of 60%), relatively easy to harvest, and to process using simple tools (Holguin et al., 2022; Bishop et al., 2023). Hazelnuts are easy to store, allowing them to be kept for consumption throughout the year. Additionally, hazelnut pericarps can be easily lignified, which is why they were frequently used from the Mesolithic period to the Bronze Age across Europe (Zvelebil, 1994; Peña-Chocarro et al., 2005; Crombe et al., 2023). Hazel nowadays is a component of the shrub layer of deciduous forests. It prefers well-lit woodlands (Miotk-Szpiganowicz et al., 2004). From Modlniczka 3 site, the results of the charcoal analyses did not show the presence of hazel in the charcoal assemblage (Moskal-del Hoyo, 2021). However, the results showed the predominance of oak *Quercus* sp. with a high share of pine *Pinus sylvestris* (Moskal-del Hoyo, 2021). The predominance of these two taxa is interpreted as a presence of open canopy woodlands, most probably oak forests. In such communities, hazel can grow well (Miotk-Szpiganowicz et al., 2004).

The wild herbaceous plants in Modlniczka probably come from a variety of habitats. Most of them are plants of ruderal habitats, belonging to the class *Stellarietea-mediae* like *Chenopodium* t. *album*, *Fallopia convolvulus*, *Galeopsis* cf. *tetrachit* and *Polygonum aviculare* (Matuszkiewicz, 2001), some of which can grow in arable land. According to the current phytosociological approach (Matuszkiewicz, 2001; Zarzycki et al., 2002), weeds of crop fields include corn-cocle (*Agrostemma githago*), which has only been recorded at a few Neolithic sites (Lityńska-Zajac et al., 2017; Kapcia and

Mueller-Bieniek, 2018), spotted lady's thumb (*Polygonum persicaria*) and small water pepper (*Polygonum minus*).

ADDITIONAL INFORMATION

CONFLICT OF INTEREST. None declared.

ETHICAL STATEMENT. None necessary.

FUNDING. No.

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