Accuracy of the typological classifications of the Late Glacial and Early Holocene osseous projectile points according to the new AMS dates of selected artifacts from Poland

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Abstract

Late Glacial and Early Holocene bone and antler artifacts are recovered from all over the Polish Lowland. Elements of projectile weaponry, in the form of various points made of osseous raw materials, were an important part of hunter-gatherer equipment of that time. We present the results of AMS dating of a unique collection of thirteen artifacts that had previously been chrono-culturally attributed by means of relative dating using typological approaches only. The results obtained are considered alongside current knowledge and typological arrangements for these types of tools in Europe. We also attempt to determine the interpretative potential of the technological studies to which the discussed osseous points were subjected in terms of possibly identifying processing techniques that can be specific to the given periods of the Stone Age. Suggestions made in this respect are verified through the radiocarbon dating results.

Keywords Osseous projectile points · Polish Lowland · Late Paleolithic · Mesolithic · AMS dating · Typology

Introduction

Late Pleistocene and Early Holocene osseous points from the North European Plain — an outline of the state of research

One of the most important attributes of Late Glacial and Early Holocene hunter-gatherer equipment are elements of projectile weaponry in the form of various points and barbed points¹ made of osseous raw materials. There is a significant amount and quality of data collected by scholars concerning the morphology, technology, function, and role of osseous projectile weapons for prehistoric people, and this cannot be overestimated. There is a long-standing tradition of studies in this regard, and this is an important way of better understanding societies that existed in those days. Research that takes a broad perspective in this field is so far well represented in collective works such as *Projectile Technology*, edited by Heidi Knecht (1997); *La chasse dans la*

Préhistoire. Hunting in Prehistory, edited by Claire Bellier, Pierre Cattelain, and Marcel Otte (2001); *Multidisciplinary Approaches to the Study of Stone Age Weaponry*, edited by Radu Iovita and Katsuhiko Sano (2016); and *Osseous Projectile Weaponry—Towards an Understanding of Pleistocene Cultural Variability*, edited by Michelle C. Langley (2016).

Many of the Late Paleolithic and Mesolithic European osseous points come from sites with a well-dated context, such as Star Carr in England (Clark 1954; Elliott and Little 2018); Stellmoor, Friesack, and Hohen Vieheln in Germany (David 2005a, 2019; Gramsch 2000); Motala, Ulkestrup, and Svaerdborg in Scandinavia (Larsson 1983; David 2005a; Gummesson and Molin 2019); Šventoji, Zvejnieki 2, Pulli, Sūlāgals, and Kunda-Lammasmägi in the East Baltic (Indreko 1948; Rimantienė 2005; David 2005b, 2006; Zagorska 2019; Piličiauskas et al. 2020; Osipowicz et al. 2020); and Zamostje 2, Ivanovskoye 3 and 7, Stanovoye 4, Veretye 1, and the Shigir peat bog in Northwestern Russia (Lozovskii 1996; Lozovskaya

¹ The term “barbed points” is widely used in publications concerning Late Glacial and Early Holocene and unites different artifacts with a sharp tip and one or several barbs. We have decided to cease using the previous term, “harpoon head” (Orłowska and Osipowicz 2018; Osipowicz et al. 2019; Osipowicz et al. 2020) because it suggests a specific way of using the tool, which, as the results of traceological studies show, is not always confirmed in reality (e.g., Osipowicz et al. 2019).

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and Lozovski 2013, 2019; Zhilin 2015, 2017). Probably even more commonly, however, they are represented by so-called stray finds: artifacts found by accident, outside an identifiable cultural context (e.g. Verhart 1988; Vankina 1999; Gramsch 2003; Galiński 2013).

Typological classification is the first basic step when analyzing any prehistoric osseous point. It is commonly believed that their broad range of forms means that artifacts of this kind may be important cultural determinants (Kozłowski 1969; Kozłowski and Kozłowski 1977; Verhart 1990). One of the first and probably best-known typological classifications of prehistoric osseous points from Northern Europe was made in the 1930s by John Grahame Douglas Clark (1936). His work still serves as a point of reference for other European researchers examining late Paleolithic and Mesolithic artifacts of this kind, and the typological systems that they have created (Indreko 1948; Andersen 1970; Kozłowski and Kozłowski 1977; Larsson 1978; Gramsch 1973; Vankina 1999; 2003; Verhart 1990; Charniauskis 2007, Fig. 67–68; Girininkas 2011, Fig. 26; Zhilin 2015; Lozovskaya and Lozovski 2019; Savchenko 2019).

The problem of the chronological and cultural affiliation of Late Pleistocene and Early Holocene osseous points from the area that is today Poland has been of interest to researchers since the late 1960s. The first studies in this regard were conducted by Stefan K. Kozłowski (1969, 1977), and then, from the late 1980s, by Tadeusz Galiński (1986, 2013, 2020). Both researchers aimed to add detail to the Clark's typology, and to modify it where necessary, taking it beyond the Maglemose technocomplex that was the subject of Clark's research (Table 1).

The northern areas of Poland are relatively rich in osseous point finds, the vast majority of which are stray finds. There is information in the subject literature on nearly a hundred items of this type found in the North European Plain (Galiński 2013). Only few have been subjected to radiocarbon dating or pollen relative dating. The others were classified as either Late Paleolithic or Mesolithic based on their morphological features, the raw material used for making them, and the place/context in which they were found. Unfortunately, it is likely that only twenty-five of these artifacts have been preserved to this day. It is therefore a very small group, particularly when juxtaposed with numerous stone finds from this area. This is why these products should be regarded as valuable from the scientific point of view, despite having been found outside specific archaeological context.

Chronological and cultural diversity of Late Pleistocene and Early Holocene osseous points from the North European Plain

At the area of the southern Baltic zone (between the mouths of the Oder and Niemen rivers), several hundred osseous

points have been found so far that can be dated with varying degrees of probability to the end of the Pleistocene (starting from the Bølling) and the early Holocene. Thanks to ¹⁴C datings, typological studies, and finds from dated and secured contexts researchers managed to assign some types of points with given periods or even cultures, despite the very complex cultural situation in the southern Baltic zone at that time. The existing basic arrangements in this regard will be presented below (the numbers in parentheses correspond to the main types proposed by J.G.D. Clark; 1936). A more detailed description of findings on this topic can be found in the proper literature (e.g., Kozłowski 1969; Kozłowski and Kozłowska 1977; Galiński 2013, 2020). Detailed data for the typological and cultural-chronological affiliation of the analyzed points based on findings presented by J.G.D. Clark (1936), L. Verhart (1990), and T. Galiński (2020) are presented in Table 2. The aim of the mentioned table is to show the high typological complexity and differences in both nomenclature and chronological terms for identical types of points proposed by different authors.

We want to emphasize that the interpretation of cultural affiliation of points was not the purpose of our article. In the case of the Polish lands, the cultural situation, especially in the early Holocene, was very complex, and the ranges of occurrence of many cultures overlapped with each other (chronologically and geographically). For this reason, we decided not to do too far suggestions in this regard and to limit our interpretations to the level of chronological affiliation, what changed a lot in the present knowledge on the issue anyway (as can be concluded from the discussion conducted in the article).

The Late Paleolithic forms

For the Late Paleolithic, most typical are barbed points with well-pronounced barbs (types 9, 10, 11, 12A, and 12B according to Clark). They are often linked with the tanged point technocomplex (Kozłowski 2006), especially with the Ahrensburgian culture (Cziesla and Masojć 2007). However, they are also known from inventories related to Hamburgian and Świderian culture (Kozłowski 1969). Another characteristic forms of points are tanged points of triangular section (type 13 according to Clark), and shovel-shaped points of the Pentekinnen type (Clark's no. 17). These two types can be connected with Świderian culture (Kozłowski 1969).

The Mesolithic forms

Based on current research on the European Mesolithic, it can be concluded that notched points (Clark's types 2, 4, and 8) are connected primarily with the Duvensee complex, while single-barbed points (Clark's type 5) and points with barbs, of the so-called Mullerup type (Clark's no. 7), are

associated with the Maglemosian complex (Kozłowski 1969; Galiński 2013). Kunda type notched points (Clark's no. 6), and the plain points of circular section (Clark's no. 1), are common in all Mesolithic groups of the eastern Baltic. In turn, the Shigirian conical points (Clark's no. 16), some of the single-barbed points (Clark's no. 12A), tanged points of triangular section (Clark's no. 13) and shovel-shaped points of the Pentekinnen type (Clark's no. 17), can primarily be connected with assemblages of the Eastern European Kunda technocomplex (Kozłowski 1969; Galiński 2013). The cultural attribution of slotted points with flint insets (Clark's type 21A and 21B) can be linked to both the Mesolithic Janislavician Complex and the so-called post-Swiderian communities of north-western Russia (e.g., Galiński 2013; Manninen et al. 2021).

Objectives

This article presents radiocarbon (AMS) datings of a group of 13 osseous projectile points from the Polish Lowlands. The main objectives of this study are as follows:

1. *Establishing the correct chronological position of the analyzed osseous projectile points from Poland.* Until now, only a few bone points, being a stray find, discovered in Poland had AMS radiocarbon age determinations. The obtained dating will significantly enlarge the existing ^{14}C dataset (almost all points found without context known from the territory of Poland will have radiocarbon dates now). The information obtained thanks to this study will be very important for the research on the spread of the different types of points in Europe, because they will largely fill the gap that until now was the lack of knowledge about the absolute chronology of these artifacts from the area of Poland.
2. *Verification of typological findings relating to the time of use of the types of points included in the article on the territory of Poland.* As can be deduced from the data in Table 2, individual typological classifications determine the chronological and cultural range of use of specific points in a slightly different way, which introduces confusion in interpretation. This situation results from the lack of a sufficient number of ^{14}C dating (especially to the Polish lands) and the determination of individual artifacts' chronological and cultural position based on analogies from other regions. Thanks to the radiocarbon dating carried out for this article, this problem will be largely resolved.
3. *Discussion on the suitability and/or credibility of the existing typological classifications.* Verifying the existing typological findings on the period of use of individual types of points with the help of radiocarbon dating will also become the basis for a discussion on the

reliability of currently used typological classifications. It will also verify the validity of their use to determine the relative age of the stray finds of the type in question.

4. *Evaluation of the interpretative potential of technological studies to identify processing techniques specific to the particular Stone Age periods.* The radiocarbon dating results will be used to answer whether the differences and similarities observed in the processing techniques applied to the artifacts from particular periods result from chronological/cultural/geographical factors or other reasons. Our previous suggestions in this regard (cf. Orłowska, Osipowicz 2018) will be discussed in light of the obtained radiocarbon dating results.

Materials

Thirteen specimens of osseous points from the Polish Lowlands were subjected to radiocarbon dating (cf. Figure 1; Table 1) and were linked to Late Glacial or Early Holocene hunter-gatherer societies based on their morphological characteristics (Table 1). These products are diverse in terms of form; however, in most cases, specific forms find analogies to artifacts from other regions of the North European Plain. The points were classified into five main types: plain points with a circular cross-section, tanged points with a triangular cross-section, single-barbed points, uniserial barbed points, and biserial barbed points with protruding barbs. This division was based on the classification presented by Clark in 1936, Leo Verhart in 1990, and to the most recent classification of this type of artifact for the area of Poland, authored by Galiński (2020).

Plain points with a circular cross-section

Points of this type were classified by Clark as type 1 (cf. Table 2). There are two artifacts of this form, a point from Witów and a point from Kosierzewo.

Witów, Piątek commune (Fig. 2A)

This artifact was found in 1937 by workers extracting peat in the area of Witów village, Piątek commune (Table 1; Fig. 1). There were originally four points in the find (but only one still survives) and a fragment of reindeer antler. The artifacts were deposited in peat at a depth of about 2 m. According to archival records, the excavated points were all analogous in terms of form, and varied in length only (Koszańska 1947). The preserved specimen is in excellent condition and is characterized by a slender shape, a circular cross-section, and a double beveled base. It is 21-cm long with a maximum diameter of about 1.2 cm. It is made of reindeer antler (Koszańska 1947; Galiński 2020). Galiński

Fig. 1 Map showing the location of described osseous points from the Polish Lowland: 1 — Witów, 2 — Kosierzewo, 3 — Lake Niegocin, 4 — Lisi Ogon, 5 — Lake Gil Wielki, 6 — Wiele, 7 —

Gniewino, 8 — Orzysz, 9 — Staświny, 10 — Sołdany, 11 — Bydgoszcz, 12 — Lake Duży Mausz, 13 — Baltic Sea, 14 — Bolków, 15 — Wieprz-Krzna, 16 — Orle, 17 — Węgliny

classified points with a circular cross-section and a double bevel base in Poland as the Nowe Juchy type (Table 2). It is suggested that they were used not only in the Mesolithic but also the Late Paleolithic (Koszańska 1947; Galiński 2020). At present, this artifact is stored as part of the collection at the Museum of Archaeology and Ethnography in Łódź. It was recently subjected to traceological analysis (Orłowska 2021).

Kosierzewo, Malechowo commune (Fig. 2B)

This point was found in undefined peat at a depth of about 6 m, probably at the end of the nineteenth century (Table 1; Fig. 1; cf. Galiński 1982). It is 18-cm long with a diameter of 0.8 cm. The artifact is slender with an oval cross-section. It is made of an unidentified long bone of a mammal of the Cervidae family. The point was classified by Galiński as a Mesolithic type Bonin (Galiński 2020); however, in our opinion, it should be classified as a Nowe Juchy type, like

the point from Witów, since it has a double beveled base, analogous to the Witów point (cf. Figure 2A), which is a distinctive element that makes these artifacts stand out from Clark's type 1 points. The artifact is stored in the requesting unit at the National Museum in Szczecin.

Tanged points with a triangular cross-section

These points are classified by Clark as type 13 (cf. Table 2). Two artifacts of this form are included in this study: a point from Lake Niegocin and a point from Lisi Ogon.

Lake Niegocin (properly Upały), Giżycko commune (Fig. 2C)

This point was found in 1924 during peat extraction works, along with a barbed point, an arrowhead, and a processed tooth (of a roe deer?; Table 1; Fig. 1). It was probably discovered north of the Stasswinner Canal (*Stasswinner Kanal*)

Table 1 Contextual information and general description of all analyzed artifacts

No	Site	Date of recovery	Context of recovery	Dimensions (cm)			Morphology	Raw material	Species, element	Current holding
				Length	Width of the stem	Thickness				
1	Witów, Piątek commune	1937	Peat bog	21.0	1.2	1.1	Plain point of circular section	Antler	Reindeer (<i>Rangifer tarandus</i>)	Museum of Archaeology and Ethnography in Łódź
2	Kosierzewo, Malechowo commune	Before 1887	Peat bog	18.0	0.8	0.8	Plain point of circular section	Bone	Red deer (<i>Cervus elaphus</i>) Long bone	National Museum in Szczecin
3	Lake Niegocin (Upały), Gizzycko commune	1924	Lake	16.0	1.3	1.0	Tanged point of triangular section	Bone	Unspecified Long bone	Museum of the Piska Land in Pisz
4	Lisi Ogon, Białe Błota commune	The acquisition date of the point by the Museum is 1906	Lacustrine lime deposits	13.8	1.2	0.8	Tanged point of triangular section	Bone	Large mammal (<i>Cervidae</i> ?) Long bone	Leon Wyczółkowski District Museum in Bydgoszcz
5	Lake Gil Wielki, Miłomłyn commune	End of the 1980s	Lake	19.9	1.7	0.8	Single-barbed point	Bone	<i>Cervidae</i> Metatarsal	Museum in Ostróda
6	Wiele, Mrocza commune	1992	Peat bog	21.0	2.2	1.2	Single-barbed point	Bone	Red deer (<i>Cervus elaphus</i>) Metacarpal	Leon Wyczółkowski District Museum in Bydgoszcz
7	Gniewino, Gniewino commune	End of the 1880s	Unknown	18.1	1.5	1.0	Single-barbed point	Bone	Red deer (<i>Cervus elaphus</i>) Metapodium	National Museum in Szczecin
8	Orzysz, Pisz commune	2000s	Riverbank of river Orzysz	17.5	1.7	0.8	Uniserial barbed point with protruding barbs	Bone	Large ruminant Long bone	Museum of the Piska Land in Pisz
9	Soldany, Giżycko commune	1971	Lacustrine lime deposits	21.5	1.1	1.0	Uniserial barbed point with protruding barbs	Bone	Reindeer (<i>Rangifer tarandus</i>) Metapodium	Museum of Warmia and Mazury in Olsztyn
10	Staświny, Miłki commune	1969	Peat bog	23.0	15.9	8.4	Uniserial barbed point with protruding barbs	Bone	Elk (<i>Alces alces</i>) Metatarsal	Museum of Warmia and Mazury in Olsztyn
11	Bydgoszcz, Bydgoszcz commune	Beginning of the twentieth century	Unspecified watercourse	10.6	1.3	0.7	Uniserial barbed point with protruding barbs	Bone	Large mammal Long bone	Leon Wyczółkowski District Museum in Bydgoszcz
12	Lake Duży Mausz, Sulęczyno commune	1960s	Lake	23.7	2.5	1.5	Uniserial barbed point with protruding barbs	Bone	Red deer (<i>Cervus elaphus</i>) Metatarsal	Museum in Koszalin
13	Baltic Sea	1985	Baltic Sea, between Dziwnów and Międzywodzie	23.5	0.9	0.6	Biserial barbed point with protruding barbs	Antler	Red deer (<i>Cervus elaphus</i>) or Elk (<i>Alces alces</i>)	Regional Museum in Wolin

Table 2 Typological classification of analyzed points according to systems proposed by Clark (1936), Verhart (1990), and Galiński (2020)

SITE	Typological classifications					
	After J.G.D. Clark (1936)		After L. Verhart (1990)		After T. Galiński (2020)	
	Type	General chronology of described type	Type	General chronology of described type	Type	General chronology of described type
Witów	Type no. 1 (plain points of circular section)	Mesolithic (Maglemose culture)	01.02 (big plain points, L:W = > 5:1)	Not specified	Nowe Juchy type (plain points of circular section, with base truncated on two sides)	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Kosierzewo	Type no. 1 (plain points of circular section)	Mesolithic (Maglemose culture)	01.02 (big plain points, L:W = > 5:1)	Not specified	Bonin type (plain points of circular section)	Mesolithic
	Type no. 13 (tanged points of triangular section)	Mesolithic (Maglemose culture)	08.06 (points with triangular cross-section)	Not specified	Assignment after Clark type no. 13	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Lisi Ogon	Type no. 13 (tanged points of triangular section)	Mesolithic (Maglemose culture)	08.06 (points with triangular cross-section)	Not specified	Assignment after Clark type no. 13	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Lake Gil Wielki	Type no. 5 (single-barbed points)	Mesolithic (Maglemose culture)	04.01 (points with a single medium barb)	C. 9000–6000 B.P	Gniewino type (single-barb forms)	Mesolithic
Wiele	Type no. 5 (single-barbed points)	Mesolithic (Maglemose culture)	04.01 (points with a single medium barb)	C. 9000–6000 B.P	Gniewino type (single-barb forms)	Mesolithic
Gniewino	Type no. 5 (single-barbed points)	Mesolithic (Maglemose culture)	04.01 (points with a single medium barb)	C. 9000–6000 B.P	Gniewino type (single-barb forms)	Mesolithic
Orzysz	Atypical	Not specified	06.07 (points with barbs and binding barb/notch)	Not specified	Atypical	Not specified
Soldany	Type no. 12A (single-barbed points with stem of circular section. Havel type)	Mesolithic (Maglemose culture)	06.06 (points with curved barbs with or without perforation)	C. 11,000–8500 B.P	Wąż type variant (forms with pointed, curved, protruding, and convex barbs)	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Staświny	Type no. 12A (single-barbed points with stem of circular section. Havel type)	Mesolithic (Maglemose culture)	06.06 (points with curved barbs with or without perforation)	C. 11,000–8500 B.P	Wąż type variant (forms with pointed, curved, protruding, and convex barbs)	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Bydgoszcz	Type no. 12A (single-barbed points with stem of circular section. Havel type)	Mesolithic (Maglemose culture)	06.05 (points with straight barbs)	C. 11,000–8500 B.P	Nearest to specimens of the Surbajny-Rękawczyn type (forms with massive protruding, sharp, and slightly curved or triangular barbs)	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)
Lake Duży Mausz	Atypical	Not specified	Atypical	Not specified	Atypical	Protoneolithic
Baltic Sea	Type no. 12B (double barbed points with stem of circular section. Havel type)	Mesolithic (Maglemose culture)	06.03 (biseriate points with alternating barbs)	C. 11,000–8500 B.P	Gortz type variant (forms with protruding convex, angular and rhomboid barbs, widely spaced)	Late Paleolithic and Epi-paleolithic (understood as Kunda Technocomplex)

and west of the so-called Stasswinner Meadow (*Stasswinner Wiesen*). The artifact is slender with a triangular cross-section, and has a small tang. It is 16-cm long, and its maximum width is about 1.3 cm. The point is made of an unidentified long bone (Galiński 2020). The artifact is stored in the requesting unit at the Museum of the Pisz Land in Pisz.

Lisi Ogon, Białe Błota commune (Fig. 2D)

This point was found during lake lime (gyttja/marl) extraction works in an open pit mine situated at the bottom of the Thorn-Eberswalder Urstromtal by its southern edge (south of the Bydgoszcz Canal, between its seventh and eighth lock; Table 1; Fig. 1). It was deposited at a depth of 1.8–2 m under a layer of peat (Olszewski 2010, 98). The point has a well-defined tip, a trapezoidal cross-section, and a double beveled base. It is 13.8-cm long and 1.2-cm wide. It is made of bone, probably a metacarpal or a metatarsal bone of a large mammal, probably a cervid (Olszewski 2010, 104). The point is currently stored in the requesting unit at the Leon Wyczółkowski District Museum in Bydgoszcz. The artifact was independently subjected to a traceological analysis (Orłowska and Osipowicz 2018).

Single-barbed points

The reported studies include three artifacts of this type: a point from Lake Gil Wielki, a point from Wiele, and a point from Gniewino. According to Clark, artifacts of this form are classified as type 5, whereas in Poland, they are identified as the Gniewino type (cf. Table 2).

Lake Gil Wielki, Miłomłyn commune (Fig. 3A).

This artifact was discovered in the vicinity of Ostrów Wielki village, Miłomłyn commune, in the late 1980s (Table 1; Fig. 1). It was retrieved from Lake Gil Wielki during cast net fishing by the western shore of a peninsula. It was found about 70 m off the present-day shoreline at a depth of about 5 m. The point is 19.9-cm long and 1.7-cm wide. It is made of the right metatarsal bone of an adult mammal of the Cervidae family (Sobieraj and Makowiecki 1998). The artifact is stored in the requesting unit at the Museum in Ostróda.

Wiele, Mroczka commune (Fig. 3B).

Two almost identical osseous single-barbed points were discovered in July 1992, in Wiele village, in the course of meadow recultivation works (Table 1; Fig. 1; cf. Mroczyński and Olszewski 1995). One was subjected to ^{14}C dating. The artifact has been preserved in its entirety and has a

well-defined barb. The length of the point is 21 cm, and its width is 2.2 cm. It is made from the metacarpal bone of a red deer (*Cervus elaphus*; Mroczyński and Olszewski 1995, 50). The artifact is stored in the requesting unit at Leon Wyczółkowski District Museum in Bydgoszcz. Both single-barbed points found in Wiele have recently been subjected to traceological analyses (Osipowicz 2016).

Gniewino, Gniewino commune (Fig. 3C).

This object was found in the nineteenth century during marl extraction works in a peaty kettle hole (Table 1; Fig. 1). Around 1889, it was transported together with a needle made of antler or bone to the National Museum in Szczecin, where it is presently stored. This flat-oval point with a slightly double bevel base is made of red deer bone (Sulgosłowska 2012). It is 18.1-cm long and about 1.5-cm wide.

Uniserial barbed points with protruding barbs

Of the five artifacts of this type described herein, three can be classified as Clark's 12A (the points from Sołdany, Staświny, and Bydgoszcz), and two are atypical forms (the points from Orzysz and Lake Duży Mausz — cf. Table 2). The points from Sołdany and Staświny were identified as the Wąż type (forms with pointed, curved, protruding, and convex barbs) in Galiński's classification (2020), whereas the point from Bydgoszcz was found to be closest to the Surbajny-Rękawczyn form (forms with massive protruding, sharp, and slightly curved or triangular barbs — Galiński 2020, 38).

Sołdany, Giżycko commune (Fig. 4A).

This point was found during lake lime extraction works at a depth of about 2 m (Table 1; Fig. 1). In 1971, it was donated to the Museum of Warmia and Mazury in Olsztyn, where it is still currently stored. The item has been preserved almost in its entirety, although its surface bears traces of erosion caused by plant roots that grew on it. The specimen base is flattened, asymmetric, and distinguished by means of a cut made on the edge with a series of barbs (originally there were four of them, but only three have been preserved). Between the base and the nearest barb, there is also a type of poorly distinguished spike with a triangular longitudinal section. The base is separated from the lower barb below the triangular projection. The total length of the specimen is 21.5 cm, and the width of the shaft is 1.1 cm. The point is believed to be made from the long bone of reindeer (Galiński 2013). It is thus associated with the Late Paleolithic (Galiński 2020). The specimen has recently been subjected to traceological analyses (Orłowska and Osipowicz 2018).

Fig. 2 Osseous points dated in our dating program: (A) Witów, (B) Kosierzewo, (C) Lake Niegocin, (D) Lisi Ogon (photos (B) and (C) by J. Orłowska, photos (A) and (D) by W. Ochotny)

Fig. 3 Osseous single-barbed points dated in our dating program: (A) Lake Gil Wielki, (B) Wiele, (C) Gniewino (photos (A) and (C) by J. Orłowska, photo (B) by W. Ochotny)

Staświny, Miłki commune (Fig. 4B).

This point was found during peat extraction works and donated to the Museum of Warmia and Mazury in Olsztyn in 1969, where it is still kept (Table 1; Fig. 1). It is very well preserved. It has a subtly distinguished symmetrical base and four relatively short barbs arranged in a line. The specimen is 23-cm long, and the width of its shaft is around 1.6 cm. Galiński (2013, 2020) notes that it is made of reindeer antler. However, this suggestion is unquestionably erroneous, and this is the long bone from a mammal of the *Cervidae* family. It is considered Late Paleolithic or epi-Paleolithic (Galiński 2020). The object was subjected to traceological analyses before our study (Orłowska and Osipowicz 2018).

Bydgoszcz (surrounding area), Bydgoszcz commune (Fig. 4C).

This point was found in an undefined watercourse near Bydgoszcz (Table 1; Fig. 1; cf. Olszewski 2006). The lower section with one barb and a distinct shield-like symmetrical base have been preserved. The length of the preserved fragment is approximately 10.6 cm, and the width of the shaft is 1.3 cm. The specimen is made of an unidentified long bone and is considered a product of Late Paleolithic communities (Olszewski 2006). The artifact is stored in the requesting unit at the Leon Wyczółkowski District Museum in Bydgoszcz. It has recently been subjected to traceological analyses (Orłowska and Osipowicz 2018).

Orzysz, Pisz commune (Fig. 4D).

This point was found on a peat mound formed as a result of dredging the River Orzysz (Table 1; Fig. 1). In 2011, it was donated to the Museum of Warmia and Mazury in Olsztyn, but the donor explained that it had been found around 5 years earlier. The object is heavily damaged, with numerous splinters and cracks visible on its surface. Its base is flattened, asymmetrical, and well-defined on the side with the barbed edge. The remains of two barbs have been preserved. The former, preserved almost entirely, is located at the base, whereas the latter is visible in the upper part of the specimen. In its present state of preservation, the point is about 18.7-cm long, and the shaft is 1.2-cm wide. The object is made from the long bone of a large ruminant and is considered Mesolithic (Sobieraj 2020). It is stored in the requesting unit at the Museum of the Pisz Land in Pisz.

Lake Duży Mausz, Sulęczyno commune (Fig. 4E).

This point was found in the 1960s during fishing in the shallows of Lake Duży Mausz (Table 1; Fig. 1; cf. Galiński 1992, 224; 2019, 357). It has three well-defined barbs, and

its base is flat with a natural opening. It is in a poor state of preservation. The surface is cracked and flaked. There are also identifiable traces of modern-day gluing. The point is made of a red deer long bone (Galiński 2013). It is 23.7-cm long and about 2-cm wide. The specimen's form escaped previous typological classification systems (Table 2), and this might have been one of the reasons it was assigned to the proto-Neolithic groups allegedly functioning in the Polish Lowlands in the second half of the Atlantic period (Galiński 2020). The artifact is stored in the requesting unit at the Museum in Koszalin.

Biserial barbed points with protruding barbs

There is only one artifact of this type in the current study, which was fished out of the Baltic Sea. Clark groups points of this form as type 12B. In Poland, they are classified as a Gortz type variant (forms with wide-spaced protruding convex, angular, and rhomboid barbs; cf. Table 2).

From the Baltic Sea near Dziwnowo (Fig. 4F).

This artifact was fished out of the Baltic Sea in 1985, from a location opposite the area between Dziwnów and Międzywodzie (Table 1; Fig. 1). Its point has twelve barbs, eight of which are complete. The base of the specimen is broken off. The point surface is eroded and visibly smoothed. Its current length is 23.5 cm, and the shaft is about 0.9-cm wide. It may be made of red deer antler (Kaube 1985) or elk antler (Galiński 2013, 2020). The artifact is stored in the requesting unit at the Regional Museum in Wolin.

Methods**Bone surface characteristics**

The taphonomic observations were made according to relevant literature concerning artifacts made of bone and antler (e.g., Behrensmeyer 1978; Olsen and Shipman 1988; Fisher 1995; Madgwick 2014). Analysis was made using a Nikon SMZ-2 T microscope. We are aware that the chemical/mineral composition of the sediments in which the bone was “deposited,” atmospheric conditions, and deposition time significantly impact the structure and characteristics of the bone surface (e.g., Fernández-Jalvo and Andrews 2016). We are also aware of the possibility of using old bone or some other (old) artifact to produce the bone points in prehistory (for example, David and Pelegrin 2009; Osipowicz et al. 2020).

Fig. 4 Osseous uniserial and biserial barbed points with protruding barbs dated in our dating program: (A) Söldany, (B) Staświny, (C) Bydgoszcz, (D) Orzysz, (E) Lake Duży Mausz, (F) Baltic Sea (photos (A), (B), (D), (E), and (F) by J. Orłowska, photo (C) by W. Ochotny)

Sampling procedure

As it was not possible to borrow the points required for the study, samples for radiocarbon dating were taken by the authors in the museums in which they were stored. Permission was given to take only the absolutely minimum essential amount of raw bone material (around 0.3–0.4 g), which was sufficient for the purposes of dating, although it prevented

additional isotope analyses from being carried out. Samples were taken using a Dremel-type tool with a core drill bit. This allowed samples to be drawn in the form of ‘cores’ from inside the artifacts. The drill bit was cleaned using acetone before each subsequent sample was taken. During sampling, we avoid damaging any technological or functional traces or diagnostic parts of the points to preserve as much information as possible for future studies.

AMS radiocarbon dating

Dating analyses of the collected samples were conducted in the Poznań Radiocarbon Laboratory (Poland). Collagen extraction was performed using the procedures described by Longin (1971) with further modifications (Piotrowska and Goslar 2002). Before extraction, the degree of collagen degradation was checked by measuring the content of N and C in bone using analyzer Flash EA 1112 Series. The samples were forwarded for collagen extraction if N content in bone was not lower than 0.6% and ratio C/N was not higher than 5. The bones were crushed mechanically to granulation < 0.3 mm. The bone powder was treated with 2 M HCl at room temperature for 20 min. Only one sample (Lisi Ogon Poz-142874) was treated with NaOH solution. Skipping the NaOH treatment for rest of the samples was caused by their size (0.25–0.4 g). The Poznań Radiocarbon Laboratory intended to minimize the loss of material available for collagen extraction.² After each step of treatment, the sample was centrifuged, and the residuum was collected. Extraction of collagen was processed in HCl (pH = 3, 80 °C, 10 h), and after centrifugation, the residuum was removed. The extracted collagen was ultrafiltered on pre-cleaned Vivaspin 15 MWCO 30-kD filters (Bronk Ramsey et al. 2004). The quality of the collagen was ultimately assessed basing on C/N atomic ratio (interval of acceptance: 2.7–3.5) and collagen extraction yield (acceptance threshold: 0.5%). The obtained collagens were combusted in closed quartz tubes under vacuum together with CuO and Ag wool under 900 °C over 10 h. The obtained gas (CO₂_water vapor) was then dried in a vacuum line and reduced with H₂ using 2 mg of Fe powder as a catalyst. The obtained mixture of carbon and iron was then pressed into special aluminum holder, according to the description provided by Czernik and Goslar (2001). The content of ¹⁴C was measured using the NEC-produced “Compact Carbon AMS” (Goslar et al. 2004), by comparing intensities of ionic beams of ¹⁴C, ¹³C, and ¹²C measured for each sample and standard samples (modern standard: “Oxalic Acid II” and ¹⁴C-free carbon: “background”). The conventional ¹⁴C age was calculated using correction for isotopic fractionation (Stuiver and Polach 1977), based on ¹³C/¹²C measured in the AMS spectrometer simultaneously with the ¹⁴C/¹²C. Uncertainty of calculated ¹⁴C age was determined using uncertainty implied from counting statistics, and also standard deviation of partial ¹⁴C/¹²C results, whichever was bigger. Uncertainties of

¹⁴C/¹²C ratios measured on standard and background samples were additionally taken into account. Calibration of ¹⁴C age was performed against IntCal20 (Reimer et al. 2020) with OxCal ver. 4.4 (Bronk Ramsey 2020).

Chronological findings

The chronology findings presented in the article were based on the classical climatic-stratigraphic division related to the GRIP and GISP cores (Björck et al. 1998; Rasmussen et al. 2006; Lowe et al. 2008). We are aware that new data on the chrono-climatostratigraphy of the Polish territory has recently been presented, which in some matters (particularly in the periodization of specific stages of the Holocene) departs from previous suggestions (Starkel et al. 2013). We decided to adopt the traditional approach to the subject in this study, regardless, as the vast majority of the artifacts covered in this study and, primarily, the analogies made, were chronologically described and classified exactly in accordance with these criteria. The introduction of a new system would force us to significantly address the literature data pertaining to other areas of Europe, which would cause much chaos and require a lot of space.

Technological interpretations

The technological studies used in this paper have already been discussed in detail elsewhere (Osipowicz 2016; Orłowska and Osipowicz 2018, 2019; Osipowicz et al. 2020, 2021), and so they are not presented here extensively; instead, they are mentioned only in the context of the dispute over the chronological-cultural position of specific types of points with reference to relevant literature sources.

Results

Taphonomic observations

The points included in the article are in good or very good condition and do not bear any traces of modern repairs and restoration procedures. The macroscopic and microscopic analyses of the surfaces of dated points have not revealed any taphonomic changes in the raw material used to produce the analyzed artifacts that could be an indicator of the use of old (fossil) bone or re-use of the older product (e.g., differences in texture, color, and degradation of osseous surfaces). If something like this happened (and it is not observable for some reason), it has not influenced the chronological affiliation of the artifacts because the dating received for particular points generally harmonizes with the knowledge on the time use of given types of artifacts.

² ¹⁴C age measured on sample Lisi Ogon Poz-142874 (see the Table 3), appeared the same as that obtained without NaOH treatment. So, in situation that both the compared ages had uncertainties of ± 50 ¹⁴C years, we claim that the dating error caused by skipping the NaOH step was rather minor, and should rather not exceed ± 100 radiocarbon years.

Radiocarbon dating results

Collagen content and the C/N ratio were both sufficient for the dating results to be considered reliable in most of the bone samples. Only one sample had a collagen content below the minimum amount required for dating bones, which is 1% (e.g., Brock et al. 2010). This sample was taken from the point from Kosierzewo (Poz-125200), and the collagen content was only 0.4%, making its resulting date unreliable. Similarly, there were some problems related to atypically low nitrogen content in collagen in the sample taken from the point found in Lake Gil Wielki (Poz-124938), resulting in an extremely high C:N ratio (4.4; compare with Table 3).³ With this in mind, the examined collagen might be contaminated with “alien” carbon and the reported date ought thus to be regarded as uncertain. It was therefore also omitted in the interpretation of the findings.

Discussion

As noted in the “Introduction” section, the key objective of typological classification, including that of osseous points, is to identify formal characteristics of the artifacts that would allow them to be culturally and chronologically assigned (cf. Kozłowski 1977; Verhart 1990; Galiński 2013, 2020). The raw material also often plays a large role in this process, and points made of reindeer antler or (less often) elk antler are usually associated with the Late Glacial, whereas those made of bones and red deer antler are assigned to later periods (Kozłowski and Kozłowski 1977). Naturally, there are many exceptions to this simple pattern, since elk antler was also often used for making tools in the Holocene (e.g., Zhilin 1998; Gummeson and Molin 2019; Lozovskaya and Lozovski 2019). There is even evidence that “Glacial” raw material such as reindeer antler was used in Mesolithic communities in the Polish Lowlands in that period (Osipowicz et al. 2017). In this case, all chronological interpretations based on raw material classification should be considered with caution.

The artifacts dated for this study included specimens that represent two types of points without barbs, that is, plain points with a circular cross-section (Clark’s type 1) and tanged points with a triangular cross-section (Clark’s type 13). Plain points with a circular cross-section are common in the North European Plain, among both communities of the Late Pleistocene and those of the Early Holocene. Differences in the way their bases were formed and the general proportions of the form have led to a number of subtypes

and variants being distinguished within the original homogeneous Clark’s type 1 (cf. Kozłowski and Kozłowski 1977; Verhart 1990; Galiński 2013). This did not allow a more detailed chronological-cultural classification, however. An example of Late Paleolithic artifacts of this kind is the rich collection from the region of Havelland (Brandenburg, Germany) linked to, inter alia, the Federmesser culture (Gramsch 2003). Pollen dating demonstrated that this type of point found in Gusiev, Russia (Galiński 2020) originated from Allerød. It is worth mentioning Starr Carr, England (Clark 1954); Friesack, northern Germany (Gramsch 1990, 2000, 2004); Lundby, Denmark (Henriksen 1980; Hansen 2003); and Motala, Sweden, among a number of Mesolithic sites in Western and Northern Europe where such points were found (Gummeson and Molin 2020). There is also an impressive collection of this type of artifact from Eastern Europe, including at sites Zvejnieki 2 (bottom layer), Sūlagals, Pulli, Kunda, Veretye 1, and Nizhneye Veretye; Oleneostrovski cemetery, Zamostje 2, Ivanovskoye 3 and 7 (layers IIa, III, and IV), Stanovoye 4 (layer III, trenches 2 and 3), Sakhtysh 9 and 14 (layer IV), and the Shigir peat bog (Zhilin 2020). Points of this type should therefore be considered intercultural forms with a very long chronology, whose specific chronological classification requires absolute dating. AMS dating results obtained for the point from Witów, estimated at $11,170 \pm 60$ B.P. (Poz-129291), that is, 13,177–12,921 cal B.P. (Table 3; Fig. 5), indicate that it was made in Allerød. A similar dating result ($10,815 \pm 160$ B.P., or 13,101–12,478 cal B.P.; Gro-828) was obtained for a charcoal sample from a hearth discovered within the area of the suggested remains of a shelter/hut structure identified at the same site (Chmielewska 1957). Based on the characteristics of flint materials from Witów, the point can be connected to communities of the Arch Backed Piece technocomplex (Chmielewska 1961a, b).

Tanged points with a triangular cross-section and a small tang (Clark’s type 13) are abundant in the Eastern Baltic region. They were found, among other places, in Early Holocene sites such as Zvidze (Loze 1988), Zvejnieki 2 in Latvia (Zagorska 1980; Zagorska and Zagorskis 1990), Kunda-Lammasmagi, Pulli in Estonia (Jaaniits and Jaaniits 1975, 1978), and a peat bog in Lubana (Vankina 1999). In central Russia, individual points of this type were found at Veretye 1, Ivanovskoye 3, and Ozerki 5 (Zhilin 2019a, b). They are very rare in other areas, and usually considered typical of the post-Sviderian communities of the Kunda culture (Kozłowski 1977, 145; Zhilin 2019b). Nonetheless, some researchers extend their chronology up to the Late Glacial, drawing attention to suggestions made as far back as the 1920s (Gaerte 1927, 1929; Engel 1935), according to which some points of this type from the Kaliningrad Region were made of reindeer antler (Kozłowski 1977; Galiński 2013; 2020). In line with these suggestions, items of this

³ A collagen C:N ratio of between 2.9 and 3.5 is widely utilized as an indicator of acceptable organic preservation for AMS radiocarbon dating (van Klinken 1999; Brock et al. 2007). Contamination is likely when the atomic C:N ratio falls outside this range (DeNiro 1985).

Table 3 The radiocarbon dating results

Site	Laboratory code	Date uncal B.P	cal B.P. (95.4%)	Sample weight (mg)	Collagen yield (%)	Nitrogen fraction in bone (%)	Carbon fraction in bone (%)	Nitrogen fraction in extracted collagen (%)	Carbon fraction extracted collagen (%)	C:N ratio	$\delta^{13}C$ (AMS)	Chronostratigraphic phase
Witów	Poz-129291	11,170 ± 60 B.P	13,177–12,921	320	6.6	4.2	13.1	19.4	52.7	3.2	– 23	Allerød
Baltic Sea	Poz-124935	10,140 ± 60 B.P	11,945–11,402	350	4.8	4.2	13.9	18.4	51.9	3.3	– 18.5	Younger Dryas/Preboreal
Lake Gil Wielki	Poz-124938	9900 ± 60 B.P	Rejected sample	320	1.2	1.8	16.7	12.8	48.4	4.4	– 23.6	Rejected sample
Lake Niegocin (Upały)	Poz-129292	9400 ± 50 B.P	10,759–10,445	340	5.3	4.2	13.7	18.8	51.0	3.2	– 23.5	Preboreal
Lisi Ogon	Poz-124940	9240 ± 50 B.P	10,561–10,252	380	5.5	3.9	12.1	17.7	50.4	3.3	– 22.3	Preboreal
Lisi Ogon	Poz-142874	9230 ± 50 B.P	10,555–10,249	250	4.4	-	-	13.4	37.3	3.2	– 21	Preboreal
Orzysz	Poz-129290	8850 ± 50 B.P	10,168–9719	340	5.6	2.7	10.7	18.7	51.5	3.2	– 23.4	Boreal
Wiele	Poz-124941	8770 ± 50 B.P	10,116–9552	330	3.3	4.0	13.7	17.8	50.8	3.3	– 20.4	Boreal
Soldany	Poz-129288	8510 ± 50 B.P	9546–9445	280	8.6	4.3	14.9	19.6	52.7	3.1	– 21.2	Boreal
Gniewino	Poz-124933	7960 ± 50 B.P	8991–8644	250	2	3.8	12.6	16.8	48.1	3.3	– 21.5	Boreal/Atlantic
Staświny	Poz-129289	7930 ± 50 B.P	8985–8604	230	4.8	4.6	14.1	19.3	50.1	3.0	– 23	Boreal/Atlantic
Kostierzewo	Poz-125200	7420 ± 50 B.P	Rejected sample	230	0.4	3.9	11.5	-	-	-	– 27	Rejected sample
Bydgoszcz	Poz-124939	7380 ± 50 B.P	8330–8035	300	6.17	3.6	12.3	16.9	48.6	3.4	– 23.2	Atlantic
Lake Duży Mausz	Poz-124937	6930 ± 50 B.P	7920–7671	420	23.1	3.5	11.6	18.2	51.9	3.3	– 23.1	Atlantic

OxCal v4.4.2 Bronk Ramsey (2020); r:5 Atmospheric data from Reimer et al (2020)

Fig. 5 Calibrated radiocarbon date plots of osseous points dated in the study

kind could have already been used in Allerød by representatives of the Tanged Points Technocomplex communities (Kobusiewicz 1999; Olszewski 2010; Sobkowiak-Tabaka 2011). Such a cultural affiliation and the Early Preboreal period were suggested regarding the point from Lisi Ogon described in this study. This suggestion was based on a report pertaining to other products found together with this artifact, primarily the fragment of a Lyngby mattock made of reindeer antler, usually associated with the Late Paleolithic (cf. Galiński 2020, 48), and a Tarring-type harpoon (Olszewski 2010).

The AMS dating result obtained for the point from Lisi Ogon, 9240 ± 50 B.P. (Poz-124940), or 10,561–10,252 cal B.P. (Table 3, Fig. 5), is definitely far from that expected, and identifies the chronology of this artifact as the second half of the Preboreal period. The youngest ^{14}C dating results obtained for Late Paleolithic materials from Poland from sites such as Bolków 1 (Galiński 2018, Table 1), Całowanie 3 (Schild 2014, Table 2), and Murowana Goślina (Goslar et al. 2006, 7; cf. also Płonka et al. 2020) indicate that they are over 500 radiocarbon years younger, which rules out

any correlation between the described artifact and Late Paleolithic communities, and allows it to be classified as a Mesolithic product. Given the lack of grounds for suggesting that the artifact could possibly be younger, such a chronological affiliation for this object requires that the collection of products found with it be regarded as probably non-homogeneous. At the same time, the results of the AMS dating obtained for both type 13 points, that is, the artifact from Lisi Ogon and the point from Lake Niegocin (9400 ± 50 B.P., or 10,759–10,445 cal B.P.; Poz-129292) show that they date back to the Holocene and are possibly related to post-Swiderian communities of the Kunda culture, which means the suggestion that this type of objects was used as far back as the Late Glacial should be considered. To this end, it is undoubtedly necessary to verify the validity of pre-war interpretations about the use of reindeer antler for making points in the Kaliningrad Region, or their dating. Until then, in the light of the dating results presented, it should be concluded that there are no grounds supporting the link between the artifacts of the described type, and that Late Paleolithic communities would be more plausible.

The traceological analyses of the points from Witów and Lisi Ogon found no technological traces on their surfaces that could be considered indicative of a specific chronology (Orłowska and Osipowicz 2019; Orłowska 2021). The remains of scraping and whittling visible on these products belong to the group most commonly recorded on artifacts from various stages of the Stone Age (e.g., Clark 1954; David 2005a; Zhilin 1998, 2016; Wild and Weber 2017; Osipowicz et al. 2020; Wild 2020, 121).

Single-barbed points (Clark's type 5) are characteristic of the Northern Mesolithic cultures. They are most common in Denmark (cf. David 2005a, Pl. 22, 27), Mecklenburg and Brandenburg in northern Germany (cf. David 2005a, Pl. 31, 47, 58), and Pomerania in Poland (cf. Kozłowski 1969; Galiński 2020). Singular specimens of this type are also known from the Kaliningrad Region in Russia, Estonia, Lithuania, and Latvia (Kozłowski 1969, 138–139). In general, the chronology of most of this type of points falls within the Boreal period and the Early Atlantic period of the Holocene. Danish specimens from Mullerup and Lundby have been dated back to the Boreal (cf. David 2005a, 20, Fig. 9). A similar chronology was determined for barbed points from Hochen Viecheln, Germany (David 2019) and from Kunda-Lammasmagi, Estonia (Indreko 1948). The age of an artifact of this form from Zedmar-Ostrowski (Kaliningrad Region, Russia) was estimated by means of pollen dating to the turn of the Atlantic period (Galiński 1986, 39, 49–50).

AMS dating results obtained for both type 5 points (Table 3, Fig. 5) fit the presented chronology perfectly. The date 8770 ± 50 B.P. or $10,116\text{--}9552$ cal B.P. (Poz-124941) obtained for the point from Wiele indicates that it dates back to the first half of the Boreal period, and the dating result for the artifact from Gniewino, which is 7960 ± 50 B.P. or $8991\text{--}8644$ cal B.P. (Poz-124933), falls within the turn of the Atlantic period. There are at least 13 known type 5 points from the area of Poland, of which only two have been subjected to radiocarbon dating as yet. The AMS dating result obtained for the artifact from Bolków (7760 ± 50 B.P., i.e., $8605\text{--}8420$ cal B.P.; MKL-1871–Galiński 2015, 134, 149) is very similar to that of the point from Gniewino, and is perfectly consistent with the time frame outlined for using objects of this kind. Pollen dating was used for the point from Orle (Galiński 2020); however, interpretative issues have arisen regarding radiocarbon dating of the point excavated during the Wieprz-Krzna Canal constriction works. The Preboreal date obtained for it, namely, 9380 ± 50 B.P. or $10,740\text{--}10,436$ (Poz-31597 — Libera 2017) seems too early and might need to be verified.

The presence of typically Mesolithic technological ideas in type 5 points and the fact that they have been spread across large areas of Europe were confirmed by means of a traceological analysis of the barbed points from the site

in Wiele (including the specimen described in this article). Societies inhabiting a considerable part of Poland during the Early Holocene were strongly influenced by ideas from both northern and eastern Europe. According to current conceptions, from the point of view of bone technology, Europe was divided into two main technocomplexes during the Early Mesolithic: a northern complex around the North Sea (Maglemosian tradition) and a north-eastern complex around the Baltic Sea (e.g., David 2007; Bergsvik, David 2015). Traceological analyses of the points from Wiele showed that these typical Maglemose forms bear traces of techniques characteristic of the north-eastern technocomplex (cf. Osipowicz 2016), namely, the shaft-wedge-splinter technique (the so-called Z-method — David 2007). This observation is perfectly consistent with remarks made relatively recently about analogous technological influences noted in bone adzes from site 7 in Krzyż Wielkopolski (Kabaciński 2016, 234).

Typological classifications of groups of prehistoric uniserial barbed points with protruding barbs from Europe made over decades have led to a number of subtypes distinguished on the grounds of, particularly, differences in the shape of barbs (e.g., Kozłowski 1977; Verhart 1990; Galiński 2013). It is believed that points of this kind appeared in the North European Plain as far back as in the Federmesser culture in Allerød (Cziesla 2002, 58; Cziesla and Petit 2003, 27, Fig. 5); however, they are mostly derived from communities of the tanged point technocomplex (e.g., Cziesla 2004; Galiński 2013), which is dated to the Younger Dryas/Early Preboreal, c. 12,800–11,000 cal B.P. (i.a. Cziesla 2004; Galiński 2013). Late Paleolithic artifacts of this form from Poland are probably related to both of these cultural circles (Płonka 2012, 110). The Early Holocene uniserial barbed points with protruding barbs mainly come from sites representing post-Swiderian and Neman traditions such as Kunda-Lammasmagi in Estonia (Indreko 1948), Lake Lubana and Zvejnieki II in Latvia (Zagorksa and Zagorskis 1985; Vankina 1999), and Balsupiai and Rudninkai in Lithuania (Rimantiene 1971). Some similar forms are also present in collections from the Mesolithic sites in Russia, such as Ivanovskoje 7 (Skakun et al. 2011), or Neolithic materials like those from the Konnu site in Estonia (Luik 2013). This type of barbed point from the Kaltanénai site in Lithuania had a very late AMS radiocarbon dating designation (3772 ± 38 B.P. or $4287\text{--}3987$ cal. B.P.; FTMC-ET70-2) (Piliciauskas et al. 2020). This confirms that such tools were also undoubtedly used in Eastern Europe during the very late Neolithic.

As noted above in the section presenting the sources covered in this article, three of the analyzed uniserial barbed points with protruding barbs (points from Słodany, Staświny, and from the vicinity of Bydgoszcz) can be classified as Clark's type 12A (1936). The AMS dating results for the artifacts from Słodany and Staświny (8510 ± 50

B.P. or 9546–9445 cal B.P.; Poz-129288 and 7930 ± 50 B.P. or 8985–8604 cal B.P.; Poz-129289, respectively — cf. Table 3, Fig. 5) date the former to the mid-Boreal period and the latter to the turn of the Atlantic period. The date obtained for the point from the vicinity of Bydgoszcz was the youngest, from the Early Atlantic period: 7380 ± 50 B.P. or 8330–8035 cal B.P. (Poz-124939).

Aside from the artifacts dated for this study, only two type 12A barbed points from Poland have been subjected to radiocarbon dating. The former is the specimen from Węgliny, for which a very early date of $12,120 \pm 60$ B.P. or 14,129–13,803 cal B.P. (Poz-10674) was obtained, meaning that the time frame in which they were being used falls within the turn of Allerød (Cziesla, Masojć 2007). The latter is the point from Orzysz, dating back to the Atlantic period (7180 ± 35 B.P. or 8035–7879 cal B.P.; AAR-26650 — Philippsen et al. 2019). This collection is complemented by the point from Łęgno, the age of which was determined by means of pollen analyses as in the Early Boreal (Galiński 2013).

It can be concluded from this summary that of all the type 12A barbed points subjected to radiocarbon dating from the area of Poland only the point from Węgliny should be associated with late Paleolithic communities. The other artifacts of this kind are significantly younger, with their use falling within various stages of the Holocene. This allows us to propose that as far as the points of this type from the West European Plain can be dated to the Late Glacial (Cziesla 2004; Galiński 2020, 50), such artifacts from the area of Central and Eastern Europe are largely related to either post-Swiderian communities (as in the case of the North-Eastern Europe — Kozłowski 1977; Galiński 2020, 50) or the people of the Mesolithic Duvensee and Maglemose complexes, who adopted eastern models.

The Holocene AMS dating result obtained for the barbed point from Soldany means that suggestions regarding the origin of the raw material it is made of (among others, Galiński 2013, 2020) must also be questioned. The *bâton percé* from Gołębiewo 47 site was examined by interdisciplinary studies, which found that reindeer antler might have been used by Mesolithic communities inhabiting the area of Poland in the Boreal period (cf. Osipowicz et al. 2017). This case should be considered exceptional, however, and indicative of long-distance exchange instead of a higher accessibility of this raw material in that area in that specific period, because as far as we currently know, reindeer were present in the area of modern Central Europe, but also southern Scandinavia and the British Isles no later than the Preboreal Holocene (cf. Ukkonen et al. 2006; Sommer et al. 2014; Wygal and Heidenreich 2014; Osipowicz et al. 2017).

The points from Orzysz and Lake Mausz are uniserial barbed points with protruding barbs, as described in this study, and have escaped previous typological classification

systems. The former was dated to 8850 ± 50 B.P. or 10,168–9719 cal B.P. (Poz-129290 — cf. Table 3, Fig. 5), which falls within the Early Boreal period. The latter was dated to the Atlantic period, the youngest of all results obtained for the points analyzed in this study: 6930 ± 50 B.P. or 7920–7671 cal B.P. (Poz-124937). The forms of both specimens are unique, which might suggest that their characteristics stem to some extent from random factors, such as the functional or personal preferences of their makers instead of from deeper cultural traditions. It is thus exceptionally difficult to specify their affiliation in this regard. Only the specimen from Orzysz can be suggested as related to eastern (post-Swiderin) traditions, as its shape and the location of a cut intended for fixing a cord visible on the base of the specimen mean it is similar to points from Lake Lubana in Latvia (Vankina 1999).

As noted in our previous papers reporting the results of traceological studies of the uniserial barbed points with protruding barbs described in this article, these artifacts differ in terms of the technology applied to form their barbs. The points from Orzysz, Staświny, and Lake Mausz are distinguished by the use of sawing or/and whittling, while the artifacts from Bydgoszcz and Soldany probably used drilling (Orłowska and Osipowicz 2018). The dates obtained for the specimens assigned to these two groups are very inconsistent and place specific artifacts in different stages of the Holocene. The technological inconsistencies we have pointed out are probably not connected to specific cultural-chronological backgrounds, but were caused by other factors instead, such as the individual preferences of their makers. This finding verifies our previous observation concerning this matter to some extent (cf. Orłowska and Osipowicz 2018).

The last of the products analyzed in this study was a biserial barbed point with protruding barbs: type 12B according to Clark's classification (1936). Artifacts of this type are distributed from Denmark in the west to Latvia in the north-east, and along the south and southwest shores of the Baltic Sea (Taute 1968; Zagorska 1972, 1994; Kozłowski 1976). The origins of this form may be traced back to the Magdalenian of Western Europe (Julien 1982, 98–104). Based mostly on the finds from Stellmoor, but also, for example, from Denmark (Andersen 1988, 535, Fig. 17: 2, 3), these points are dated to the Younger Dryas and Younger Dryas/Preboreal transition (Fisher and Tauber 1986, 9–10). They do not seem to occur in later periods of the Stone Age in Northern Europe. The artifact analyzed in this study is one of the few double-row harpoons known from the area of Poland. The closest analogy to this is the point from Lachmirowice (Galiński 2013). The point was AMS dated to $10,140 \pm 60$ B.P. or 11,945–11,402 cal B.P. (Poz-124935), thus falling within the turn of the Younger Dryas/Preboreal transition, which means it can be associated with the Tanged Point Technocomplex communities (Burdukiewicz 2011). Its

chronology is thus not far from the dates obtained for other artifacts of this type from Western Europe.

In terms of technology, the analyzed biserial barbed point is similar to both other artifacts of this type from Europe (David 2005a) and the above-described uniserial barbed points, and is analogous not only to some of the products of late Paleolithic communities but also those of Mesolithic or sub-Neolithic ones (e.g., David 2005a; Lozovskaya and Lozovski 2019; Osipowicz et al. 2020; Piličiauskas et al. 2020).

It can be concluded that the results of radiocarbon dating analyses are not always consistent with chronological-cultural findings for the prehistoric osseous points based on typological classification systems (Table 4). This does not mean that this type of classification system is not useful; however, requiring only that caution is remembered when drawing conclusions in this way. Central Europe witnessed violent cultural transformations in the final stage of the Ice Age and in the Early Holocene, and, as noted on several occasions in this article, it is a place where many ideas came together, stemming from both the western and eastern parts of the continent. It therefore requires particular focus, and an awareness of the high complexity of the situation, manifested also in the form and chronology of the discovered osseous points. This matter is best illustrated by dating results for tanged points with a triangular cross-section and the type 12A uniserial barbed points described in this article. These artifacts were too hastily linked to the Late Glacial, despite their broad analogies with artifacts from Mesolithic communities in North-Eastern Europe, with which they (or at least some of them) are more probably associated.

It is also worth reiterating the problem of somewhat automatic suggestions that some of the points typologically assigned to the Late Glacial are made of reindeer antler or bone (i.a., Kozłowski 1967, 1977; Galiński 2013, 2020; Płonka 2017). It is hard to find a reliable basis for these

interpretations in the literature, although they are repeated in some cases for decades on end, justifying chronological-cultural identifications suggested by authors. Opinions of this sort might be considered reliable if they are not confirmed by means of paleobiological analyses such as ZooMs or DNA studies. Findings might also be verified based on radiocarbon dating results, as in this study. Such verification should be considered necessary. By removing the existing “information noise” caused by interpretations of this kind, typological classification systems would definitely become better organized, with noticeably higher reliability/analytical usefulness.

Despite the critical overtones of the above discussion based on the results of the AMS dating performed, it should be also noted that the radiocarbon dating results obtained for some types of the analyzed points fully confirm previous typological and chronological-cultural findings. This is true for the single-barbed points (Clark’s type 5), which ought to be regarded as typically Mesolithic products that seem to have a relatively short chronological frame of use.

In light of the radiocarbon dating analyses conducted, we should also address how indicative the technological activities performed when making the osseous points covered in the study, identified by means of a traceological analysis, are of a given chronology. The results of the studies conducted in this regard show that it is currently impossible to use technological studies to determine the relative chronology of the vast majority of the analyzed point types. Our previous suggestions that this might be possible (cf. Orłowska and Osipowicz 2018) are not supported. It is likely that statistically argued inference will be possible in this respect after microscopic observations are carried out on a larger number of artifacts from different regions of the continent. Since the collection of points covered in this study was minimal, it was impossible to obtain reliable data that could highlight possible statistical regularities. However, there is a relatively optimistic outlook

Table 4 The expected chronological position of the radiocarbon-dated osseous points compared to their verified chronological position according to the radiocarbon dates

Site	Laboratory code	Expected chronological position	Date uncal B.P	cal B.P. (95.4%)	Chronological position after ^{14}C
Witów	Poz-129291	Late Pleistocene/Holocene	11,170 ± 60 B.P	13,177–12,921	Late Pleistocene
Baltic Sea	Poz-124935	Late Pleistocene	10,140 ± 60 B.P	11,945–11,402	Late Pleistocene
Lake Niegocin (Upałty)	Poz-129292	Late Pleistocene/Holocene	9400 ± 50 B.P	10,759–10,445	Holocene
Lisi Ogon	Poz-124940	Late Pleistocene/Holocene	9240 ± 50 B.P	10,561–10,252	Holocene
Orzysz	Poz-129290	Late Pleistocene/Holocene	8850 ± 50 B.P	10,168–9719	Holocene
Wiele	Poz-124941	Holocene	8770 ± 50 B.P	10,116–9552	Holocene
Soldany	Poz-129288	Late Pleistocene	8510 ± 50 B.P	9546–9445	Holocene
Gniewino	Poz-124933	Holocene	7960 ± 50 B.P	8991–8644	Holocene
Staświny	Poz-129289	Holocene	7930 ± 50 B.P	8985–8604	Holocene
Bydgoszcz	Poz-124939	Late Pleistocene	7380 ± 50 B.P	8330–8035	Holocene
Lake Duży Mausz	Poz-124937	Holocene	6930 ± 50 B.P	7920–7671	Holocene

regarding the potential of this kind of study, for at least one relatively chronologically homogeneous typological group, the single-barbed points, where the use of technological processes (the shaft-wedge-splinter technique — David 2007), which research findings suggest are apparently typical of only one period, the Mesolithic, was observed.

Conclusions

The significance of the results presented here lies mostly in the verification of the chronological and cultural position of the collection of unique Late Paleolithic and Mesolithic osseous projectile points from Poland. The radiocarbon dating of the artifacts was of particular importance for establishing their correct age, and led to the verification of typological assessments and discussion about their value and accuracy in this regard.

These new dating results significantly increase the existing ^{14}C dataset for the region, and thus also the potential for, and the credibility of, interpretations regarding the chronology and cultural affiliation of various types of prehistoric osseous bone points in this part of Europe.

The presented analyses also brought to light several important problems that the current typological classification systems for these types of artifacts are struggling with. Solving these problems is particularly important for areas where ideas stemming from different cultural centers overlapped, resulting in, among other things, the “long chronology” of some forms and the presence of products that escape the standard typological classifications.

To conclude, we would like to express our hope that the remarks made in this study will improve the reliability of the cognitive value of the conclusions drawn from the analysis of stray finds discussed herein and consequently intensify efforts to conduct similar research in other regions of Europe. Given that artifacts made of organic raw materials related to prehistoric hunter-gatherer communities are unusual finds, we believe that this is the only way to create a detailed image of their osseous artifacts as well-documented in the source literature, and the correct interpretation of the numerous cultural phenomena across the continent in the final stage of the Ice Age and in the Early Holocene.

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Declarations

Conflict of interest The authors declare no competing interests.

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