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Osseous pendants from Spiginas and Donkalnis as instigators of a discussion on technological traditions, intergroup exchange and mobility in the early and middle Holocene in Central and Northeastern Europe.

Abstract: This article attempts to verify the possibility of studying the mobility patterns of prehistoric communities based on the technological features of the artefacts, identified through traceological analyses. The research subject were animal tooth pendants from several dozen key early and middle Holocene hunter-gatherer-fishers sites in Central and Northeastern Europe. The starting point for the studies was traceological research conducted on a collection of pendants from Mesolithic burials at Spiginas (grave 4) and Donkalnis (graves 2, 4, and 5) in Lithuania. These results were compared with the findings, as yet largely unpublished, from microscopic tests conducted by the authors on 12 collections of artefacts from major early and middle Holocene sites in Poland, Lithuania, Latvia, and Estonia together with literature information about collections from other sites in these areas, and from sites in Russia, Sweden, Denmark and Germany. Results were used to examine ways in which cord attachment areas were prepared in animal tooth pendants in Central and Northeastern Europe. In this regard, three major technological traditions were distinguished in the region which allows analysis of intercultural influences and the flow of people in the early and middle Holocene. An important part of this study involved co-ordinating the results of the technological analyses of the pendants from Spiginas and Donkalnis with the findings of stable isotope ratio measurements ($^{87}Sr/^{86}Sr$) conducted on the human remains from these cemeteries. Both research tools have been shown to be complementary in the context of research related to the mobility of early Holocene groups.

Keywords: Mesolithic, Subneolithic, pendants, bone, traceology, technology

1. Introduction

Historically, academic interpretation of the cosmologies of the North European Hunter-Gatherers of the early and middle Holocene is that of a 'magic type' culture, a holistic view of the natural world which informed all activities and social relations (Pałubicka, 1984, 44-48; Buchowski, Burszta 1986; Kowalski, 1999; Płonka, 2012, 26-29). This way of perceiving the world is characterised by syncretism, understood as a comprehensive understanding of reality in which all events are closely linked. It is suggested, that all activities, economic, communication and worldview, undertaken by people in societies of this type, were considered as one and highly overlapping (Buchowski & Burszta, 1992, 19). In simple terms this means in the Stone Age, procedures that are presently considered purely utilitarian also played an important role in communication and determining the worldview, in the meaning of cultural identity and belongingness, of the people who performed them. Taking this into consideration, it can be suggested that differences in technological traditions observed between collections of prehistoric artefacts can constitute a way to understand the actual ethnic divisions of that period.

One of the main results of intercultural contacts in traditional hunter-gatherer societies was the exchange of gifts (Sahlins 1992). This was usually subject to strict rules that have already been the subject of many studies (including Malinowski 1922; Woodburn 1982; Gurven 2004; Patton 2005; Kelly 2013). One of the fundamental achievements of anthropological theory can be considered the discovery that gift exchange in early traditional societies exemplifies the so-called "total social fact" (French: "fait social total") (Mauss 2001). In this approach, in archaic cultures, a gift simultaneously has a magical, religious, social, economic, and communicative function. Regardless of whether it takes the form of a material object, person or action, it becomes a kind of bridge, a path enabling contacts between culturally different groups (Kowalski 1998). However, a gift received by someone was not an object from nowhere. It bore the mark of otherness, came "from the outside", and was treated in such a special way until the signs of its foreignness was erased in social consciousness (cf. van der Leeuw 1997, 347). From an archaeological perspective, this means maintaining the attributes of "difference", technological and form in the case of products and social in the case of people, for a very long time. The subject of the gift/exchange should, therefore, be identifiable in the archaeological context through stylistic/technological analyses of artefacts, and, in the case of people, for example, the layout of prehistoric cemeteries.

Mobility in prehistoric societies means the actual "movement" of human groups and individuals. In some cases, it does not leave material traces in the archaeological record, which is why, until recently, it was believed that "it is difficult to study mobility archaeologically" (Kelly 1992, 54). Currently, this problem has been solved to some extent by applying paleobiological methods to research the mobility of ancient communities. These include mitochondrial DNA (aDNA) analyses and stable isotope ratio measurements (87Sr/86Sr). Research of the first type allows for the interpretation of long-term demographic changes and movements of entire cultural units. Isotope studies track the movements of people and animals at the individual and short-term levels (Bentley 2006; Ericson 1985; Beard, Johnson 2000; Montgomery 2010). Data collected through both types of analyzes allow discussion of different mobility patterns, communication routes, population dynamics, etc. (i.a. Brusgaard et al. 2019; Frei et al. 2015; Frei et al. 2019a; Gron et al. 2016; Knipper 2011; Montgomery and Evans 2006; Sjögren et al. 2009; Scheeres et al. 2013; Parker Pearson, et al. 2016; Osipowicz et al. 2018; Lugli, et al.2019; Blank et al. 2021; Kowalik et al. 2020).

However, the results of research on the mobility of prehistoric communities, conducted using paleobiological methods, require verification and detail. This can be done through a multi-aspect analysis of artefacts carried by moving people, which (according to the theoretical assumptions presented above) constitute a very good carrier of cultural content and are a reliable basis for the interpretation of signs of exchange and intergroup contacts.

Studies on the flow of raw materials and products in prehistory have been conducted for a long time. Examples include research on the spread of jade axes (Klassen et al., 2011) and the Mediterranean shell Spondylus gaederopus (Windler 2019) in Neolithic Europe, as well as studies on the prehistoric trade in salt (Stöllner, 2012) and obsidian at the continent (e.g. Hughes et al. 2018; Szeliga et al. 2021). Research on the mobility of prehistoric communities based on precise technological analyses is undoubtedly rarer. An example here are studies on the spread of knowledge of the pressure technique in the processing of flint raw materials in Europe, the so-called: conical core pressure blade concept (Hartz et al. 2010; Damlien, 2016; Sørensen et al., 2013). Its introduction is believed to mark the first migration of people and technological knowledge in the 9th millennium BC from the eastern Russian plains and the coast of the Baltic Sea to northwestern Europe.

Research on the conical core pressure blade concept is linked to one of the few studies in this field that is carried out for bone artefacts, i.e. studies on the spread of the idea of composite slotted bone tool technology in northern Europe and the East European Plain (Manninen et al. 2021), as well as (more generally) the technology of making bone products in different parts of Mesolithic Europe (Bergsvik & David, 2015; David, 2009). So far, however, no studies have been conducted on the mobility of prehistoric communities based on technological features (or rather microtechnological elements) visible on seemingly formally identical artefacts, which were identified through detailed traceological analyses.

Animal tooth pendants serve a particular role among artefacts identified at prehistoric sites. They were the carriers of many cultural data and fulfilled various social roles (Taborin, 1993; Alvarez-Fernandez, 2009). Ethnographic sources uniformly confirm that their symbolic meaning is significant among hunter-gatherer communities and are often identified with ethnic identity and origin (e.g., Miller, 2009; Seeger, 1975; Strathern 1979). They are commonly perceived as a particularly important archaeological source for the interpretation of social and cultural characteristics which cannot be confidently interpreted from other types of artefacts (Joyce, 2005; Kuhn & Stiner, 2007; Moro Abadía & Nowell, 2015; Newell et al.,1990; Vanhaeren & d'Errico, 2006). However, historically in most of Europe, tooth pendants have rarely been found in secure Stone Age contexts.

Northeastern Europe is characterised by exceptionally favourable hydrological and soil conditions which have allowed good preservation of early and middle Holocene (ca. 9500-2300 cal BC) bone and other organic material. Additionally, its position at the crossroads of influences during this period from Western Europe, for example Balkan Neolithic traditions, and hunter-gatherer traditions from the East make this a particularly fruitful area to research the cultural transformations that were taking place in the hunter-gatherer communities. Of significance are the settlements and fishing sites in Šventoji, Lithuania (Rimantienė, 2005), Pulli and Kunda-

Lammasmägi, Estonia (Indreko, 1948; Jaanits & Jaanits, 1975), and cemeteries in Spiginas and Donkalnis, northwestern Lithuania (Butrimas, 2012), Oleniy Ostrov, Russia (Gurina, 1956), Zvejnieki, Latvia (Zagorskis, 1987; 2004; David, 2003; Zagorska, 1992), and Dudka and Szczepanki, in northeastern Poland (Gumiński & Bugajska, 2016).

To date research on the technology and function of animal tooth pendants in North Eastern Europe has focused on collections from a few selected sites in the area (Zvejnieki, Latvia (David & Zagorska, 2004; David, 2006; Larsson, 2006, 2009; Macāne, 2022; Osipowicz et al., 2023), Šventoji, Lithuania (Osipowicz et al., 2020), and Yuzhniy Oleniy Ostrov, northeastern Russia (Rainio & Mannermaa, 2014; Rainio et al., 2021; Mannermaa et al., 2021, 2022). It is hoped that this paper will provide important data for co-ordinated research.

1.1. Objectives

This article attempts to verify the possibility of studying the mobility patterns of prehistoric communities based on the technological features (microtechnological attributes) of the artefacts, identified through traceological analyses. The research subject is animal tooth pendants from several dozen key early and middle Holocene hunter-gatherer-fishers sites in Central and Northeastern Europe. The starting point for the studies are the results traceological and zooarchaeological tests conducted on a collection of pendants made of animal teeth from Mesolithic burials at sites Spiginas and Donkalnis in Lithuania. The results of the traceological analyses are examined and compared with data obtained by the authors from microscopic analysis of materials from other Mesolithic and Subneolithic sites in the region and from information provided in the subject literature. The source database created is used to verify the classification of methods for making cord attachment areas on animal tooth pendants and to determine the degree to which specific methods were applied in Central and Northeastern Europe. The study aims to explore the meaning of 'foreign' methods in specific regions and discuss the possibilities of interpreting migration routes and exchange directions based on technological studies of animal tooth pendants. Traceological analysis results of the artefacts from Spiginas and Donkalnis are also compared with $^{87}Sr/^{86}Sr$ isotope ratios in human remains from these sites to verify the complementarity of both research tools and the reliability of technological studies in understanding the mobility of early Holocene groups. The research is supplemented by providing zooarchaeological characteristics and attempting to determine the function of the pendants from the analysed sites.

1. 2. Donkalnis and Spiginas: sites description

Donkalnis (55.8076N; 22.4222E) and Spiginas (55.7679N; 22.4172E, cf. Fig.1) are two small hills in western Lithuania well known for their prehistoric cemeteries and, at Donkalnis, settlements. These sites have been subjected to extensive investigation. Geomorphologically they mainly comprise of gravel and were formed during the Last Glaciation. In the early Holocene, they were located on two islands in Lake Biržulis.

Fig. 1. Location of the Spiginas and Donkalnis sites. A – Location of Lithuania in Europe; B - Location of the discussed sites in Lithuania.

Spiginas, an area of 420 square metres, was investigated in 1985-1986. Here the hill is about 9 metres high with steep sides and a small plateau, 110 x 40 m, at the top which comprises the burial area. Four graves were found (Butrimas, 1992). Graves 1-4 were dated 4442-4243, 2132-1749, 6814-6461 and 6442-6227 cal BC, respectively (Piličiauskas et al., 2017). The ^{14}C dates indicate that the cemetery was used at least 4500 years in the Mesolithic (graves 3 and 4), Subneolithic (grave 1) and Neolithic (grave 2).

The Donkalnis hill is 5 meters high with a wider and flatter top (170 by 50 m). During the excavation works in 1981–1982, an area of 1024 square metres was investigated and 7 graves were uncovered. A least a further 7 were destroyed during previous gravel extraction (Butrimas et al., 1985). The ^{14}C-dates (Piličiauskas et al., 2017) show that Spiginas, like Donkalnis, has a long burial history of at least 3000 years, although unlike at Spiginas, no Neolithic graves were identified at Donkalnis. Graves 2, 4, 5 and the disrupted individual V belong to the Mesolithic, whereas graves 1, 3, 6, 7 and individuals I-IV, and VI are dated to the Subneolithic.

At both cemeteries, deceased were buried individually in shallow pits in the supine position, rarely with their legs bent. An exception is grave 5 in Donkalnis, where remains of a child and an infant were found**.** Ochre was widely used in the grave filings. There were numerous pendants of wild animal teeth, usually the only type of find unearthed in the graves. They were found mostly in the head and chest areas, suggesting they had adorned burial clothing, since decayed (Butrimas, 1992; Butrimas et al., 1985).

2. Materials and methods

The discussion carried out in this article is driven by the results of the zooarchaeological and traceological analysis of animal tooth pendants from the following four early Holocene graves: Spiginas, grave 4, and Donkalnis, graves 2, 4, and 5. These studies were supplemented with the results of traceological research (already published or currently being prepared for publication), by the authors of pendants from other sites in the region, in particular Pulli and Kunda (Estonia), Zvejnieki, burial 57 and 164 (Latvia); Šventoji, sites 1-4, 6, 23 (Lithuania), Pierkunowo, grave 1, and Janisławice (Poland). In the discussion, the data contained in the literature on the subject was extensively used.

Fig. 2. Spiginas, grave no 4. Plan of the burial and teeth pendants discovered in the grave. Fig. 2.1 after Butrimas 2002, Fig. 44.

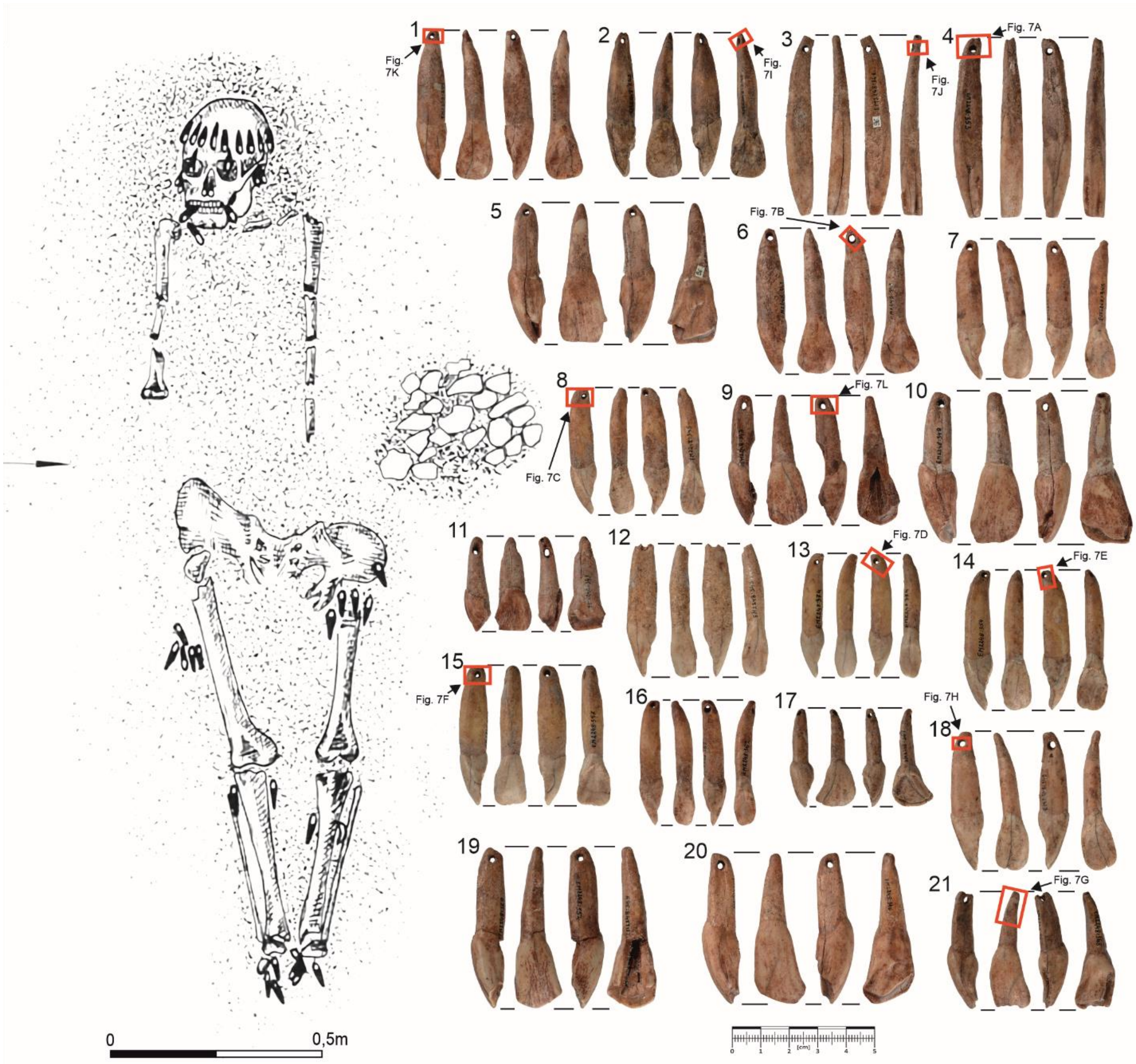

Fig. 3. Donkalnis, grave no 2. Plan of the burial and the examples of teeth pendants discovered in the grave with marked places of making microphotographs. Fig. 3.1 after Česnys, Butrimas 2009, Fig. 1.

Grave 4 in Spiginas (Fig. 2) is a burial of a woman aged 30-35 years, where seven animal teeth pendants were found. Three were found in the thoracic area, and four were found between the legs in the knee area (Butrimas 2012, 71). Neither the reports nor inventory books provide any specifics as to which one was found in which area in the grave.

Donkalnis grave 2 (Fig. 3), contained a male of 20-25 years. This grave contained 57 artefacts described as pendants (Butrimas 2012, 49-50; ID 2248: 343-374), one of which was a fragment of mollusc shell.

Fig. 4. Donkalnis, grave no 4. Plan of the burial and the examples of teeth pendants discovered in the grave with marked places of making microphotographs. Fig. 4.1 after Butrimas 2002, Fig. 29.

Donkalnis grave 4 (Fig. 4) at this site contained the body of a 50-55-year-old male and 83 pendants (Butrimas 2012, 59; Piličiauskas et al. 2017), eighty of which were subjected to traceological studies.

Two children were buried in double grave 5 in Donkalnis (Fig. 5), one about 7 years old and the other an infant (Piličiauskas et al. 2017). Forty-five pendants were found in this grave (ID 2248: 444-488).

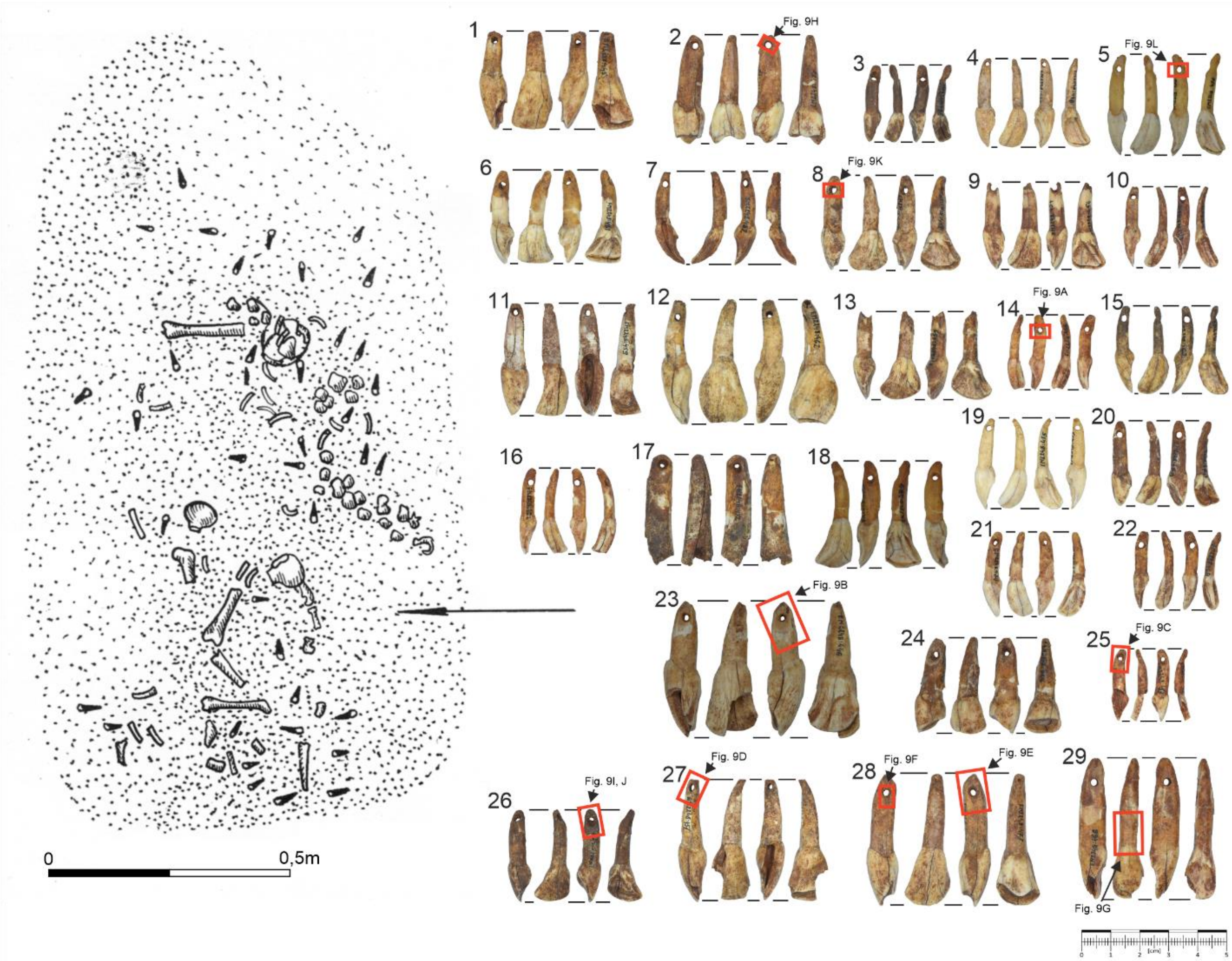

Fig. 5. Donkalnis, grave no 5. Plan of the burial and the examples of teeth pendants discovered in the grave with marked places of making microphotographs. Fig. 5.1 after Butrimas 2002, Fig. 35.

The traceological analyses were performed using two microscopes. A Nikon SMZ-745T microscope (magnification up to × 65) fitted with a Delta Pix Invenio 6EIII camera was used to take the photomicrographs presented in Fig.6:2a, 3a, b, 4a, b; 7A-L; 8A-O and 9A-L. Observations on the polish were made using a Motic AE2000MET microscope with up to × 50 magnitude (magnification up to × 500) fitted with Moticam 5+ camera. The photomicrographs presented in Fig. 6: 4c, d were also taken with this equipment. The terminology applied in this research was based on the system adopted in the literature (e.g., Newcomer, 1974; Legrand, 2007; Buc, 2011; Osipowicz et al., 2020), adjusted for the purposes and requirements of the analysis.

The research has been hindered by the condition of the artefacts. The state of preservation varies significantly, attributed to natural post-deposition damage and also to methods used for artificial preservation. The material from Spriginas is in overall better condition that that from

Donkalnis. Many of the pendants from Donkalnis have significantly eroded and flaking surfaces (e.g., Fig. 7A; 8A), and some have only survived in fragments. In addition the surface of many specimens, particularly of artefacts from Donkalnis, grave 2, are covered with ochre and other contaminations (cf. Fig. 7B). Almost all the recovered pendants have a thick layer of conservation substance which have severely limited any useful observations of the polishing. Accordingly the functional interpretations made in this research are based mainly on the analysis of the structure of the rounding of the edges of the holes made in the pendants, the zonality and the degree to which the technological traces inside them have been obliterated. The location of the wear traces observed inside the holes in the pendants was determined using a scheme based on a dial plate with specific hours on the dial plate corresponding to sectors where the traces occurred, that is sector 1 marked the area between hours 12 and 1, sector 2 the area between hours 1 and 2, and so on (cf. Osipowicz et al., 2020).

The classification of methods for making cord attachment areas employed in this article as well as the functional interpretations of the way in which the pendants were used are both based on the findings made in the source of experimental and traceological studies on the animal tooth pendants from sites Šventoji 1-4, 6, 23, Lithuania (Osipowicz et al., 2020) and graves 54 and 164 at the Zvejnieki burial ground, Latvia (Osipowicz et al., 2023). They were combined and extended to include technological procedures observed in this regard at other early and middle Holocene sites in the southeastern area of the Baltic Sea. The methods for creating cord attachment areas on animal tooth pendants constructed in this manner (and applied further in the article) are classified as follows:

MI. Drilled perforation

MI.1. Surface not prepared before perforation

MI.2. Surface scraped before perforation

MI.3. Surface planed before perforation

MII. Perforation carved

MII.1. Surface not prepared before perforation, perforation carved (applied methods: scraping, planing, grooving or cutting)

MII.2. Surface prepared using grinding or planing, perforation scraped

MII.3. Surface prepared using grinding or planing, perforation cut or grooved

MIII. Attachment without the perforation

MIII.1. Horizontal grooving/sawing of the tooth's root

MIII.2. Grinding crown and root (?)

In some cases, it can be difficult to differentiate MI.2 from MI.3, particularly on the artefacts whose surface bears significant post-depositional changes. The pendant collections analysed in this paper show however that both methods were separately used, hence the approach adopted in this study.

Methods MII.2 and MII.3 are essentially two variants of the same method that differ solely in the type of the working edge applied for carving out the perforation and statistical confirmation that these two techniques were used interchangeably at specific sites would require combining them. For the purpose of this article, this variant is referred to as method MII.2/3.

There is no clear evidence that method MIII.2 is linked to the crafting of cord attachment areas, and the purpose for grinding teeth crowns and roots remains unclear. Nonetheless, there were significant examples of this practice found in the researched graves that it was decided to consider it a method potentially for fixing pendants in some other way, possibly without using a cord, and to include it in the classification system.

The statistical analysis of the results of the technological studies, the percentages, did not include objects that were damaged and those for which it was impossible to determine the way in which the cord attachment area was made. In respect of the MII group methods and the results of the analysis of the pendants from graves 57 and 164 in Zvejnieki, a system for independent technological classification of each side of an artefact was adopted in the source compilation (cf. Osipowicz et al., 2023).

The discussion undertaken in this article does not cover pendants made of bear teeth. These products are peculiar, non-existent at Donkalnis and Spiginas, and found sparsely in early Holocene sites in northern and northeastern Europe. They appear to have served a particular role in the ritual life of early Holocene communities (cf. Grünberg, 2013), and for this reason are regarded as a separate category (Mannermaa et al., 2021).

The data cited in the article concerning the results of traceological analyses of the artefacts from sites in Pulli and Kunda Lammasmägi (Estonia) and Janisławice and Pierkunowo, grave 1 (Poland), are from the authors' studies as yet unpublished.

3. Results (artefacts from Donkalnis and Spiginas)

The data on the results of the zooarchaeological and traceological studies for specific artefacts is shown in Table 1.

3.1. Results of the archaeozoological analysis of the artefacts

The majority of the pendants found in Donkalnis and Spiginas were made from incisors of large ungulates, such as elk, aurochs/the bison, and red deer (cf. Table 2). Only one canine of a carnivore and a small cervid incisor were found in the analysed graves. There was no single species which dominated the collection. In Donkalnis, grave 2, elk tooth pendants accounted for 51.8%. They were also the most abundant in Donkalnis, grave 4 (43,8%), and the second most abundant in Spiginas, grave 4. However, in Donkalnis, grave 5, where 2 children were buried, only one elk tooth was found, while the most numerous were those of red deer (48.9%) and aurochs/ bison (46.8%). In Donkalnis, boar teeth were identified at grave 2 only, where they constitute 7% of the collection. In Spiginas, boar teeth comprised 4 of the 7 pendants found.

The pendants were made of the teeth of animals of different ages, and all permanent incisors (I1, I2, I3, I4) were used. There were teeth from young animals that were not worn at all, as well as teeth from old individuals that were heavily worn. In some cases, it was possible to identify teeth of the same individual; for instance, wild boar teeth ID 8 and 9 (Spiginas, grave 2), and at least two teeth of the same aurochs/the bison (Donkalnis, grave 4, ID 2248: 401).

Although the aurochs/bison teeth have not been differentiated it is highly probable that they are mostly aurochs teeth as in Lithuanian Subneolithic material, aurochs predominate at all sites.

Table 1. Characteristic of the teeth pendants from Spiginas (grave 4) and Donkalnis (grave 2, 4, 5) sites, studied traceologicaly.

Site	Pendant inv. number	Species	Technological traces*	Use-wear traces	Figure
Spiginas, grave 4	EM2357:7	Boar	MI.1.	Used, rounding in the perforation	Fig. 2:1
	EM2357:8	Boar	MI.1.	Used, rounding in the Perforation	Fig. 2:2
	EM2357:9	Boar	MI.1.	Used, rounding in the Perforation	Fig. 2:3
	EM2357:10	Boar	MI.1.	Used, rounding in the Perforation	Fig. 2:4
	EM2357:11	Elk	MI.1.	Used, rounding in the Perforation	Fig. 2:5
	EM2357:12	Elk	MI.1.	Used, rounding in the Perforation	Fig. 2:6
	EM2357:13	Elk	MI.1.	Used, rounding in the perforation	Fig. 2:7
Donkalnis, grave 2	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:1
	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:2
	EM2248:343	Boar	MI.1.	Used, rounding in the perforation	Fig. 3:3
	EM2248:353	Boar	MI.1.	Used, rounding in the perforation	Fig. 3:4
	EM2248:343	Auroch/bison	MI.1.	Used, rounding in the perforation	Fig. 3:5
	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:6
	EM2248:343	Elk	MI.1.	Unused or used very little	Fig. 3:7
	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:8
	EM2248:343	Auroch/bison	MI.1.	Used, rounding in the perforation	Fig. 3:9
	EM2248:349	Auroch/bison	MI.1.	Used, rounding in the perforation	Fig. 3:10
	EM2248:343	Auroch/bison	MI.1.	Used, rounding in the perforation	Fig. 3:11
	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:12
	EM2248:374	Elk	MI.1.	Unused or used very little	Fig. 3:13
	EM2248:354	Elk	MI.1.	Unused or used very little	Fig. 3:14
	EM2248:357	Elk	MI.1.	Unused or used very little	Fig. 3:15
	EM2248:362	Elk	MI.1.	Unused or used very little	Fig. 3:16
	EM2248:361	Auroch/bison	MI.1.	Unused or used very little	Fig. 3:17
	EM2248:343	Elk	MI.1.	Used, rounding in the perforation	Fig. 3:18
	EM2248:369	Auroch/bison	MI.1.	Unused or used very little	Fig. 3:19
	EM2248:346	Auroch/bison	MI.1.	Used, rounding in the perforation	Fig. 3:20
	EM2248:368	Auroch/bison	MI.3	Used, rounding in the perforation	Fig. 3:21
Donkalnis, grave 4	EM2248:389	Red deer	MI.3	Not readable	Fig. 4:1
	EM2248:430	Elk	MI.3	Probably used, rounding in the perforation	Fig. 4:2
	EM2248:427	Elk	MI.3	Probably used, rounding in the perforation	Fig. 4:3
	EM2248:432	Elk	MI.3	Not readable	Fig. 4:4

	EM2248:398	Elk	MI.3	Not readable	Fig. 4:5
	EM2248:438	Elk	MI.3	Not readable	Fig. 4:6
	EM2248:376	Elk	MI.3	Not readable	Fig. 4:7
	EM2248:400	Elk	MI.3	Not readable	Fig. 4:8
	EM2248:421	Elk	MI.3	Not readable	Fig. 4:9
	EM2248:383	Elk	MI.3	Not readable	Fig. 4:10
	EM2248:384	Elk	MI.3	Not readable	Fig. 4:11
	EM2248:386	Auroch/bison	MI.3	Used, rounding in the perforation	Fig. 4:12
	EM2248:401	Auroch/bison	MI.3	Not readable	Fig. 4:13
	EM2248:401	Auroch/bison	MI.3	Not readable	Fig. 4:14
	EM2248:401	Auroch/bison	MI.3	Not readable	Fig. 4:15
	EM2248:401	Auroch/bison	MI.3	Not readable	Fig. 4:16
	EM2248:401	Red deer	M1.1	Not readable	Fig. 4:17
	EM2248:419	Auroch/bison	M1.1	Not readable	Fig. 4:18
	EM2248:403	Red deer	M1.1	Not readable	Fig. 4:19
	EM2248:403	Auroch/bison	M1.1	Not readable	Fig. 4:20
	EM2248:382	Auroch/bison	M1.1	Not readable	Fig. 4:21
	EM2248:413	Auroch/bison	M1.1	Not readable	Fig. 4:22
	EM2248:415	Auroch/bison	M1.1	Not readable	Fig. 4:23
	EM2248:401	Auroch/bison	M1.1	Not readable	Fig. 4:24
	EM2248:401	Elk	M1.1	Used, rounding in the perforation	Fig. 4:25
	EM2248:405	Elk	Whittling	Not readable	Fig. 4:26
Donkalnis, grave 5	EM2248:445	auroch/bison	MI.1	Not readable	Fig. 5:1
	EM2248:477	auroch/bison	MI.1	Used, rounding in the perforation	Fig. 5:2
	EM2248:486	Red deer	MI.1	Not readable	Fig. 5:3
	EM2248:448	Red deer	MI.1	Not readable	Fig. 5:4
	EM2248:476	Red deer	MI.1	Used, rounding in the perforation	Fig. 5:5
	EM2248:481	Red deer	MI.1	Not readable	Fig. 5:6
	EM2248:482	Red deer	MI.1	Not readable	Fig. 5:7
	EM2248:451	Auroch/bison	MI.1	Used, rounding in the perforation	Fig. 5:8
	EM2248:454	Red deer	MI.1	Not readable	Fig. 5:9
	EM2248:464	Red deer	MI.1	Not readable	Fig. 5:10
	EM2248:459	auroch/bison	MI.1	Not readable	Fig. 5:11
	EM2248:462	auroch/bison	MI.1	Not readable	Fig. 5:12
	EM2248:453	Auroch/bison	MI.1	Not readable	Fig. 5:13
	EM2248:456	Red deer	MI.1	Used, rounding in the perforation	Fig. 5:14
	EM2248:463	Red deer	MI.1	Not readable	Fig. 5:15
	EM2248:461	Red deer	MI.1	Not readable	Fig. 5:16
	EM2248:472	auroch/bison	MI.1	Not readable	Fig. 5:17
	EM2248:479	Red deer	MI.1	Not readable	Fig. 5:18
	EM2248:455	Red deer	MI.1	Not readable	Fig. 5:19
	EM2248:470	Red deer	MI.1	Not readable	Fig. 5:20
	EM2248:480?	Red deer	MI.1	Not readable	Fig. 5:21
	EM2248:469	Red deer	MI.1	Not readable	Fig. 5:22
	EM2248:446	auroch/bison	MI.3	Not readable	Fig. 5:23
	EM2248:449	auroch/bison	MI.3	Not readable	Fig. 5:24
	EM2248:487	Red deer	MI.2.	Not readable	Fig. 5:25
	EM2248:467?	Red deer	MI.2.	Not readable	Fig. 5:26
	EM2248:457	auroch/bison	MII.1	Not readable	Fig. 5:27
	EM2248:473	Auroch/bison	MII/MI	Not readable	Fig. 5:28
	EM2248:466	Elk	MI.1	Not readable	Fig. 5:29

Tab. 2. Animal teeth pendants from Donkalnis and Spiginas graves. Composition of the animal species

Species	Burial site and grave no.							
	Donkalnis, grave 2		Donkalnis, grave 4		Donkalnis, grave 5		Spiginas, grave 4	
	n	%	n	%	n	%	n	%
Auroch/bison	18	32.1	20	25.0	21	46.7		
Elk	29	51.8	35	43.8	1	2.2	3	42.9
Red deer	3	5.4	16	20.0	22	48.9		
Roe deer			1	1.3				
Boar	4	7.1					4	57.1
Wolf/dog			1	1.3				
Large ungulate	2	3.6	7	8.8	1	2.2		
In total	56	100.0	80	100.0	45	100.0	7	100.0

3.2. Results of the technological studies

3.2.1. Spiginas, grave 4

Holes in all the seven pendants found in this grave were made by means of bilateral drilling (MI.1 – cf. Fig. 6). Additionally, the surface of one of the pendants was corrected by planing, and the top of another, in the perforation area, was unilaterally ground (Fig. 6: 4d).

3.2.2. Donkalnis

In the case of the pendants from grave 2 in Donkalnis (51 specimens), perforations were made using the method MI.1 (Fig. 3:1-20; 7C-F) with the exception of a single artefact (Fig. 3: 21) where the cord attachment areas were prepared by means of-method MI.3 (Fig. 7G). In two of the analysed pendants, fragments with the perforations are missing.

In seven cases (e.g., Fig. 3:10, 18, 20) the edges of the perforations were widened by means of planing/scraping, often leaving a corrugated surface and incisions (Fig. 7H). Two pendants (Fig. 3:2, 3) show an interesting technological procedure consisting in planing the tooth from the lower side, perforation-high, resulting in a shallow V-shaped recess (Fig. 7: I, J). On the first of these specimens, the incision is preserved only fragmentarily due to the flaking surface. The state of preservation of three pendants did not allow analysis of the techniques applied for making the perforations.

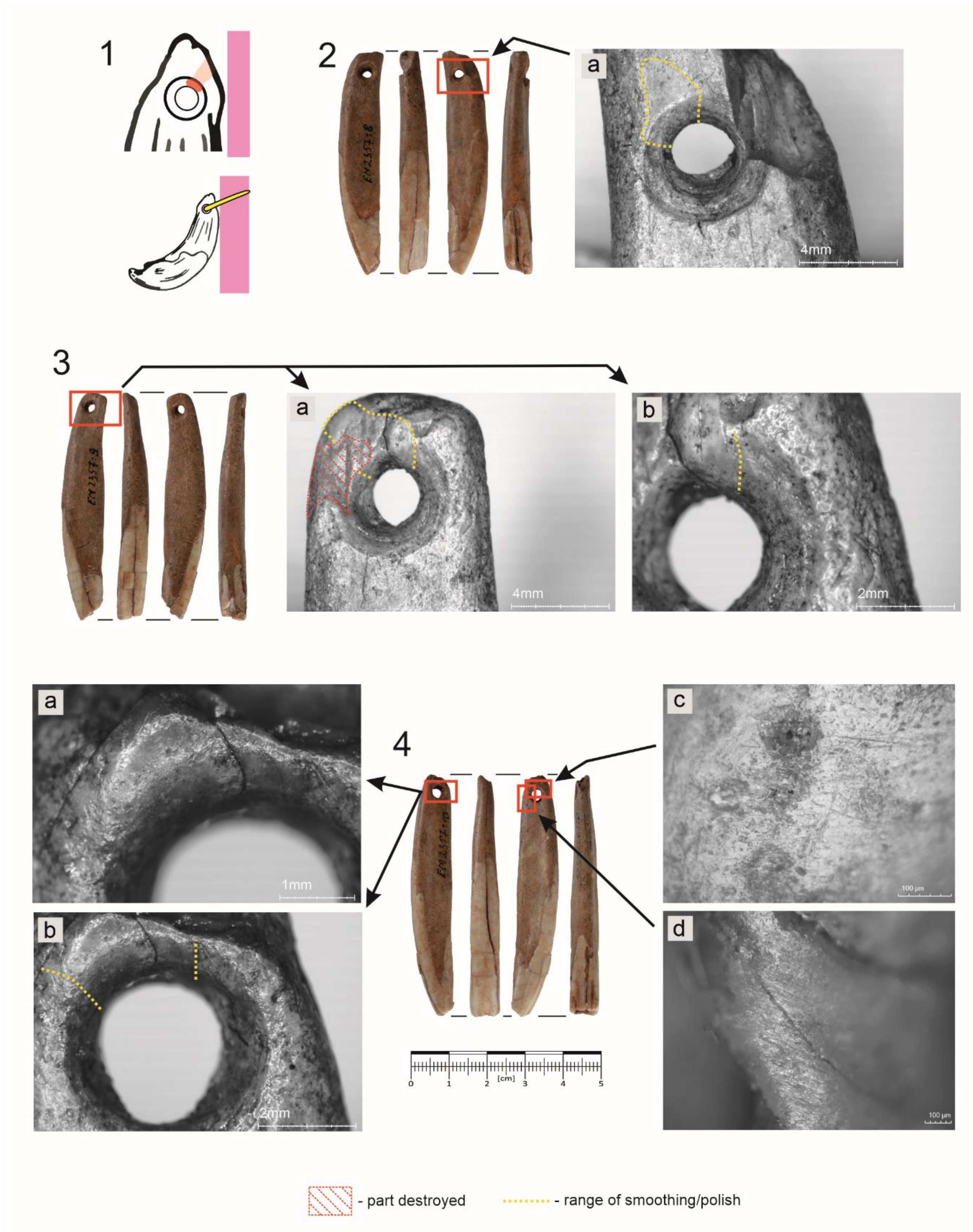

Fig. 6. Spiginas, grave no 4. The examples of the use-wear traces observed on the pendants. 1 – scheme presenting the way that pendants were mounted.

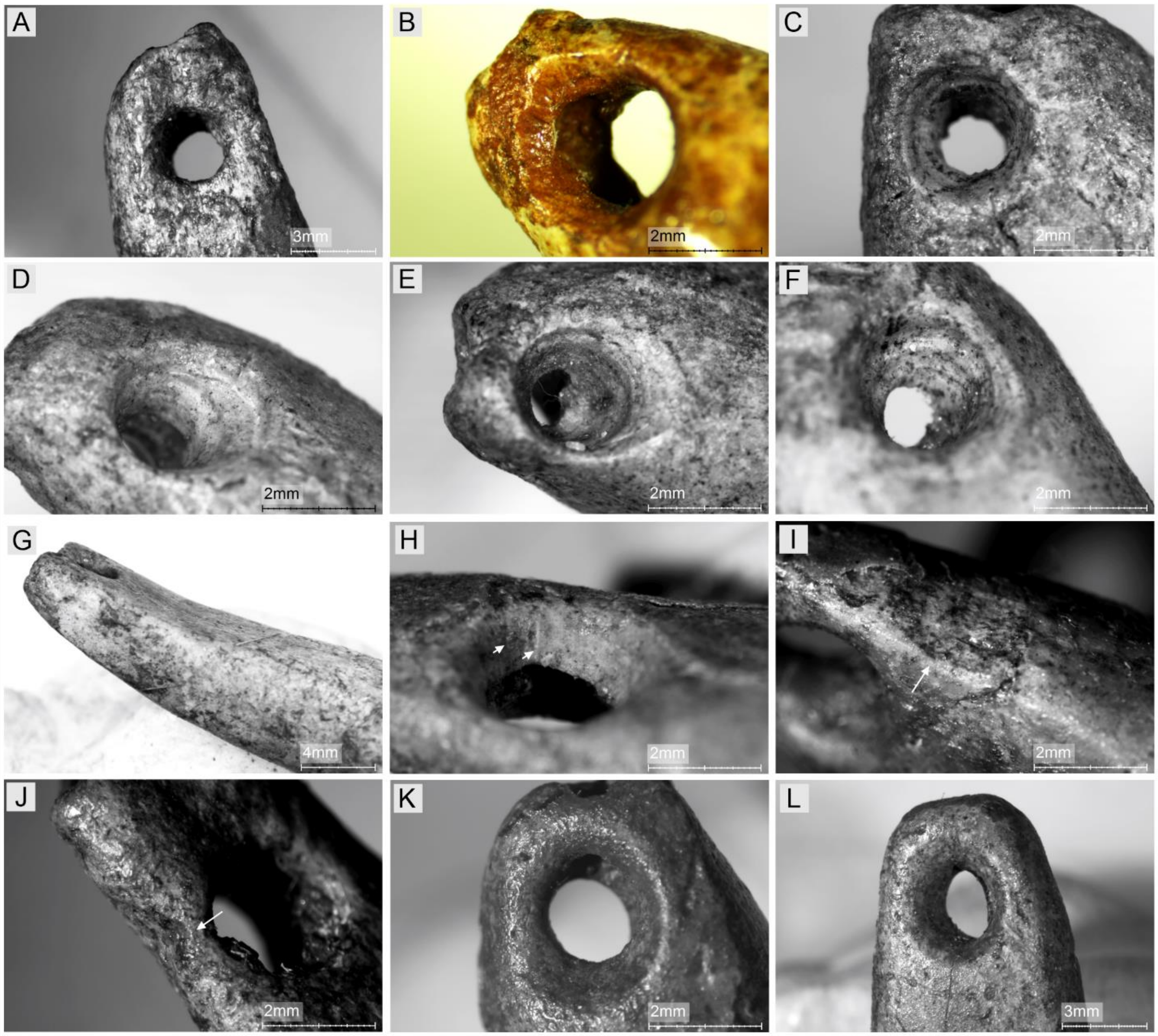

Fig. 7. Donkalnis, grave no 2. The examples of the post-depositional erosion (A), contaminants (B), technological (C-J) and use-wear (K, L) traces discovered on pendants.

Of the 80 animal teeth from grave 4 in Donkalnis that were subjected to traceological analysis, 29 bear processing traces. In one of the specimens, the root has apparently been intentionally cut and broken off (Fig. 4:1; 8B); in 26, holes were made (Fig. 4: 2-25). Unlike grave 2 at this site, the majority of cord attachments (17 cases) were formed by applying the MI.3 method (Fig. 8C-F). In 12 cases, the drilling of the hole was preceded by bilateral planing (Fig. 4: 2-5, 7, 9-11, 13-15), and in four cases the perforations were made only on one side of the pendant (Fig. 4: 6, 8, 12, 16). In the other nine pendants, cord attachment areas were made using the M1.1 method (Fig. 4: 17-25; Fig. 8G, H), although for three of them the possibility that a delicate preliminary planing was applied locally cannot be ruled out. A hole in one of the pendants (Fig. 4: 21) was formed by pre-drilling on one side in two areas (Fig. 8I), while in another case (Fig. 4: 10), the perforation in the artefact was widened by means of scraping/planing (Fig. 8J – the arrow marks the incisions). Two of the pendants bear visible traces of planing, but have no perforations (Fig. 4: 26; 8K).

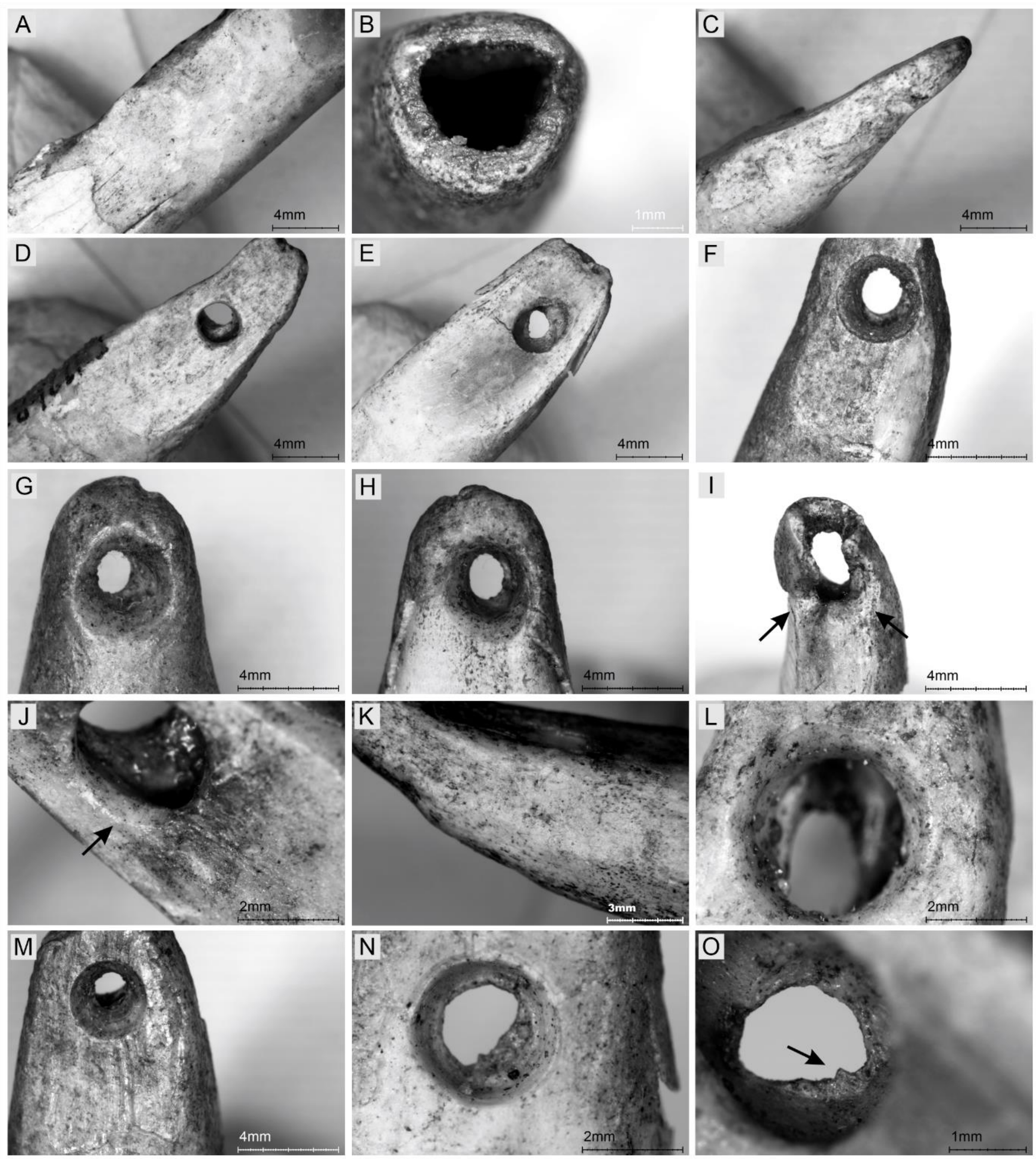

Fig. 8. Donkalnis, grave no 4. The examples of the post-depositional erosion (A), technological (B-F, I-K, M-O) and use-wear (G, H, L) traces discovered on pendants.

Among the 45 animal teeth unearthed in grave 5 in Donkalnis that were subjected to the traceological analysis, two bear no traces of processing, and three have broken fragments of roots where, possibly, holes were located. The remaining 40 have perforations made using mainly, in 33 cases, the MI.1 method (Fig. 5: 1-22; 9A). Two pendants have-perforations made using the MI.3 method (Fig. 5:23, 24; 9B). Perforations of three specimens were formed using the MI.2 method (Fig. 5:25, 26; 9C), with planing applied to prepare only one side of the root in two of these specimens. One pendant with a scraped hole was recorded (the MII.1 method – Fig. 5:27; 9D) and one in which the hole was originally carved out and 're-made' by bilateral drilling (Fig. 5: 28; 9E, F). In this grave, one pendant ornamented by cutting was found (Fig. 5:29; 9G).

3.3. Results of the functional studies

3.3.1. Spiginas, grave 4

All the pendants unearthed in this grave show wear damage. Owing to the good preservation of the artefacts, the structure and the distribution of the use-wear could be subjected to a precise analysis. In general, the characteristics of the traces recorded on individual products are similar. They are mainly visible as smoothing/polishing inside and on the edges of the perforations made in the pendants, which has the effect of erasing the technological traces of initial perforation in some sections (Fig. 6; cf. Osipowicz et al. 2020). Usually, the polish visible here have a flat topography, smooth texture, and is related to few linear traces observed in the form of black and filled in striations (mainly hair-like), perpendicularly oriented to the edge of the hole in a given area (Fig. 6:4c).

The differences in use-wear traces between individual pendants appears to be related mainly to their location and the varying degree to which they cover the surface of these artefacts. On one (Fig. 2:1), traces of this kind can be observed mainly on the left side of the perforation and cover sectors 9-3. On the second pendant (Fig. 6:2), they were recorded on both sides of the hole in sectors 9-1, with a highly clear borderline between the area covered by wear traces and the remaining part of the edge of the hole, which shows well-preserved technological traces (Fig. 6: 2a). This borderline is very clear on another pendant (Fig. 6:3), with wear traces covering sectors 10-1 on the right (Fig 6:3a-b) and sectors 9-3 on the left side of the perforation. Their arrangement is different on the fourth artefact (Fig. 6:4). which shows a delicate rounding and obliteration of technological traces on the vast part of the circumference of the hole outside its lower zone (the area of sector 6), where remains of planing are readable (Fig. 6:4d). However, here wear traces are observed to be best developed in sectors 11-1 (Fig. 6:4a, b). On two more pendants wear damage occurs in more 'lateral' parts of the holes, covering sectors 8-1 (the right side of the perforation, poorly visible on the left side) in the case of the specimen presented in Fig. 2:5 and sectors 11-5 (the right side of the perforation), and 8-1 (the left side of the perforation) on the pendant shown in Fig. 2:6. On the last of the artefacts (Fig. 2:7), a delicate smoothing was observed only in sectors 11-1.

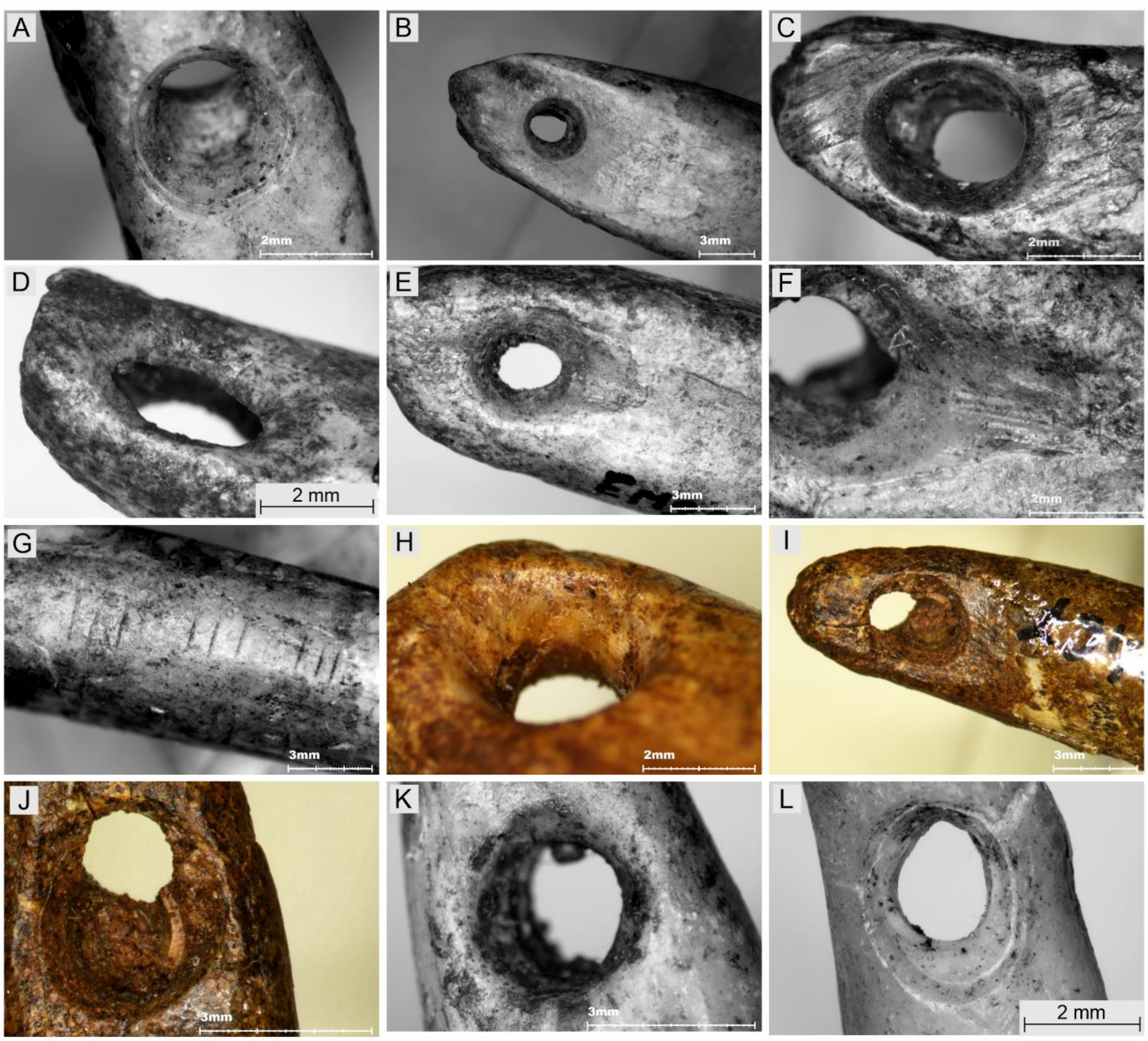

Fig. 9. Donkalnis, grave no 5. The examples of the technological (A-G), contaminants (H, I, J), and use-wear (K, L) traces discovered on pendants.

3.3.2. Donkalnis

Analysing the artefacts from this site was considerably more challenging. They had been covered with various kinds of post-deposition contaminations, including ochre (cf. Fig. 7A, B). Post excavation a preservative substance had been applied to all artefacts making it impossible in most cases to precisely analyse the usage polish. Accordingly the results are more generalised.

From grave 2 in Donkalnis, 37 pendants were identified as bearing wear traces (68.5% of the assemblage). These traces are well-developed on 25 (46.3%); where a large part of the edge and the inner part of the hole is clearly rounded/polished, and the technological traces are obliterated (Fig. 7K, L). In the remaining pendants, wear traces are either poorly developed or interpretion of the degree of development is impossible due to post-depositional damage and/or the preservative substance. In the assemblage, there are 11 pendants that were either not used or used too briefly to show any changes reflecting the usage on their surfaces (Fig. 7D-F). Additionally, four specimens are damaged to the point that rendered verification of any use-wear traces impossible. There are two fragments of pendants.

The functional structure of the artefact collection from grave 4 is different. Of the 29 animal teeth subjected to processing, 21 specimens (72.4%) bear no clear traces of use-wear damage. In the vast majority of cases, they show well-preserved technological traces related to the making of perforations (Fig. 8F, M), inside of which (on some specimens) sharp edges can be seen, caused by breaking off fragments of the raw material in the final stages of this process (Fig. 8N, O). These are delicate structures that would have been destroyed, or at least blunted or rounded, had the pendants been used for a longer period of time. If the other animal teeth, all unprocessed and unused, unearthed in the grave (51 items), are considered, the total number of deposited animal teeth which bear no clear traces of use is 90%. The presence of use-wear traces has been confirmed with a higher likelihood only for four pendants (13.8%; Fig. 4:2, 3, 12, 25) with best readability on the two final specimens of those listed (Fig. 8L, G, H). Three are too damaged or/and covered with a preservative substance to make it possible to verify if any use-wear changes are present on their surfaces.

The microscopic analysis has shown that the state of preservation of the artefacts that are part of the collection from grave 5 in Donkalnis is similar to that observed in grave 4 at this site.

However, it was far more difficult to conduct a functional interpretation in this case due to the general characteristics of the use-wear traces visible on the artefacts, which are poorly developed, and distributed quite evenly on the edges and inside the holes of the pendants. Due to the above, combined with the fact that the surface of these artefacts was highly stained with a mixture of ochre, contaminations, and a conserving substance (Fig. 9H, I) in the majority of the analysed cases, it was not possible to determine more conclusively if the visible surface modifications are poorly developed use-wear traces or only post-depositional changes. The interpretation of the examined damage was additionally hindered by the fact that there was only one pendant in the collection that could be considered unused to a high likelihood (Fig. 5: 26). This is possible due to the sharp edges and irregularities visible on the perforation of this pendant (Fig. 9J). However, this cannot be used as a reference sample for assessing the extent to which post-depositional processes affected bone products in the analysed grave, since its surface is particularly heavily damaged and covered with a preservative substance (Fig. 9I, J). For these reasons no attempt was made at devising a precise functional classification for each of the artefacts that make up this collection and only those where use wear is clear have been identified. In Donkalnis grave 5 there were four such specimens (Fig. 5: 2, 5, 8, 14), two of which (Fig. 5: 2, 8) were observed to bear well-developed use-wear marks (Fig. 9K). In the hole of one of the pendants (Fig. 5: 5), an obliteration caused by a cord is clearly visible (Fig. 9L).

4. Discussion

4.1. Pendants from Spiginas and Donkalnis from a zooarchaeological perspective

In the burial sites discussed, pendants were usually made from only a few animal species, mainly elk (38.2%), commonly aurochs/the bison (33.1%) and red deer (23%). The boar teeth were used to a much lesser extent (4.5%), and in a few cases (0.6%), the teeth of the roe deer and the dog or the wolf were employed. In Šventoji sites, coastal Lithuania, elk tooth pendants were the most numerous (45.6%), followed by pendants made of the teeth of the seal (26%), with aurochs/the bison and wild boar, each accounting for 10 %. Pendants made of bear, fox, and wolf teeth were also found (Osipowicz et al., 2020, Table 2). Thus, compared to Šventoji sites, the species diversity of Donkalnis and Spiginas pendants is lower. It is also lower than in Estonian Stone Age sites, where tooth pendants of four taxonomic groups of mammals - elk, mustelid, seal, and wild boar - are mainly found; however, teeth obtained from canids, bears, aurochs, wild horses, beavers, wild cats, and hares were also used (Jonuks & Rannamäe, 2018). In Zvejnieki, Latvia, pendants were made also from a wider range of animal species, although in the earliest middle Mesolithic graves, the range of species used for pendants was smaller, the most common being boar, elk, red deer, and aurochs (Eriksson et al., 2003; Larson, 2006; Zagorska & Lõugas, 2000).

This study involved an analysis of only four graves; for this reason, no reliable correlations could be made between the animal species and the sex or the age of the individuals buried in the graves. It can only be noted that at Donkalnis the male graves (graves 2 and 4) had more elk tooth pendants; grave 5 (child grave) was exceptionally rich in pendants made of red deer and aurochs/bison, and the female grave 4 in Spiginas had more wild boar pendants. However, the overall number of pendants in the latter was small.

4.2. The function of the pendants from Spiginas and Donkalnis

As discussed above the high level of surface contaminations of the analysed artefacts and the post-depositional changes on their surfaces combined with the method applied for conservation significantly hindered the analyses of the pendants from Donkalnis. Accordingly it was only possible to confirm previous research showing that in general terms both pendants which had long previous use and those which were unused were deposited in the early and middle Holocene graves at Donkalnis (cf. Osipowicz et al., 2023, where possible reasons for this situation are listed). This research has been unable to advance the interpretation of their pattern of distribution in the graves at this site.

More detailed data was provided by microscopic analysis of the pendants from Spiginas despite the fact that the use-wear traces observed on them are poorly developed. Studies on the manner in which use-wear polish is distributed in the perforations allowed interpretation of their use. The pendants were classified into three groups according to the findings of the experimental research conducted by the authors for the purpose of analysing this type of product~~s~~ (cf. Osipowicz et al., 2020). The following groups were distinguished: one loose pendant that corresponds to experimental group I (Fig. 2:1); three specimens (Fig. 2:2-4) that bear traces similar to those observed on the pendants from experimental group II (bracelets); and two artefacts (Fig. 2: 5, 6) that correspond to experimental group III in terms of use-wear traces (pendants on a leather band).

Here, it should be noted that the wear damage observed on all the artefacts from grave 4 in Spiginas are distributed asymmetrically, that is far more developed on one side of the perforations. This suggests that all the pendants from this grave were fixed to clothing, though the degree of 'tightness' of the ties varied. This would account for the observed differences in the traces particularly between the specimens of groups II and III.

4.3. Technological affiliation of the artefacts from Spiginas and Donkalnis: technological traditions in the manufacturing of animal tooth pendants in Central and Northeastern Europe in the early and middle Holocene

As a result of the traceological studies on the pendants from the sites in Spiginas and Donkalnis, it was identified that several methods for preparing cord attachment areas were employed. From identifying their percentages in individual collections, these methods can be classified into the following types:

Type 1. Basic method – applied in the majority of the cases (more than 60%);

Type 2. Secondary method – with a significantly high representation in the collection (10-40% of the cases);

Type 3. Marginal method – single cases of application (below 10% of the cases).

In the assemblages from Spiginas and Donkalnis graves 2 and 5, the basic method was M1.1, that is drilling with no prior preparation of the surface which was applied in 100%, 98.1%, and 82.5% cases respectively (cf. Table 3). In Donkalnis grave 4, method MI.3, was the basic method, applied in over 65% cases. In this assemblage, however, the Secondary method was M1.1, observed on 34.6% of the pendants. Marginal methods were M1.3 in Donkalnis, grave 2, and MII.1, MI.2, and MI.3 in Donkalnis, grave 5.

Tab. 3. Percentage and quantity (in brackets) contribution of distinguished methods of preparing cord attachment areas in Donkalnis and Spiginas and other included animal tooth pendant collections

	Sp4	Do2	Do4	Do5	Pu	Ku	Zv57	Zv164	Šv1	Šv2	Šv3	Šv4	Šv6	Šv23	Pi1	Ja
MI.1.	100 (7)	98,1 (51)	34,6 (9)	82,5 (33)	-	-	2,8 *4,6* (1)	-	-	-	-	25 (2)	43 (3)	24 (5)	89,8 (44)	100 (17)
MI.2.	-	-	-	7,5 (3)	-	-		-	-	100 (1)	-	25 (2)	43 (3)	67 (14)	10,2 (5)	-
MI.3.	-	1,9 (1)	65,4 (17)	5 (2)	-	-	-	-	-	-	-	-	-	-	-	-
MII.1.	-	-	-	2,5 (1)	-	-	18,9 *31,8** (7)	-	100 (1)	-	100 (1)	50 (4)	14 (1)	9 (2)	-	-
MII.2.	-	-	-	-	-	-	29,7 *50* (11)	75 (9)	-	-	-	-	-		-	-
MII.3.	-	-	-	-	-	-	8,1 *13,6* (3)	25 (3)	-	-	-	-	-		-	-
MIII.1.	-	-	-	-	100 (28)	100 (14)		-	-	-	-	-	-		-	-
MIII.2.	-	-	-	-	-	-	40,5 (15)	-	-	-	-	-	-		-	-
Others	-	-	-	2,5 (1)	-	-	-	-	-	-	-	-	-		-	-

Abbreviations used: Sp4 – Spiginas, grave 4; Do2, 4, 5 – Donkalnis, grave 2, 4, 5 ; Pu – Pulli; Ku – Kunda Lammasmägi; Zv57, 164 – Zvejnieki, burial 57, 164; Šv1, 2, 3, 4, 6, 23 – Šventoji 1, 2, 3, 4, 6, 23; Pi1 – Pierkunowo, grave 1; Ja – Janisławice;

* the percentage share without the MIII.2 method is marked in italics

This classification is also adopted for other pendant collections from early Holocene sites in the region subjected by the authors to traceological analyses (cf. Table 3). In Pulli and Kunda Lammasmägi, Estonia, the basic method (100%) is MIII.1. In the site in Janisławice, Poland, an analogous meaning was attributed to the method MI.1. Similarly in the collection from Pierkunowo 1 (Poland), M1.1 is the basic method (90%). The other specimens show cord attachment areas made using MI.2, which should be deemed a secondary method in this collection.

As for the pendants from burial 164 in Zvejnieki, the basic method is MII.2. (75%). The secondary method is MII.3, which accounts for all other pendants. Thus it is worth noting that if both these methods are to be considered jointly (the MII.2/3 variant specified in the introduction), the cord attachment methods in all cases were similar.

A specific situation was observed in the collection of animal teeth from burial 57 in Zvejnieki (cf. Table 3). The presence of a numerous group of products made using the MIII.2 method is noted, but their clear connection to serving as pendants has not been unequivocally confirmed. Once these artefacts are excluded, different variants of the 'carving method' (MII.1-3) predominate in the collection. However, none of them fulfils the criteria for the basic method, except for the MII.2/3 variant. In this assemblage, MI.1 is considered a marginal method.

An interesting situation was observed in the pendant assemblages from the site complex in Šventoji (Lithuania). At site Šventoji 23, the basic method is MI.2 (67% of the cases), MI.1 is the secondary method (24% of the cases), and the method MII.1 is marginal (Table 3). In the collections from other sites there were few pendants. At sites Šventoji 4 and 6 (Table 3), there was no clear basic method. Šventoji 6 produced seven pendants of which three were manufactured using methods MI.1 and three MI.2, each 43% of the assemblage, so both secondary methods, and one using method MII.1, so marginal (cf. Table 3).

The assemblage from Šventoji 4 comprised eight pendants, the cord attachment of four of which were formed using the MII.1 method, so 50%. Although the most prevelant method this cannot be regarded as a primary method for the site and should be treated as a secondary method together with methods MI.1 and MI.2 (Table 3) which account for the other pendants.

It is proposed that the data collected in this way can be complemented by relevant information provided in the literature and that an overview could allow for the identification of broad patterns in the ways in which animal tooth pendants were made in this part of Europe.

At site Yuzhniy Oleniy Ostrov, northwestern Russia, there is a clear prevalence of pendants manufactured using the MIII.1 method (Mannermaa et al., 2021). The situation is analogous to the Popovo cemetery, graves III and VIIII, Russia (Oshibkina, 2017). This method was also applied for making the only pendant discovered in the middle Neolithic graves at site Sakhtysh-IIa also in Russia (Kostyleva, 2018). As at Sakhtysh-II, younger Late Neolithic burials in this cemetery contained predominantly previously drilled pendants (Macāne, 2022).

In the vast majority of the 44 graves in Zvejnieki analysed by Larsson, there is a prevalence of pendants with cord attachment areas made using the MII method that is, in the very same manner like those of the above-mentioned artefacts from graves 57 and 164 at the same site (cf. Larsson, 2006). The exceptions here are the pendants from the oldest grave in the cemetery, grave 170, which were made using the MI method, and those from graves 24, 27, 29, 31, 33, and 74, where the basic method is MIII.1. At the site, there were also single burials for which no basic method can be determined, only secondary methods.

Based on photographic evidence (Macāne & Nordqvist, 2021, Fig. 9, p. 15), the pendants found in grave 15 at the burial site of Kreici, Latvia, were made most likely by 'carving methods' similar to the methods used at Zvejnieki.

In Poland, at sites Dudka and Szczepanki (cf. Gumiński, 2003, 2004), and a grave in Kamieńskie, site 1 (Łapo, 1998; Grężak et al., 1998) pendants whose cord attachment areas were formed by drilling, most likely the MI.1 method. A similar situation can be seen at German sites such as Bad Dürrenberg (Grünberg et al., 2016), Groß Fredenwalde (Terberger et al., 2015), Friesack 4, phase II (David, 2005a, 529, Pl. 55), and Hohen Viecheln, Horizon (David, 2005a, 518, Pl. 44), as well as Swedish sites such as Skateholm, (Larsson & Douglas Price, 2022), Ringsjöholm, Strandvägen, and Kanaljorden (Gummesson, 2018). Drilling was also the only method for creating cord attachment areas at sites Ulkestrup Lyng Øst II and Mullerup 1 (Sarauw's Island), however, in all the analysed specimens it was preceded by preparatory scraping of the surface (David, 2005a). A singular situation was observed at site Ajvide, Gotland, where in grave 62, additional to pendants with a drilled perforation there were numerous specimens with cord attachment areas made with a single broad cut on the tooth root in which an additional hole was occasionally drilled (Rainio & Mannermaa, 2014). This last method, that is without drilling, can be considered a derivative of MIII.1.

The data presented above appears to identify three technological traditions that express different approaches to making cord attachment areas in pendants made of animal teeth in the early and middle Holocene, in central and northeastern Europe (Fig. 10A). In order to verify this hypothesis it is necessary to consider whether the patterns do not arise from zoological or chronological factors.

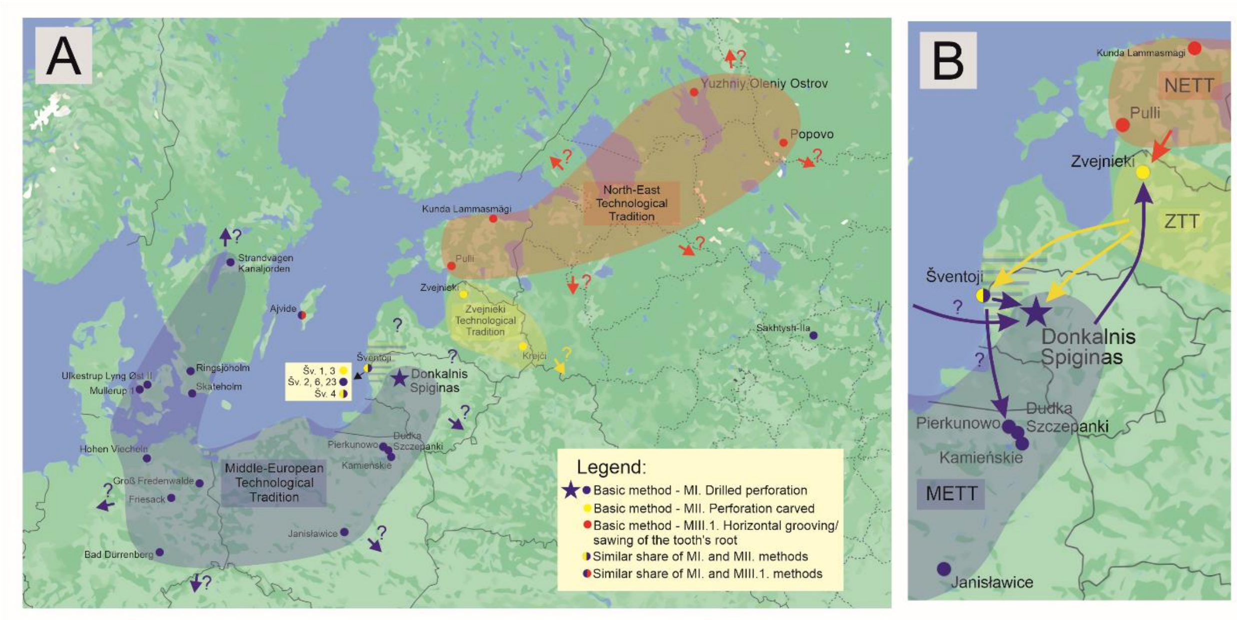

Fig. 10. Technological traditions in the production of animal tooth pendants in central and north-eastern Europe during the 6th and 5th millennia BC: A – technological classification of the archaeological sites mentioned in the article in terms of the basic method used to make places of cord attachment on the pendants from animal teeth. The geographical range of distinguished technological traditions. B - directions of influence between the distinguished technological traditions based on the results of traceological research.

At Spiginas and Donkalnis there is no variation in the methods applied among the pendants made of teeth of different species. In Donkalnis, grave 2, the dominant method, MI.1, was used for creating cord attachment areas on products made of teeth of a diverse range of animals, such as elk, aurochs/ bison, wild boar, and red deer (cf. Tables 1, 2). At grave 5 it was used to make pendants from teeth of red deer, aurochs/the bison, and elk. At Spiginas, grave 4, they were of elk and wild boar. The academic literature discloses a similar situation in sites across northeast Europe. For instance, in Kamieńskie, site 1, Poland, the MI method was applied to pendants made of teeth of aurochs, red deer, and wild boar (Łapo, 1998; Gręźak et al., 1998), whereas in Skateholm, Sweden, it was employed for processing teeth of red deer, wild boar, elk, bear, aurochs, and wolf (Larsson & Douglas Price, 2022). In Zvejnieki, grave 122-123, the MII method was used on pendants made from teeth of elk, wild boar, red deer and aurochs (Larsson, 2006), while in Pulli, Estonia, the method used was MIII.1 teeth of elk, wild horse, wolf, dog/the wolf, mustelids, and beaver.

No clear patterns based on zoological type could be discerned. Products made of elk teeth were manufactured using the MIII.1 method, for example at Yuzhniy Oleniy Ostrov, Russia (Mannermaa et al., 2021), Pulli (David, 2005b), and Sakhtysh-IIa, Russia (Kostyleva, 2018), using variants of the MII method at Šventoji, Lithuania (Osipowicz et al., 2020), Kreiču (Zagorskis, 1961), and Zvejnieki, Latvia (Osipowicz et al., 2023), and using the MI method, for example at Kamieńskie (Łapo, 1998; Grężak et al., 1998), Sakhtysh-IIa (Kostyleva, 2018) and Šventoji, Lithuania (Osipowicz et al., 2020). The situation is similar for the pendants made of red deer teeth, whose cord attachment areas were manufactured using methods from the MI group, such as at Skateholm (Rainio & Tamboer, 2018; Larsson & Douglas Price, 2022), Groß Fredenwalde (Terberger et al., 2015) and Kamieńskie (Łapo, 1998; Grężak et al., 1998), from the MII group, such as at Kreiču (Zagorskis, 1961) and from the MIII group such as at Zvejnieki, graves 7, 93, and 147 (Macāne, 2022, Table 6.5, 190-191). A third example shows that wild boar teeth were scraped and drilled, MI.2, grooved, MII, or drilled, MI.1. In some cases this variety is visible even within the same site complex, as at Šventoji, Lithuania (Osipowicz et al., 2020). A significant number of wild boar teeth were also manufactured using the MIII.1 method, e.g., Zvejnieki, graves 24, 27, 31, 32, 33, 37, 43, 51, 62, 74, 93, 100, 108, 190 (Macāne, 2022, Table 6.8., 207-210), or Sakhtysh IIa, grave 56 (Macāne, 2022, 213).

A chronological analysis of cord attachment methods appears to demonstrate the existence of deep regional traditions (Table 4). MIII.1 was the basic method employed in the northeastern part of Europe as early as the second half of the 10th millennium cal BC, as confirmed by the oldest dating results for the site in Pulli, Estonia (c. 9300-8200 cal BC; David, 2005b) and for the cemetery in Popovo, Russia (9300-8450 cal BC; Oshibkina, 2017). It was the basic method used in the 7th millennium cal BC, as shown by the chronology of site Yuzhniy Oleniy Ostrov (c. 6250–6000 cal BC; Mannermaa et al., 2021), and probably even later, that is in the 5th and in the beginning of the 4th millennium cal BC, as indicated by the presence of this type of pendant in the middle Neolithic horizon at site Sakhtysh-IIa (Kostyleva, 2018). Unfortunately, it is not possible (at this moment) to determine the exact chronology of the pendants made using the MIII.1 method from the Kunda Lammasmägi site in Estonia (Sander, Kriiska 2015).

In the area of the present-day Latvia, methods from the MII group dominated the manufacture of animal tooth pendants at least from the beginning of the 6th millennium cal BC, see graves 57 and 76 at Zvejnieki (5750-5250 cal BC and 5978-5656 cal BC – Table 4; cf.-Larsson, 2006; Zagorska et al., 2018; Osipowicz et al., 2023). Unfortunately, there is no data from this area that would allow interpretation of earlier patterns. In grave 170 at Zvejnieki which is over 1000 years older, only drilled pendants were found (cf. Table 4; Larsson, 2006). However, this collection is 'unique' (singular), which makes it difficult to determine conclusively the degree to which it reflects the general situation. MII continued to dominate until the Zvejnieki burial ground stopped being used in approximately the mid-3rd millennium cal BC (Mannermaa et al., 2021). Relative dating results show the 4th millennium BC for graves containing pendants made in this manner at the site in Kreici (Zagorskis, 1963; Macāne & Nordqvist, 2021).

In the lowland part of central Europe, predominantly pendants made using methods from the MI group were identified. Their dominant importance was confirmed by numerous dating results (cf. Table 4), for the period from the 8th millennium cal BC, e.g., Mullerup 1 (8198-7520 cal BC; David, 2005a) until the end of the 5th millennium cal BC, e.g., Szczepanki (4329-4054 cal BC; Gumiński, 2004) and Donkalnis, grave 5 (4313-4001 cal BC; Butrimas, 2012, 2016). This chronology can be revised to the mid-3rd millennium cal BC if dating results are considered from Šventoji and Ajvide, where pendants made with this method are prevalent in some collections.

The above research suggests that central and northeastern Europe in the 6th and the 5th millennium cal BC three main technological traditions of cord attachment methods can be distinguished which can be identified as the North-East Technological Tradition (NETT), the Zvejnieki Technological Tradition (ZTT), and the Middle European Technological Tradition (METT). In line with the present state of research, they cover the following areas (cf. Fig. 10A):

North-East Technological Tradition (NETT): the northern areas of the East European Plain, from and including the region of Lakes Onega and Lacha in the east to Estonia in the west;

Zvejnieki Technological Tradition (ZTT): northeastern Latvia;

Middle-European Technological Tradition (METT): the central part of Lithuania, the Polish Lowlands and the lowlands in the eastern part of Germany, Zealand, and southern Sweden.

Table 4. List of sites mentioned in the text, along with detailed information about their chronology and basic method of cord attachment (the bold lines divide given geographical regions).

Site	Type	Basic method of preparing places of cord attachment	Chronology	Gender of the buried	References
Popovo, Grave VIII	Cemetery	MIII.1	9520±140 (GIN-10210) 9265-8483 cal BC	Male (20 yr old)	Oshibkina 2017
Popovo, Grave III	Cemetery	MIII.1	9520±130 BP (GIN-4442) 9253-8550 cal BC	Male (50-60 yr old)	Oshibkina 2017
Pulli	Settlement site	MIII.1	c. 9300-8200 cal BC	-	David 2005b
Kunda Lammasmägi	Settlement site	MIII.1	8700-1900 cal BC	-	Sander, Kriiska 2015
Yuzhniy Oleniy Ostrov	Cemetery	MIII.1	c. 6250–6000 cal BC	Varied	Mannermaa et al. 2021
Sakhtysh-II, IIa	Cemetery	MI	c. 5th–4rd millennium cal BC	Varied	Kostyleva 2018 Macane 2022
Zvejnieki, grave 170	Cemetery	MI	8150 ± 80 BP 7460-6831 cal BC	Adult male	Larsson 2006
Zvejnieki, grave 74	Cemetery	MIII.1	7165±30 BP 6050-5650 cal BC*	Adult female	Larsson 2006 Zagorska et al. 2018
Zvejnieki, grave 57	Cemetery	MII	6825±60 BP (Ua-3636) 5838-5624 cal BC 5750-5250 cal BC*	Adult female	Zagorska et al. 2018 Osipowicz et al. 2022
Zvejnieki, grave 76	Cemetery	MII	6900 ± 75 BP 5978-5656 cal BC	Adult female	Larsson 2006
Zvejnieki, grave 122-123	Cemetery	MII	6395 ± 75 BP 5481-5214 cal BC	Aldult+Infans	Larsson 2006
Zvejnieki, grave 164	Cemetery	MII	5230±95 BP (Ua-15544) 4326-3801 cal BC	Adult male	Osipowicz et al. 2022

Kreicĭ, grave 15	Cemetery	MII	Hunter-gatherer c. 4th millennium BC	Child	Zagorskis 1961 Macane, Nordqvist 2021
Mullerup 1 (Sarauw's Island)	Settlement site	MI	8330±110 BP 7580-7080 cal BC 8660±120 BP 8198-7520 cal BC	-	David 2005a
Ulkestrup Lyng Øst Ii	Settlement site	MI	8180±100 BP 7511-6834 cal BC 8030±140 BP 7450-6596 cal BC	-	David 2005a
Hohen Viecheln, Horizon C	Settlement site	MI	Early Boreal. Early Mesolithic (Maglemose)	-	David 2005a
Friesack 4, Phase Ii	Settlement site	MI	Early–Middle Boreal. Early Mesolithic (Maglemose)	-	David 2005a
Bad Dürrenberg	Burial	MI	7080–6230 cal BC	Adult woman	Grünberg et al. 2016
Ringsjöholm	Settlement site	MI	c. 7000–6000 cal BC	-	Sjöström 1997; Gummesson 2018, 34
Pierkunowo, grave 1	Burial	MI	7600±45 (GdA-5131) 6571-6386 cal BC 7575±50 (OxA-26260) 6567-6260 cal BC	Female (35–39 yr old) + 3-yr-old child	Piotrowska et al. 2019 Sulgostowska 2019
Groß Fredenwalde	Burial	MI	6500 - 6300 cal BC	Multiple burial	Terberger et al. 2015
Spiginas, grave 4	Burial	MI	7470±60 BP (GIN-5571) 6442-6227 cal BC	Female (30-35 yr old)	Butrimas 2012
Donkalnis, grave 2	Burial	MI	7405±45 BP (CAMS-85221) 6400-6089 cal BC	Male (20-25 yr old)	Butrimas 2012
Kamieńskie, site. 1	Burial	MI	6940±280 BP (Gd-9766) 6406-5371 cal BC	Infans II/Iuvenis	Łapo 1998 Sulgostowska 2016

Strandvägen	Settlement site	MI	c. 6000–4500 cal BC	-	Gummesson 2018, 36
Donkalnis, grave 4	Burial	MI	6995±60 BP (OxA-5924) 5987-5742 cal BC	Male (50-60 yr old)	Butrimas 2012
Kanaljorden	Settlement site	MI	c. 5900–5500 cal BC	-	Gummesson 2018, 36
Janisławice	Burial	MI	6580±80 (Gd-2432) 5642-5374 cal BC	Male (30 yr old)	Sulgostowska 2016
Skateholm I, II	Cemetery	MI	c. 5200 - 4800 cal BC	Varied	Larsson, Price 2022
Szczepanki	Settlement site	MI	c. 4490 - 4050 cal BC	-	Gumiński 2004 Gumiński 2011
Donkalnis, grave 5	Burial	MI	5313±35 BP (Poz-57706) 4313-4001 cal BC	Children (7 yr old and 5 yr old)	Butrimas 2012 Butrimas 2016
Dudka	Settlement site	MI	Leyer with the Late Neolithic, Trench III c. 3960 - 2620 cal BC	-	Gumiński 1998 Gumiński and Fiedorczuk 1990
Šventoji 1	Dwelling site	MII	3200–2500 cal BC	-	Osipowicz et al. 2020
Šventoji 2	Dwelling site	MI	3200–2500 cal BC	-	Osipowicz et al. 2020
Šventoji 3	Dwelling site	MII	3200–2500 cal BC	-	Osipowicz et al. 2020
Šventoji 4	Dwelling site	MI and MII	3200–2500 cal BC	-	Osipowicz et al. 2020
Šventoji 6	Dwelling site	MI.	3200–2500 cal BC	-	Osipowicz et al. 2020
Šventoji 23	Dwelling site	MI	3200–2500 cal BC	-	Osipowicz et al. 2020
Ajvide	Cemetery	MI and MIII.1	c. 2900-2300 cal BC	varied	Rainio, Mannermaa 2014

Here, it is worth drawing attention also to the situation at sites in Šventoji, Lithuania. They are characterized by a mixed technological tradition with a high percentage of ZTT and METT elements as well as a significant percentage of applications of the MI.2 technique not recorded elsewhere (Table 3). The sites in Šventoji are of a settlement nature though, and the context of the pendants is unclear (Osipowicz et al., 2020). Identifying a local variant might be possible if the pendants can be attributable to dated grave collections.

The beginnings of NETT and METT can be dated back to at least the eight millennium BC but no evidence is available for ZTT until the sixth millennium BC.

It is acknowledged that the geographical ranges of the technological traditions differentiated here are provisional. The biggest issue here lies in NETT, which covers a vast area, with data from only four sites, Pulli and Kunda Lammasmägi in Estonia and Yuzhniy Oleniy Ostrov and Popovo in Russia, at considerable distance from each other. Unfortunately, there are no other early Holocene collections of artefacts involving animal tooth pendants known from this region that have been subjected to technological analyses. Publishing such studies could consequently verify the conclusions made in this article.

If the above classifications are applied to the technological classification of bone industries in early Mesolithic Europe introduced by E. David (2007) for the period between Late Preboreal and the Boreal-Atlantic transition, that is preceding the solidification of ZTT, the technological traditions of NETT and ZTT cover the area that belongs to the North-East Technocomplex, whereas METT includes areas that are within the eastern range of the Northern Technocomplex, the southwestern range of the North-East Technocomplex, and the 'no man's land' in between (cf. David, 2007, p. 43, Fig. 10).

4.4. Intergroup contacts of the early and middle Holocene hunter-gatherer communities of the western part of the East European Plain visible

The wider archaeological evidence, particularly in the Baltic Sea area, suggests contact between early and middle Holocene peoples representing different technological traditions and that there was a flow of ideas and an exchange of goods. This is visible, for example, in the distribution and manufacture of slotted bone tools, the shaft-wedge-splinter technique used in bone processing

(Hartz et al., 2010; Bergsvik & David, 2015; Manninen et al., 2021), and the conical core pressure blade concept (Sørensen et al., 2013). The exchange of some items was sometimes exceptionally long-range, as shown by research on the *bâton percé* from site 47 in Gołębiewo, Poland (Osipowicz et al., 2017). Concepts and ideas were followed by people who transfered cultural content to other communities, sometimes with very different visible cultures. Direct evidence for such migrations is provided by isotope studies, such as the strontium stable isotope study conducted for the site in Donkalnis. Owing to the study results, it was possible to suggest a non-local origin for at least four individuals from 11 buried in that grave field (cf. Piličiauskas et al., 2022, this topic is further elaborated on below). Similar results were obtained for many other early Holocene hunter-gatherer sites in various parts of Europe (cf. Grünberg, 2017), such as Téviec and Hoëdic, France (Schulting & Richards, 2001), Lepenski Vir and Vlasac, Serbia (Borić & Price, 2013), or Tågerup (Ahlström, 2003), Østenkær (Enghoff, 2011) or Henriksholm-Bøgebakken (Brinch Petersen, 2015), Denmark.

When people were migrating, it appears that they took objects which later became burial goods. Such goods should mark burials which stand out from the local 'background' (cf. Borć & Price, 2013), as those of individuals who did not have the opportunity or the time to culturally integrate. Such graves should be characterised by the presence of a basic method for making cord attachment areas different to the local technological tradition. In turn, the ongoing cultural integration of 'outsiders' should be visible as a gradual loss of percentage, suggesting loss of meaning of the basic method of their origin, to the benefit of the tradition of the local community, and other signs such as damaged pendants being replaced with new ones made using the local technology. The assemblages from such graves might show equalisation of the rank of the technological traditions related to the source community and that of the target community, thus gaining the status of secondary methods, with no basic method identified for the collection. The echoes or remnants of this type of cultural integration would be identifiable in the marginal methods, in the single pendants made using a technological tradition different to the local one, a remnant of the past, occasional exchange, migrants' clothing from their homeland, or parents or grandparents of a member of a local community who came from a 'technologically' different group of people.

4.4.1. Spiginas and Donkalnis

The above hypothesise allow a starting point for discussing the results of the technological studies on the pendants from Spiginas and Donkalnis presented in this article in the context of the findings provided by the isotope analyses performed for these sites (Piličiauskas et al., 2021, 2022).

The Mesolithic burial from Spiginas presents a clear picture in that both the results of the technological studies presented here and the findings of the isotope analyses show that the hunter-gatherer buried there was a local. Interpretation of the cemetery at Donkalnis is far more problematic.

In the light of the results of $^{87}Sr/^{86}Sr$ isotope analyses, the individual from grave 2 at Donkalnis was classified as a ‘non-local’, and his homeland was suggested as Fennoscandia. At the same time, it was suggested that the most probable region he came from is the northeastern Baltic region, most likely Finland or Karelia. This assumption was based specifically on the absence of direct evidence for the Baltic Sea being crossed by early Holocene hunter-gatherers, between the Scandinavian Peninsula and the area of the present-day Lithuania, Latvia, and Estonia, as opposed to the relatively small distance between Lithuania and Finland, that is the shortest distance to an area whose isotope parameters correspond to those of Donkalnis, grave 2. However, this hypothesis is not supported by the results of the technological analyses described here. In that grave there were only pendants made using the MI.1 technology, which allows this assemblage to be considered a typical example of METT. Unfortunately, it is not possible to determine the technological tradition of the area of present-day Finland as no early Holocene animal tooth pendants have been preserved there due to unfavourable soil conditions (Ahola, 2017), however, even assuming that this area is proved linked to METT, migrating from there to the area of the present-day Lithuania would have entailed crossing a region of two different technological traditions, specifically, NETT and ZTT (cf. Fig. 10A). Most likely, that would result in some transfer of ideas/artefacts from that environment, particularly in the case of repeated migration, as suggested by the results of the isotope studies. Evidence of such contact was not observed in Donkalnis, grave 2. It is suggested that as an alternative interpretation, this individual came from the area of the present-day southern Sweden. This region corresponds to the $^{87}Sr/^{86}Sr$ values obtained for grave 2 in Donkalnis and is situated within the range of the well-developed METT (cf. Fig. 10A). The possible route of this migration would run across Gotland, where the use of methods from the MI group has been confirmed (Rainio & Mannermaa, 2014), located around 90 km from the coast of Sweden. The time it took to cover this distance using the means and the knowledge of boatbuilding available in the early Holocene is estimated at approximately 38 hours (Pydyn, 2015), suggesting the minimum time required for navigating from Gotland to the coast of the present-day Latvia (about 130 km) would be approximately 55 hours. It is acknowledged that there is no direct evidence of such crossings at this time, but equally this hypothesis cannot on present research be ruled out.

To date the individual buried in Donkalnis, grave 4 has not been subjected to any isotope testing. Results from such testing could add significantly to this research since the basic method for forming cord attachment areas in the burial in question is MI.3 a method that has not been recorded at any other site covered in this study (cf. Table 3). Importantly, it is not prevalent in the other collections from Donkalnis and, therefore, it cannot be deemed an example of the local technological tradition, but it is, marginally, present there. This likely indicates that the community was in contact with another group of hunter-gatherers in which MI.3 served as the basic method and that the individual buried in grave 4 probably comes from that group. This hypothesis could be verified or disproved if isotope results were available.

Comparison of this technological research and the findings of the isotope analyses for the Mesolithic grave 5 in Donkalnis is interesting. The first two measurements of the $^{87}Sr/^{86}Sr$ ratios fit well with the local baseline so that this individual could have been born close to the Donkalnis cemetery. However, according to further measurements, in very early childhood, he/she migrated to the seashore, a distance of 85 km, and then, before death, returned to the Donkalnis area at the age of about 7 years. Importantly, 7.5% of the pendants unearthed in the grave (3 specimens) are products made using the MI.2 method, the application of which, aside from this grave and site Pierkunowo 1, Poland, has only been identified in the site complex in coastal Šventoji (Table 3). Additionally, grave 5 contained two pendants, originally manufactured using the MII.1 method, which is typical of ZTT; however, at Šventoji, this method constitutes a very significant component, too. Therefore, in the case of Donkalnis, grave 5, the results of the isotope tests and the technological studies are consistent and show migration of the children buried there, who came from the coastal area of Šventoji. However, it should be noted that no animal tooth pendants were found in in the Šventoji settlement site in contexts of a similar age to grave 5 and the classification is based on younger artefacts (Osipowicz et al., 2020). Significantly, one of the grooved pendants unearthed in the discussed burial shows clear marks of correcting the original perforation made using MII.1, a method that was foreign in Donkalnis, by local drilling, which is typical of the METT (Fig. 5: 28; 9E, F). Most likely, this pendant is an example of converting or repairing an imported object by a person who favoured the local technological traditions.

4.4.2. Other sites in the region

These analyses (Table 3) and the literature data collected for the purpose of this research show many directions of possible intercultural influences, exchange and migration in Central and Northeastern Europe in the early and middle Holocene. The most significant of them, from the technological analyses, are presented in Fig. 10B. At Šventoji, the evidence suggests that a specific local technological tradition formed, syncretising local elements, the MI.2 method, and those originating in METT and ZTT. The MI.2 method is clearly present also at the site in Pierkunowo, grave 1, Poland, where it occurs as a secondary method (Table 3). This complex is around 500 years older than the oldest dated site in Šventoji (Table 4), which makes it impossible to link conclusively these two places. The area of Šventoji cannot be definitively ruled out as the source area of possible influences that are seen at Pierkunowo, but the extent of the use of the MI.2 method at Šventoji cannot be identified with the accuracy available in other early or middle Holocene sites in Central and Northeastern Europe. It also cannot be ruled out that the MI.2 method was first used in Poland in the Mesolithic in a completely independent manner.

Here, it is worth adding a few words about the Zvejnieki burial ground. The use of the MIII.2 method on the inventory from grave 57 (cf. Table 3) shows influence from the NETT environment (cf. Osipowicz et al., 2023). There is other, more direct evidence for this type of contact at this site. Arguably the most significant is the series of female and child burials with a dominant, nearly 100%, use of methods from the MIII.1 group for making pendants out of animal teeth (graves 24, 27, 29, 31, 33, and 74, cf. Larsson, 2006). All these graves, except for feature 74 approximately 15 metres away from the main group, form a dense concentration on the west end of the grave field, with burials 27, 29, 31, and 33 being part of two mass graves situated next to each other (cf. Zagorskis, 1987, pp.12-13, Fig. 3). Arguably it is likely that these are a group of related people, newcomers or outsiders, from the NETT environment, buried in a dedicated part of the cemetery, on its border, and outside the burial zone for members of the local community linked to the ZTT. Considering that these are female and child graves only, it can be suggested that these are features of an inter-group exchange as suggested for several early Holocene hunter-gatherer sites such as Téviec and Hoëdic, France (Schulting & Richards, 2001), or Lepenski Vir and Vlasac, Serbia (Borić & Price, 2013). This important issue could possibly be solved by $^{87}Sr/^{86}Sr$ isotope content or aDNA analysis at Zvejnieki, which it is hoped will be conducted in the near future and cover also other burials in that burial ground that are 'mixed' in terms of technological tradition.

5. Conclusions

It is argued that the classification system developed within this research for methods used for making cord attachment areas on animal tooth pendants, taken together with the technological traditions evidenced in the wider source material allows the possiblity of precisely classifying early and middle Holocene sites (ca. 9500-2300 cal BC) in Central and Northeastern Europe in this respect. It seems also valid to claim that the identification of "secondary" and "marginal" methods can serve as a sound premise for a discussion on intergroup contact and of the flow of goods and people between groups with different technological cultures. It is considered that comparison of the results of the technological studies performed on the pendants from Spiginas and Donkalnis with the findings of the isotope analyses conducted on the dead buried in these burial grounds have significantly advanced research in this area. The results from the burials in Spiginas and grave 5 from Donkalnis appear to complement each other and the results from Donkalnis, grave 2, have allowed an interesting and far-reaching interpretation of migration directions in the early Holocene.

These results are limited by a small source database. It is proposed that traceological research on the animal tooth pendants from the region should be intensified and interdisciplinary research be prioritised to allow a larger body of results to be correlated with findings of palaeobiological research, particularly isotope analyses. However, considering the research results reported in this article, it can already be suggested that generally, studies on the mobility of prehistoric communities based on technological (traceological) analysis of artefacts are prospective. They can provide extremely interesting information on this issue, and can be a good platform for verifying research in this area conducted using paleobiological and other methods.

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