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

Justyna Orłowska1 · Grzegorz Osipowicz1

Received: 1 August 2021 / Accepted: 1 December 2021 / Published online: 16 December 2021
© The Author(s) 2021

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 Katsuhiro 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); Śventoji, Zvejnieki 2, Pulli, Sūļagals, 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 (Lozovski 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).
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 (Kozlowski 1969; Kozlowski and Kozlowski 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; Kozlowski and Kozlowski 1977; Larsson 1978; Gramsch 1973; Vankina 1999; 2003; Verhart 1990; Charniauxki 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. Kozlowski (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 archeological 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 Bolling) and the early Holocene. Thanks to 

\[ ^{14} \text{C} \] 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., Kozlowski 1969; Kozlowski and Kozlowska 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 (Kozlowski 2006), especially with the Ahrensburgian culture (Cziesla and Masojć 2007). However, they are also known from inventories related to Hamburgian and Świderian culture (Kozlowski 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 (Kozlowski 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
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 Upałty), 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).
| No | Site                        | Date of recovery | Context of recovery | Dimensions (cm) | Morphology                        | Raw material | Species, element                | Current holding                        |
|----|-----------------------------|------------------|---------------------|-----------------|----------------------------------|--------------|---------------------------------|----------------------------------------|
| 1  | Witów, Piątek commune       | 1937             | Peat bog            | 21.0 1.2 1.1    | Plain point of circular section  | Antler       | Reindeer (Rangifer tarandus)    | 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 (Cervus elaphus) Long bone | National Museum in Szczecin             |
| 3  | Lake Niegocin (Upałty), Gżycko 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 Blota 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 (Cervidae?) Long bone Cervidae Metatarsal | Leon Wyczółkowski District Museum in Bydgoszcz |
| 5  | Lake Gil Wielki, Młomłyn commune | End of the 1980s | Lake                | 19.9 1.7 0.8    | Single-barred point              | Bone         | Red deer (Cervus elaphus) Metacarpal | Museum in Ostróda                        |
| 6  | Wiele, Mroczą commune        | 1992             | Peat bog            | 21.0 2.2 1.2    | Single-barred point              | Bone         | Red deer (Cervus elaphus) Metatarsal | Leon Wyczółkowski District Museum in Bydgoszcz |
| 7  | Gniewino, Gniewino commune   | End of the 1880s | Unknown             | 18.1 1.5 1.0    | Single-barred point              | Bone         | Red deer (Cervus elaphus) 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  | Sołdany, Gżycko commune      | 1971             | Lacustrine lime deposits | 21.5 1.1 1.0    | Uniserial barbed point with protruding barbs | Bone         | Reindeer (Rangifer tarandus) Metatarsal | Museum of Warmia and Mazury in Olsztyn    |
| 10 | Staświny, Milki commune      | 1969             | Peat bog            | 23.0 15.9 8.4   | Uniserial barbed point with protruding barbs | Bone         | Elk (Alces alces) Metatarsal     | Museum of Warmia and Mazury in Olsztyn    |
| 11 | Bydgoszcz, Bydgoszcz commune | Beginning of the twentieth century | Unspecified water-course | 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 (Cervus elaphus) 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       | Reindeer (Cervus elaphus) or Elk (Alces alces) | Regional Museum in Wolin                |
| SITE | Typological classifications | General chronology of described type | Type | General chronology of described type | Type | General chronology of described type |
|------|-----------------------------|--------------------------------------|------|--------------------------------------|------|--------------------------------------|
|      | 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 Epipaleolithic (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 |
| Lake Niegocin (Upalty) | 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 Epipaleolithic (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 Epipaleolithic (understood as Kunda Technocomplex) |
| Lake Gil Wielki | Type no. 5 (single-barred 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-barred 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-barred 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 bars and binding bar/notch) | Not specified | Atypical | Not specified |
| Soldany | Type no. 12A (single-barred 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 | Waż type variant (forms with pointed, curved, protruding, and convex bars) | Late Paleolithic and Epipaleolithic (understood as Kunda Technocomplex) |
| Staświny | Type no. 12A (single-barred 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 | Waż type variant (forms with pointed, curved, protruding, and convex bars) | Late Paleolithic and Epipaleolithic (understood as Kunda Technocomplex) |
| Bydgoszcz | Type no. 12A (single-barred 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 Epipaleolithic (understood as Kunda Technocomplex) |
| Lake Duży Mausz | Atypical | Not specified | Atypical | Not specified | Atypical | Pro toneolithic |
| Baltic Sea | Type no. 12B (double barbed points with stem of circular section. Havel type) | Mesolithic (Maglemose culture) | 06.03 (biserial 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 Epipaleolithic (understood as Kunda Technocomplex) |
and west of the so-called Stasswiner Meadow (*Stasswiner 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, Mrocza 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. Mroczynski and Olszewski 1995). One was subjected to ¹⁴C 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 (Sułgostowska 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 Soldany, Staświny, and Bydgoszcz), and two are atypical forms (the points from Orzysz and Lake Duży Mausz — cf. Mroczyński and Olszewski 1995). The points from Soldany 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).

**Soldany, 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 Orzysza (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, Suleżyno 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 Miedzywodzie (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).
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. 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). With this in mind, the examined collagen might be contaminated with “alien” carbon and the reported date ought 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; Gummesson and Molin 2019; Lozovskaya and Lozovski 2020). 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 (Gummesson and Molin 2020). There is also an impressive collection of this type of artifact from Eastern Europe, including at sites Zvejnieki 2 (bottom layer), Sūlīgals, Pulli, Kunda, Veretye 1, and Nizhnaya Veretye; Oleneostrovskiy cemetery, Zamostje 2, Ivanovskoye 3 and 7 (layers IIa, III, and IV), Stanovoye 4 (layer III, trenches 2 and 3), Sakhych 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 ± 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 ± 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 techno-complex (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 Zvidże (Loze 1988), Zvejnieki 2 in Latvia (Zagorska 1980; Zagorska and Zagorskis 1990), Kunda-Lammasmagi, Pulli in Estonia (Jaanits and Jaanits 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-Svidarian 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 | d13C (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       | Boreal       | Allenid                  |
| 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 | Rejected sample          |
| Lake Gil Wielki Poz-124938 | 9900 ± 60 B.P. Rejected sample | 11,935–11,402 | 320              | 1.2                | 1.8                | 16.7                        | 12.8                        | 48.4                                     | 4.4                                   | −23.6     | Preboreal     | Preboreal                |
| Lake Niegocin (Upałty) 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     | 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     | Preboreal                |
| Lisi Ogon Poz-142874  | 9230 ± 50 B.P 10,555–10,249 | 250              | 4.4                | -                  | -                            | 13.4                        | 37.3                                     | 3.2                                   | −21       | Preboreal     | 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       | 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       | 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       | Boreal Atlantic          |
| 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 | 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       | Boreal Atlantic          |
| Kosierzewo Poz-125200 | 7420 ± 50 B.P Rejected sample | 230              | 0.4                | 3.9                | 11.5                        | -                            | -                                        | -                                    | −27       | Rejected sample | Rejected sample          |
| Bydgoscz Poz-124939   | 7380 ± 50 B.P 8330–8035 | 300              | 61.7               | 3.6                | 12.3                        | 16.9                        | 48.6                                     | 3.4                                   | −23.2     | Atlantic     | Atlantic                 |
| Lake Duży Mańcz Poz-124937 | 6930 ± 50 B.P 7920–7671 | 420              | 23.1               | 3.5                | 11.6                        | 18.2                        | 51.9                                     | 3.3                                   | −23.1     | Atlantic     | Atlantic                 |
kind could have already been used in Allerød by representa-
tives 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 Paleo-
lithic (cf. Galiński 2020, 48), and a Torring-type harpoon
(Olszewski 2010).

The AMS dating result obtained for the point from Lisi
Ogon, 9240 ± 50 B.P. (Poz-129490), 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 14C 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 sug-
uggesting 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 prob-
ably 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 Niegołćin
(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 dat-
ing. 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 Hochten 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 10,116–9552 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 8991–8644 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., 8605–8420 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 construction works. The Preboreal date obtained for it, namely, 9380±50 B.P. or 10,740–10,436 (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; Galkinski 2013), which is dated to the Younger Dryas/Early Preboreal, c. 12,800–11,000 cal B.P. (i.a. Cziesla 2004; Galkinski 2013). Late Paleolithic artifacts of this form from Poland are probably related to both of these cultural circles (Plonka 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 Zviejnieki II in Latvia (Zagorska and Zagorski 1985; Vankina 1999), and Balsupiai and Rudninkai in Lithuania (Rimantiene 1991). Some similar forms are also present in collections from the Mesolithic sites in Russia, such as Ivanovskyje 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 Kaltanenai site in Lithuania had a very late AMS radiocarbon dating designation (3772±38 B.P. or 4287–3987 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 Soldany, Staświny, and from the vicinity of Bydgoszcz) can be classified as Clark’s type 12A (1936). The AMS dating results for the artifacts from Soldany 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 ± 60 B. P. or 12,129–13,803 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 Legno, 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 last of the products analyzed in this study was a bisearial 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 (Tauta 1968; Zagorska 1972, 1994; Kozłowski 1976). The origins of this form may be traced back to the Magdalenian of Western Europe (Juliën 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 Lubiwana in Latvia (Vankina 1999).

As noted in our previous papers reporting the results of traceological studies of the uniserial barbed points with protruding bars described in this article, these artifacts differ in terms of the technology applied to form their barbs. The points from Orzysz, Staświny, and Lake Mauz 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 points from Orzysz and Lake Mauz 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 Lubiana in Latvia (Vankina 1999).
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., Kozlowski 1967, 1977; Galiński 2013, 2020; Plonka 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

| Site                  | Laboratory code | Expected chronological position | Date uncal B.P | cal B.P. (95.4%) | Chronological position after 14C |
|-----------------------|-----------------|---------------------------------|----------------|------------------|---------------------------------|
| 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 (Uşały)| Poz-129292      | Late Pleistocene/Holocene        | 9400 ± 50 B.P  | 10,759–10,445    | Holocene                        |
| Lisi Ogon             | Poz-129490      | 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.

Acknowledgements We would like to thank the Director and employees of the Museum of Warmia and Mazury in Olsztyn, the Museum of Archaeology and Ethnography in Łódź, the National Museum in Szczecin, the Museum of the Piska Land in Pisz, the Leon Wyczółkowski District Museum in Bydgoszcz, the Museum in Koszalin, the Museum in Ostróda, and the Regional Museum in Wolin for allowing access to the materials and for creating a workspace and atmosphere that facilitated the collection of all samples for the needs of this study. We are extremely grateful to Tomasz Goslar from the Poznań Radiocarbon Laboratory (Poland) for all comments and information concerning the collected samples and radiocarbon dating results. We are also grateful to two anonymous reviewers for their helpful detailed comments and constructive suggestions that profoundly improved the composition of this work.

Funding This research was funded by the National Science Centre, Poland, project no. 2019/32/C/HS3/00615.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Andersen SH (1971) Ertebøllekulturens harpuner. Kuml, 21(21): 73–126. https://tidsskrift.dk/kuml/article/view/105515

Andersen SH (1988) A survey of the Late Palaeolithic of Denmark and Southern Sweden. In: Otte M (ed) De la Loire à l’Oder. Les civilisations du Paléolithique Final dans le Nord-Ouest Européen. British Archaeological Reports, International Series 444, pp 523–566.

Behrensmeyer A (1978) Taphonomic and ecologic information from bone weathering. Paleobiology 4(2):150–162

Bellier CL, Catteelain P and Otte M (2001) La chasse dans la Préhistoire. Hunting in prehistory. Actes du colloque internationale de Treignes, 3–7 octobre 1990. Bruxelles & Liège, Bulletin de la Société royale belge d’Anthropologie et de Préhistoire 111 & Études et Recherches Archéologiques de l’Université de Liège 51. Treignes, Cedarc (Artefacts 8).

Bergsvik KA, David É (2015) Crafting bone tools in Mesolithic Norway: a regional eastern-related know-how. Eur J Archaeol 18(2):190–221. https://doi.org/10.1179/1461957114Y.0000000073

Björck S, Walker MJC, Cwynar LC, Johnsen S, Knudsen K-L, Lowe JJ, Wohlfarth B, Members INTIMATE (1998) An event stratigraphy for the Last Termination I in the North Atlantic region based on the Greenland ice-core record: a proposal by the INTIMATE group. J Quat Sci 13(4):283–292. https://doi.org/10.1002/(SICI)1099-1417(199807/08)13:4<283::AID-JQS366>3.0.CO;2-A

Brock F, Higham T, Bronk Ramsey C (2007) Radiocarbon dating bone samples recovered from gravel sites. English Heritage Research Department Report Series 30/2007. English Heritage, London. http://ads.ahds.ac.uk/catalogue/archive/bigravels_en_2007/

Brock F, Higham T, Bronk Ramsey C (2010) Pre-screening techniques for identification of samples suitable for radiocarbon dating of
poorly preserved bones. J Archaeol Sci 37(4):855–865. https://doi.org/10.1016/j.jas.2009.11.015

Brick Ramsey C (2020) OxCal 4.4. Oxford Radiocarbon Accelerator Unit, Oxford

Brick Ramsey C, Higham T, Bowles A, Hedges REM (2004) Improvements to the pretreatment of bone at Oxford. Radiocarbon 46(1):155–163

Burdzukiewicz JM (2011) Late Glacial hunter-gatherer reactions to the Younger Dryas cooling event in the southern and eastern Baltic regions of Europe. Quatern Int 242:302–312. https://doi.org/10.1016/j.quaint.2011.02.013

Charniauski MM (2007) Bone and horn articles at the settlements of Kryvina Peat Bog (Neolithic–Early Bronze Age). Belaruskaja Navuka, Minsk

Chmielewska M (1961) A Late Paleolithic and Mesolithic site at Witów, district Łęczyca. Archæologia Polona 4:77–87

Chmielewska M (1961) Obozowisko ze schyłku Allerød w Witowie w pow. łęczyckim w 1961 r. Prace i Materiały Muzeum Archeologicznego i Etnograficznego w Łodzi. Seria Archeologiczna 6:9–47

Clark JGD (1936) The Mesolithic settlement of Northern Europe: a study of the food-gathering peoples of Northern Europe during the early post-glacial period. Cambridge University Press, Cambridge

Clark JGD (1954) Excavations at Star Carr. Cambridge University Press, Cambridge

Czernik J, Goslar T (2001) Preparation of graphite targets in the Gliwice Radiocarbon Laboratory for AMS 14C dating. Radiocarbon 43(3):283–291

Cziesla E (2002) Spätpaläolithische Widerhaken spitzen aus dem Heinemuseum in Friesack, Lkr. Havelland. Veröffentlichungen Des Brandenburgischen Landesmuseums Für Ur-Und Frühgeschichte 33:51–63

Cziesla E (2004) Late Upper Palaeolithic and Mesolithic cultural continuity or: bone and antler objects from the Havelland. In: Terberger T, Eriksen BV (Eds) Hunters in a changing world -Environment and archaeology of the Pleistocene - Holocene transition [ca. 11000–9000 B.C.] in Northern Central Europe, pp 165–182.

Cziesla, E. Pettitt P (2003) AMS-14C-Datierungen von Spätpaläolithischen und Mesolithischen Funden aus dem Bültze (Brandenburg). Archäologisches Korrespondenzblatt 33:21–38

Cziesla E, Masojć M. 2007. The uniserially barbed harpoon from Węgliny (Wodra Valley, Lower Lusatia, Poland) and some cultural implications. In: Masojć M, Ponka T, Ginter B, Kozłowski SK, editors. Contributions to the Central European Mesolithic. Wrocław, pp 33–41.

David É (2005a) Technologie osseuse des derniers chasseurs préhistoriques en Europe du Nord (Xe-VIIIe millénaires avant J.-C.) Le Maglemosien et les technocomplexes du Mesolithique. Monographie de these. Ed. Monique, Mergoil (2005) [available at: http://web.mae.uparis10.fr/recherche/mpEvadavid.html]

David É (2005b) Preliminary results on a recent technological study of the Early Mesolithic bone and antler industry of Estonia, with special emphasis on the Pulli site. In: Luik H, Choyke AM, Batye CE and Lóugas L, editors. From the hooves to horns: from mollusk to mammal: manufacture and use of bone artefacts from prehistoric times to the present. Proceedings of the 4th international meeting of the ICaz Worked Bone Research Group (ICAZ-WBRR), Tallinn, 26–31 August 2003. Tallinn, Book Printers Ltd (Muinasaja teadus 15), pp 67–74.

DAVID É (2006) Technical behavior in the Mesolithic (9th-8th millennia cal. B.C.): the contribution of the bone and antler industry from domestic and funerary contexts. In: Larsson L and Zagorska I, editors. Back to the origin. New research in the Mesolithic-Neolithic Zvejnieki cemetery and environment, Northern Latvia. Lund, Almqvist & Wiksell International (Acta Archaeologica Lundensia, Series in 8° — 52), pp 235–252.

David É (2007) Technology on bone and antler industries: a relevant methodology for characterizing early post-glacial societies (9th–8th millennium B.C.). In: C. Gates St.-Pierre and R. Walker (eds) Bones as tools: current methods and interpretations in worked bone studies. B.A.R. Intern. Series 1622. Oxford, Archaeopress, 35–50.

David É (2019) The osseous technology of Hohen Viecheln: a Maglemosian idiosyncrasy?, in: Gross et al. (edd.). Working at The Sharp End at Hohen Viecheln, Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum, Vol. 10, pp 127–162. https://doi.org/10.23797/9783529018619-3.

DeNiro MJ (1985) Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. Nature 317:806–809. https://doi.org/10.1038/317806a0

Elliot B, Little A (2018) Barbed points. In: Milner N, Conneller C, Taylor B (eds.) Star Carr Volume 2: studies in technology, subsistence and environment, pp. 273–295. London: White Rose University Press. https://doi.org/10.22599/book2.k.

Engel C (1935) Vorgeschichte der altpreußischen Stämme.

Fernández-Jalvo Y, Andrews P (2016) Atlas of taphonomic identifications: 1001+ images of fossil and recent mammal bone modifications. Springer, Dordrecht

Fischer A, Tauber H (1986) New C-14 datings of Late Palaeolithic cultures from northwestern Europe. Journal of Danish Archaeology 5(1):7–13

Fisher JW (1995) Bone surface modifications in zooarchaeology. J Archaeol Method Theory 2:7–68

Gaerte W (1927) Ostpreußen. Steinzeit. In: Ebert M (ed) Reallexikon Der Vorgeschichte, vol. 7, Brandenburgische Landesmuseums Für Ur-Und Frühgeschichte 32:7–69

Gaerte W (1927) Ostrza kościane z Kosierzewa i Bonina, woj. Koszalin. Materialy Zachodniopomorskie 28:6–12

Galiński T (1982) Ostrza kościane z Kosierzewa i Bonina, woj. Koszalin. Materialy Zachodniopomorskie 28:7–12

Galiński T (1986) Późnoplejstoceńskie i wczesnoholoceskie harpuny i ostrza kościane i rogowe na południowych wybrzeżach Bałtyku między ujściem Niemna i Odry. Materialy Zachodniopomorskie 32:7–69

Galiński T (2013) Typological, chronological and cultural verification of Pleistocene and Early Holocene bone and antler harpoons and point from the southern Baltic zone. Przegląd Archeologiczny 61:93–144

Galiński T (2015) Borealy Bolków. Nowe Badania Obozowisk Mezolitycznych Nad Jeziorem Świdwie, Folia Praehistorica Posnaniensis 20:127–151

Galiński T (2018) Empahrensburgian: Osadnictwo paleolityczne w początkach holocenu na stanowisku w Bolkowie na Pomorzu Zachodnim. Przegląd Archeologiczny 66:5–30

Galiński T (2019) Paleolity i Mezolity na Pomorzu. Szczecin

Galiński T (2020) Znaleziska plejstoceńskich i wczesnoholoceskich harpunów i ostrzy kościanych i rogowych w południowej strefie Morza Bałtyckiego. Szczecin.

Girininkas A (2011) Baltų kultūros ištakos II. Klaipėdos universiteto leidykla, Klaipėda

Gramsch B (1990) Die frühmesolithischen Knochenspitzen von Friedenau, Kr. Naumen. Veröffentlichungen Des Museums Für Urund Frühgeschichte Potsdam 24:7–26

Springer
Gramsch B (2000) Friesack: Letzte Jäger und Sammler in Brandenburg. 
Jahrbuch Des Römisch-Germanischen Zentralmuseums Mainz 47:51–103

Gramsch B (2003) Spindelförmige Knochenspitzen aus Brandenburg (BRD). Bulletin De La Société Préhistorique Luxembourgeoise 25:43–72

Gramsch B (2004) From the Late Paleolithic to the Early Mesolithic in northeastern Germany. In: Terberger T, Eriksen BV (eds) Hunters in a changing world: environment and archaeology of the Pleistocene–Holocene transition (ca. 11000–9000 BC) in Northern Central Europe. Rahden, Leidorf (Internationale Archäologie 5), pp 183–201.

Gummesson S, Molin F (2019) Points of bone and antler from the Late Mesolithic settlement in Motala, eastern central Sweden. In: Gross et al. (eds.), Working at The Sharp End at Hohen Viecheln, Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum, Vol. 10, 263–287. 
https://doi.org/10.23797/9783529018619-10.

Hansen KM (2003) Pre-Boreal elk bones from Lundby Mose. In: Larsson L, Kindgren H, Knutsson K, Loeffler D, Åkerlund A (eds) Mesolithic on the move. Oxbow, Oxford, pp 521–526

Iovita R, Sano K (Eds) (2016) Multidisciplinary approach to the study of Stone Age weaponry, Springer, Dordrecht.

Henriksen BB (1980) Lundby-holmen: Pladser af Maglemose-type i Indreko R (2004) From the Late Paleolithic to the Early Mesolithic. Rahden, Leidorf (Internationale Archäologie 5), pp 183–201.

Jaanits L, Jaanits K (1975) Frühmeso lithischen Siedlung in Pulli. Eesti NSV Teadustud Akademia Toimetised, Ühisnetateadused 24(1):64–70

Jaanits L, Jaanits K (1978) Ausgrabungen der frühmesolithischen Siedlung von Pulli. Eesti NSV Teadustud Akademia Toimetised, Ühisnetateadused 27(1):56–63

Julien M (1982) Les harpons magdaleniens. Gall. Prehistoire 17 (Suppl. ment). Editions du C.N.R.S., Paris.

Kabaciński J (2016) Chapter 11. After the ice. In: Kabaciński J (ed) The past societies, 1, 500,000 – 5,500 BC, Polish lands from the first evidence of human presence to the early Middle Ages. Warszawa: Institute of Archaeology and Ethnology, Polish Academy of Sciences, pp 249–270.

Kauhe, A (1985) Harpun z poroża wyłowiony z Bałtyku. Materiały Vitterhets Hist. och Antik. Akad. Handl. 66, Stockholm 1948.

Libera J (2018) The first find of a harpoon from the Lublin Region. Recherches Archéologique Nouvelle Serie 9:235–242

Lozovskaya O, Lozovski V (2013) Barbed points from the site of Zamostje 2. In: Lozovski V, Lozovskaya O, Clemente-Conte I (eds) Zamostje 2. Öhri, Öhri, Öhri, Öhri, Öhri, Öhri. Vitterhets Hist. och Antik. Akad. Handl. 66, Stockholm 1948.

Loze IA (1988) Stone Age habitation sites of the Lubana lowland. The Mesolithic, Early and Middle Neolithic. Riga: Quacsi.

Lozovskaya O, Lozovski V (2019) Bone and antler projectile points from the Meso-Neolithic site Zamostje 2, Moscow region, Russia. In: Gross et al. (eds) Working at The Sharp End at Hohen Viecheln, Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Ostseeraum, Vol. 10, pp. 341–365. 
https://doi.org/10.23797/9783529018619-14.

Lozovski VM (1996) Zamostje 2: the Last Prehistoric Hunter-Fishers of the Russian Plain. Treignes, Editions du CEDARC.

Luik H (2013) Seals, seal hunting and worked seal bones in Estonian coastal region in the Neolithic and Bronze Age. In: Choyke A, O’Connor S (eds) From these bare bones: raw materials and the study of worked osseous objects. Oxbow Books, Oxford, pp 73–87

Madgwick R (2014) What makes bones shiny? Investigating trampling as a cause of bone abrasion. Archaeol Anthropol Sci 6(2):163–173

Makarowicz P, Goslar T, Górski J, Taras H, Szczepanek A, Pospieszny RDC.

Manninen MA, Asheichyk V, Jonuks T et al (2021) Using radiocarbon dating. Nature 230(5291):241–242

Mazzoni S, Shipman P (1988) Surface modification on bone: trampling as a cause of bone abrasion. Archaeol Anthropol Sci 6(2):163–173

Makarowicz P, Goslar T, Górski J, Taras H, Szczepanek A, Pospieszny RDC.

Manninen MA, Asheichyk V, Jonuks T et al (2021) Using radiocarbon dates and tool design principles to assess the role of composite slotted bone tool technology at the intersection of adaptation and culture-history. J Archaeol Method Theory 28:845–870. 
https://doi.org/10.1007/s10816-021-09517-7

Mrozowski W, Olszewski PA (1995) Mezolitische osztra kościane i materiały krzemienne ze stanowiska 33 w Wielu, gm. Mroczka, woj. Bydgoskie Komumykaty Archeologiczne 7:47–59

Olsen S, Shipman P (1988) Surface modification on bone: trampling versus butchery. J Archaeol Sci 15:535–553

Olszewski PA (2010) Zabytki kościane i rogowe z kopalni województwa kujawsko-pomorskiego w Lisim Ogonie, stanowisko 13, gmina Biała Błotna, powiat bydgoski oraz ich wymowa chronologiczno-kulturowa. Pomorania Antiqua 23:97–124
antler assemblages from northern Germany, southern Scandinavia and the Paris Basin. Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Osteuropa 12 (Kiel/ Hamburg 2020).

Wild M, Weber MJ (2017) Ein schräger Typ – Eine Geweihspitze aus Lasbek (Kr. Stormarn) und ihr Verhältnis zum europäischen Jung- und Spätpaläolithikum. In: Eriksen BV, Abegg-Wigg A, Bleile R, Ikerodt M U (eds) Interaktion ohne Grenzen. Beispiele archäologischer Forschungen am Beginn des 21. Jahrhunderts / Interaction without borders. Exemplary archaeological research at the beginning of the 21st century. Band 1 / Volume 1. Schleswig. Stiftung Schleswig-Holsteinische Landesmuseen Schloss Gottorf, pp 23–34.

Wygal BT, Heidenreich SM (2014) Deglaciation and human colonization of Northern Europe. J World Prehist 27(2):111–144. https://doi.org/10.1007/s10963-014-9075-z

Zagorska I (1972) Akmens Laikmeta Harpunas Latvija. Latvijas PSR Zinatnu Akademijas Vestis 8(301):80–98

Zagorska I (1980) Das Frühesolithikum in Lettland. Veröffentlichungen Des Museums Für Ur- Und Frühgeschichte Potsadam 14(15):73–82

Zagorska I (1994) Saliktie Makskeraki Latvijas Arheologiskaja Materiala. Arheologija Un Etnografia 17:129–138

Zagorska I (2019) The Early Mesolithic bone and antler industry in Latvia, eastern Baltic, in: Gross et al. (ed.), Working at The Sharp End at Hohen Viecheln, Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Osteuropa, Vol. 10, pp 305–318. https://doi.org/10.23797/9783529018619-12.

Zagorska I, Zagorskis F (1990) The bone and antler inventory from Zvejnieki II, Latvian SSR. In: Bonsall, C. (ed.), The Mesolithic in Europe: Papers Presented at the 3rd International (Mesolithic) Symposium, Edinburgh 1985. 414–23. Edinburgh, John Donald

Zhilin MG (1998) Technology of the manufacture of Mesolithic bone arrowheads on the Upper Volga. Eur J Archaeol 1(2):149–176

Zhilin MG (2015) Early Mesolithic bone arrowheads from the Upper Volga. Fennoscandia Archaeologica 32:35–54

Zhilin MG (2016) Mesolithic bone arrowheads from Ivanovskoye 7 (Central Russia): technology of the manufacture and use-wear traces. Quatern Int 30:1–15. https://doi.org/10.1016/j.quaint.2015.09.095

Zhilin MG (2017) Mesolithic bone arrowheads from Ivanovskoye 7 (central Russia): technology of the manufacture and use-wear traces. Quatern Int 427:230–244. https://doi.org/10.1016/j.quaint.2015.09.095

Zhilin MG (2019a) Early Mesolithic barbed bone points in the Volga-Oka interfluve. In: Gross et al. (eds) Working at The Sharp End at Hohen Viecheln, Untersuchungen und Materialien zur Steinzeit in Schleswig-Holstein und im Osteuropa, Vol. 10, pp 319–339. http://dx.doi.org/https://doi.org/10.23797/9783529018619-13.

Zhilin MG (2019b) Mesolithic bone arrowheads as a marker of cultural unity from the Baltic to Trans-Urals PRAEHISTORIA New Series Volume 1–2 (11–12): 135-148

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.