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EARLY MESOLITHIC BONE ARROWHEADS FROM THE VOLGA-OKA INTERFLUVE, CENTRAL RUSSIA

Abstract

Several different types of bone arrowheads were produced and used during the Early Mesolithic in the Volga-Oka interfluve. In this paper, recent research on these artefacts is reviewed, and their means of manufacture and ways of use determined through microscopy and experimental research. The research highlights the skill of the Early Mesolithic inhabitants of the Volga-Oka interfluve in manufacturing bone arrowheads, used for hunting various animals. A similarity was observed between the flint industry of pre-boreal sites of the Volga-Oka region and those of southern Finland, especially with respect to tanged flint arrowheads. The similarity suggests that the Early Mesolithic population of southern Finland and Karelian Isthmus most probably produced and used bone arrowheads similar to those described in the article. However, because bone artefacts are generally missing in the latter regions because of acrid soils, the conclusion should be regarded as a working hypothesis.

Keywords: Early Mesolithic, bone, projectile points, Upper Volga, eastern Baltic, southern Finland

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INTRODUCTION

Excavations of peat bog sites in the Volga-Oka interfluve during the last three decades have produced rich lithic, bone and antler industry associated with reliably dated find layers. These materials show that various types of bone arrowheads played a very important role in the hunting equipment of the inhabitants of the region during the Mesolithic. Since the publication of first works devoted to Mesolithic bone industry of the Volga-Oka area (Zhilin 1993; 2001; Lozovskiy 1996), a significant amount of new research on the topic has been carried out. The aim of this article is to present the results of recent research particularly on bone arrowheads from Early Mesolithic sites of the region.

During the past few decades, a number of Early Mesolithic sites have been discovered and excavated in southern Finland and on the Karelian Isthmus. These sites, dated by AMS radiocarbon to c 9500–9200 BP have produced artefacts made of local lithic raw materials, mainly quartz, as well as imported high-quality Cretaceous and Carboniferous flint (Takala 2004; Hertell & Tallavaara 2011; Manninen & Hertell 2011). The flint industry of these sites has been compared to sites like Pulli in the eastern Baltic region, as well as early sites belonging to the Butovo culture in the Volga-Oka interfluve. The types of flint artefacts and technology of flint processing indicate that the pioneer population came to southern Finland from territories to the south and to the east of the country (Zhilin 2002; 2003a; Takala 2004; 2009; Jussila et al. 2007; 2012; Gerasimov et al. 2010).

The sites in Finland and on the Karelian Isthmus are located on sandy soils, where organic materials are not preserved, and thus we do not know the bone industry which, judging by the lithic artefacts, was surely present at these sites during the time of their habitation. However, finds of bone artefacts from Antrea Korpilahti (Pälsi 1920)

– dated to the same time as above-mentioned sites (Matiskainen 1996) – indicate the existence of a bone industry on the Karelian Isthmus during the Pre-boreal period. Likewise, as noted, the great similarity of tanged flint arrowheads and inserts from Early Mesolithic sites in southern Finland (such as Lahti Ristola and Saarenoja 2) with contemporary finds in the eastern Baltic and the Volga-Oka region suggests that bone arrowheads similar to ones from Early Mesolithic sites of these regions were probably produced and used in southern Finland and on the Karelian Isthmus as well, even if as present this should only be regarded a working hypothesis.

MATERIALS AND METHODS

Early Mesolithic Upper Volga sites with bone industry

A number of Early Mesolithic sites that have yielded well-preserved bone artefacts, including bone points, have been excavated in the forest zone of northern Eurasia. The sites are dated by pollen analysis to the Pre-boreal period and radiocarbon dates indicate an age of c 10 000–9000 BP (c 9600–8500 calBC). Some of the better known sites include Starr Carr in England (Clark 1954), Friesack in northern Germany (Gramsch 1990; 2000; 2004), Lundby in Denmark (Henriksen 1980; Hansen 2003), Zvejnieki 2 (Zagorska 1980; 1993; Zagorska & Zagorskis 1989) and Sūļagals (Loze 1988) in Latvia, Pulli in Estonia (Jaanits & Jaanits 1975; 1978), and the sites of Beregovaya 1 and 2, Shaytanskaya cave, and the Lobvinskaya cave in the Trans-Urals region of Russia (Chairkin & Zhilin 2005; Savchenko 2014) (Fig. 1). A comparison of bone arrowheads from the Volga-Oka area with these materials will be carried out in the discussion section below.

Before the year 1990, the Mesolithic of the Volga-Oka interfluve was mainly represented by sites on dry land, where organic materials were not preserved. Several archaeological cultures, the most significant of which are known as Butovo and Ienevo, were identified and characterised based on of the flint industry recovered from dry land sites (Kol'tsov 1989). Only three Mesolithic sites with bone artefacts were excavated in the region before 1989 (Kraynov & Khotinskiy 1984; Kol'tsov & Zhilin 1999). The situation has changed drastically since 1990, as more than

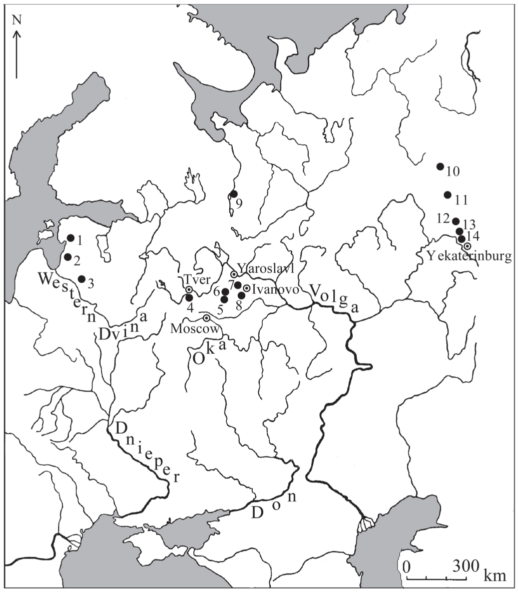

Fig. 1. Mesolithic sites with bone arrowheads mentioned in the text: 1 – Pulli; 2 – Zvejnieki 2; 3 – Sūļagals; 4 – Ozerki 16; 5 – Berendeyevo 18; 6 – Ivanovskoye 3 and 7; 7 – Stanovoye 4; 8 – Sakhtysh 9 and 14; 9 – Veretye 1; 10 – Shaytanskaya cave; 11 – Lobvinskaya cave; 12 – Koksharovsko-Yur'inskaya 1 and 2; 13 – Beregovaya 1 and 2; 14 – Shigir peat bog. Drawing: M.G. Zhilin.

thirty peat bog sites with Mesolithic find layers have been discovered and sixteen of them have been excavated (Lozovskiy 1996; Zhilin 2001). Altogether thirteen of the sites are associated with the Butovo culture, one with Resseta culture, one with Ienevo culture, while the cultural affiliation of one site is still not certain.

Sites belonging to the Butovo culture have produced abundant finds, including faunal and floral remains and various artefacts made from stone, bone, antler, wood and other organic materials. Reliable stratification and good preservation of organic materials have enabled an extensive program of pollen analyses and ^{14}C-dating. As a result, we now have a good sequence of reliably dated sites and find layers covering the entire Mesolithic period, from the very beginning of the Holocene up until the early Atlantic period (Zaretskaya et al. 2005; Zhilin 2009). Excavations of these sites have brought to light a rich and highly developed bone industry, which played a very important role in subsistence strategies and everyday life of the Mesolithic population of the region.

The main categories of Butovo bone industry include various types of weapons, including projectile points (especially arrowheads but also some spear- and lance heads), daggers and hunters' knives. Other tools include fishing hooks, knives for processing flesh, fish and hides; awls; needles and needle cases; various scrapers; axe blades, adze blades and sleeves for their mounting; chisels, gouges and wedges; beaver mandible tools used for carving, whittling and scraping wood; picks; punches and pressure flakers; personal ornaments and figurines of animals and fantastic creatures (Zhilin 1993; 2001; 2013; Lozovskiy 1996). The present article, however, deals with only one aspect of this bone industry, namely Early Mesolithic bone arrowheads.

Six of the Early Mesolithic peat bog sites of Butovo culture in the Volga-Oka interfluve have produced bone and antler artefacts, including arrowheads (Kraynov & Khotinskiy 1984; Kraynov et al. 1990; Zhilin 1998; 2001; 2003b; 2006a&b; 2007a&b; 2009; 2013; 2014). All are situated at large peat bogs, discussed below, which developed as a result of the paludification of ancient lakes.

Podozerskoye peat bog (Fig. 1:7) is located between the cities of Ivanovo and Yaroslavl. This peat bog emerged when a glacial lake about 5 x 3 km in size was overrun by vegetation, as indicated by the spread of gyttja deposits under the peat. The River Lakhost' connects it with the Upper Volga via the Kotorosl' River. Four Mesolithic sites were discovered in the area of the bog. For the present study the site of Stanovoye 4 is the most interesting one, because it produced two Early Mesolithic find levels with rich bone industry, while the other sites yielded only Late Mesolithic and Neolithic finds. The site occupies a gentle slope of a promontory at the outlet of the river flowing out from the bog (an ancient gulf of a lake) and a boggy area just below it.

An area of about 450 square metres was excavated at Stanovoe 4 under the direction of M.G. Zhilin in 1992–2002. The lower (IV) layer at the site is the earliest known site belonging to the Butovo culture. Pollen data place this layer to the end of the Younger Dryas (Aleshinskaya 2001), and ^{14}C-dates range from 10300±70 BP (GIN-10112 II) to 9690 ±230 BP (GIN-10112 I). However, the majority of the ^{14}C-dates fall between 10060±120 BP (GIN-10127 I) and 9741±40 BP (KIA-39317). They assign the lower (IV) layer of the site to c 9600–9200 calBC (Zaretskaya et al. 2005; Hartz et al. 2010; all dates in this paper are calibrated using OxCal v. 3.9; Bronk Ramsey 2003). Bone and antler artefacts from the lower layer of Stanovoye 4 include arrowheads, lance points, a broken slotted dagger, elk scapula knives; narrow knives with rounded end; antler axe and adze blades and sleeves for mounting; awls; long side scrapers; beaver mandible tools; antler pressure-flakers and a punch; a wedge; fragments of preforms and worked bone; and an a perforated, ornamented disk made of antler (Zhilin 2001).

Layer III in trench 3 at Stanovoye 4 is dated to the second half of the Pre-boreal period by pollen (Aleshinskaya 2001), and between 9413±50 BP (KIA-35154) and 8799±44 BP (KIA-35158) by radiocarbon, or c 8800–7700 calBC (Zaretskaya et al. 2005; Hartz et al. 2010). Bone and antler artefacts include various arrowheads, barbed points, harpoon head fragments, spearheads and lance heads, daggers and hunters' knives, and fishing hooks. Numerous bone and antler tools related to domestic activities were also found: knives, scrapers, perforated plates for dragging sinew; awls, needle cases, chisels-knives-scrapers made of beaver mandibles; antler axe and adze blades and sleeves for their mounting, narrow bone chisels, punches and a pressure flaker. Personal ornaments include various tooth pendants and flat rectangular perforated pendants (Zhilin 2001).

Ivanovskoye peat bog (Fig. 1:6) is located about 150 km to the northeast of Moscow, in the midstream of River Nerl', which during the Stone Age ran through a large lake, connecting it with the Klyaz'ma River (the left tributary of the Oka River). Ten sites have been discovered in the bog. Of these, Ivanovskoye 7 is the most interesting for the current study, because it produced an Early Mesolithic find layer with rich bone industry sealed by gyttja and peat deposits. The site has been excavated on two occasions: first by D.A. Kraynov, who excavated 106 square metres in 1974–75, followed by M.G. Zhilin in 1992–97 with excavations that covered a total area of 332 square metres (Zhilin et al. 2002).

The site has three Mesolithic and two Neolithic cultural layers. The Mesolithic settlements occupied a low promontory during lake regressions, which was submerged during transgressions. The lower, Early Mesolithic (IV) layer at Ivanovskoye 7 is dated by radiocarbon between 9650±110 BP

(GIN-9520) and 9640±60 BP (GIN-9516), the calibrated range being c 9200–8800 calBC (Zaretskaya et al. 2005). Pollen dating places it to the first half of Pre-boreal period, before its optimum. During the middle Pre-boreal transgression that took place approximately 9600–9500 BP, the site was submerged and the find level was sealed with a layer of gyttja. Bone and antler artefacts include various arrowheads; fragments of spearheads and lance heads; barbed points and harpoon heads; daggers; fishing hooks; various knives; awls; scrapers; planes; axes, adzes and sleeves for their hafting; gouges; chisels; punches, and personal ornaments. Many of the items are decorated by various geometric designs (Kraynov & Khotinskiy 1984; Zhilin 2001; Zhilin et al. 2002).

The site of Ivanovskoye 3 is situated on a small island 2 km to the southeast of Ivanovskoye 7. A Late Mesolithic and several Neolithic find levels were excavated there in an excavation trench of about 160 square metres (Kraynov & Khotinskiy 1984). However, in one part of the trench three bone arrowheads were discovered buried deep in the lake bottom and under the Late Mesolithic layer (Oshibkina et al. 1992: Fig. 51:2). They find close analogies among Early Mesolithic arrowheads of the Upper Volga area (Zhilin 2001).

Berendeyevo peat bog (Fig. 1:5) is located 120 km to the northeast of Moscow and 30 km to the south of the peat bog of Ivanovskoye. The River Trubezh starts from its northern part and connects it with the Upper Volga, while River Kirzhach starts from its southern part and connects it with the Oka River via the Klyaz'ma River. Eighteen Mesolithic and Neolithic sites have been discovered in the bog, but only one of them – Berendeyevo 18 – produced a thin Early Mesolithic find layer dated by pollen to the early Pre-boreal period. The site was not excavated, but several bone arrowheads were collected from a ditch running through it (Zhilin 1993).

Sakhtysh peat bog (Fig. 1:8) is located 40 km to the southwest of the city of Ivanovo at the source of River Koyka, which connects it with the Klyaz'ma River, which in turn is the left tributary of the Oka River. Several Mesolithic sites have been excavated at this bog. The site of Sakhtysh 14 occupies a place in a peat bog at the foot of a very gentle slope of a promontory, which is part of a terrace formed by a late glacial lake. During the Early Mesolithic the settlement was located on the beach near the outlet of River Koyka. The site was discovered in 1999 by the author, and about 200 square metres were excavated in 1999–2003 by the author together with V.A. Averin. The Early Mesolithic bottom layer (IV) of the site is dated to the Pre-boreal period by pollen and between 9550±60 BP (GIN-11616) and 9350±40 BP (GIN-11179) by radiocarbon, the calibrated date being c 9100–8500 calBC (Zhilin 2003b; Zaretskaya et al. 2005). Bone and antler artefacts include arrowheads; a lance head; fragment of a harpoon head; scrapers; a fishing hook; knives; awls; gouges; antler adze blades and sleeves for mounting them; beaver mandible tools; antler punch; as well as bear, dog and elk tooth pendants.

The site of Sakhtysh 9 lies at a distance of 200 metres from Sakhtysh 14. Altogether 144 square metres of the site have been excavated (Kraynov et al. 1990), and the Early Mesolithic find level is dated by pollen to the late Pre-boreal period. The artefacts found include lithic tools and about 20 bone artefacts of Butovo culture, including arrowheads and their preforms.

Ozerki peat bog (Fig. 1:4) is located 160 km to the northwest of Moscow and 20 km to the south of Tver. A small river called Inyukha connects it with the Upper Volga via the Shosha River. Altogether 17 Mesolithic and Neolithic sites have been discovered in the bog (Zhilin 2006b). The Early Mesolithic sites were situated on a sandy island, while two Middle Mesolithic sites were buried under peat deposits at a distance of c 300 m from the island and produced bone artefacts. The bottom layer of the Ozerki 16 site is dated to the early Boreal period by pollen and has been radiocarbon-dated to 8770±40 BP (GIN-6654). It yielded three bone arrowheads, one of which is interesting for the present study.

Research methods

All of the bone artefacts from Early Mesolithic layers of Stanovoye 4, Ivanovskoye 7 and Ozerki 16 – including fragments, preforms and blanks – were studied with a help of a stereomicroscope (MBS-10, with a magnification range from 3.6x to 119x). Most traces from manufacture and use were clearly visible under magnifications from 6x to 40x. Stronger magnifications were useful for investigating details of use-wear traces, for example, very fine linear traces embedded inside broader ones, or for studies of the surface inside linear traces. A DCM 800 camera-ocular was used for taking photos through the microscope. Bone arrowheads from other Early Mesolithic sites were studied with a loupe with magnifications up to 20x.

A series of experiments was also carried out, with the aim of studying the technological process of arrowhead production, and how the arrowheads were shafted and shot using a bow. Several arrowheads of the types found in Early Mesolithic layers (needle-shaped without microblades; needle-shaped with a slot with microblade inserts fixed with glue; and arrowheads with a thickened biconical head) were made by the author and Svetlana Savchenko from long bones of an elk, using replicas of flint tools. The latter were made by the author from flint and siliceous rocks of types represented in the Early Mesolithic find material, and their shape and size were similar to the original tools, used for processing bone. The arrowheads were hafted into shafts made from pine wood and willow branches and shot using a replica of a bow of the Holmegaard type. Bows of this type were widespread in the forest zone from Denmark to the Trans-Ural region during the Mesolithic (Oshibkina 1983; Paulsen 2013; Zhilin & Savchenko 2015). After several shots had been fired, the arrowheads were studied using the afore-mentioned stereomicroscope. Use-wear traces similar to those observed on arrowheads from Stanovoye 4 and Ivanovskoye 7 were found on our experimental arrowheads.

TYPOLOGICAL CLASSIFICATION OF EARLY MESOLITHIC ARROWHEADS FROM THE UPPER VOLGA

In some cases it is very easy to make a distinction between different categories of projectile points, i.e. heads of arrows, darts, leisters, spears, lances, and harpoons, but sometimes it is less so. The shape and size of the basal part of projectile points indicate the way they were hafted, and also suggest the size of the shaft, which makes it possible to distinguish different categories. Finds of Mesolithic wooden shafts of projectiles give an idea about their real size and diameter. Rare finds of bone points still attached to the shaft show the way they were hafted as well as the correspondence between the basal part of the bone point and diameter of the shaft (Clark 1975; Andersen et al. 1982; Zagorska 1991). Traces of glue and imprints of cord, preserved at the basal parts of some bone points, also shed light on methods of hafting.

Early Mesolithic projectile points from the Volga-Oka interfluve can be divided into five distinct categories: 1) arrowheads, 2) darts or leister heads, 3) spearheads, 4) lance heads, 5) harpoon heads. The first four were tightly connected to the shaft and fixed either with glue or bound with cord, or both. They were not separated from the shaft when the projectile hit the target. They can be distinguished based on the diameter or width of the basal part: arrowheads are not more than 1 cm in diameter, darts or leister heads are about 1.5 cm wide, spearheads are about 2–2.5 cm wide, and lance heads are more than 3 cm wide. The last-mentioned most probably were not used as heads of projectiles, but served as stabbing spears (so-called 'bear spears') used at close contact with hunted mammals. Harpoon heads were separated from the shaft when they hit the target. They were attached to the shaft with a line and are supplied with perforations, protrusions, widening of the base and similar details for fastening the line. These details make it possible distinguish between harpoon heads and barbed points used as heads of arrows, darts, leisters, spears and lances. The division into different types was based on the general shape of the artefacts, while differences in detail marked different variants within the type. Arrowheads are classified and described in the present article according to the typological classification of bone points worked out and applied by the author to Mesolithic artefacts of the forest zone of eastern Europe (Zhilin 2001). Other classifications of bone points (Clark 1936; Zagorska 1974; 1991; Oshibkina 1983; Gurina 1991) do not cover the full range of Early Mesolithic arrowheads from the Volga-Oka interfluve.

Arrowheads

This category incorporates points with a base or bevel specially treated for hafting in shafts about 1 cm in diameter, which corresponds to the majority of wooden arrow shafts from northern and eastern Europe and the Trans-Ural region. Traces of glue, frequently met at bevels of arrowheads, show that they were firmly fixed in a split shaft or in a conical hollow at the end of the shaft, and that some of them were additionally bound with a plant or sinew cord. Imprints of the latter are sometimes clearly visible on the surface of the glue.

The following types of arrowheads are known in the Early Mesolithic of the Volga-Oka interfluve:

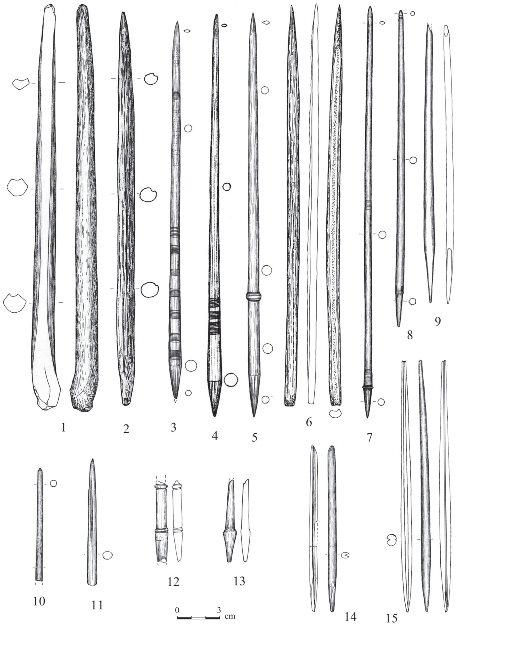

Fig. 2. Needle-shaped arrowheads. 1–2 – Sakhtysh 9; 3, 5 – Ivanovskoye 3 (lake bottom); 4 – Berendeyevo 18; 6–8, 10–11, 14–15 – Ivanovskoye 7 (layer IV); 9, 12–13 – Stanovoye 4 (layer III, trench 3). Drawing: M.G. Zhilin.

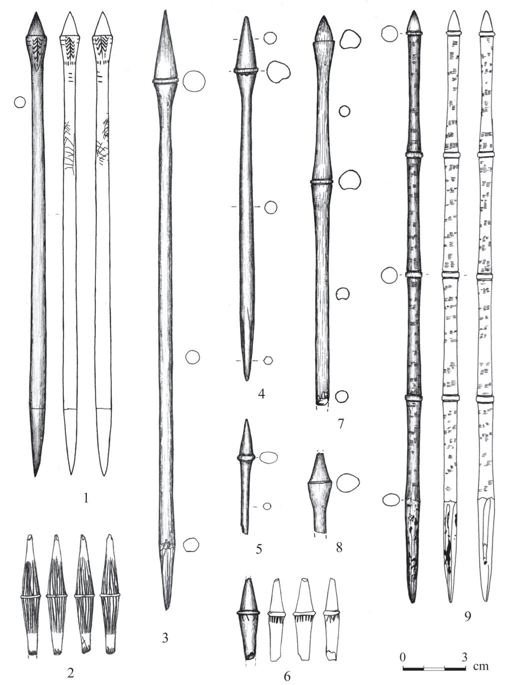

Fig. 3. Arrowheads with biconical head. 1 – Ivanovskoye 7 (layer IV); 2–9 – Stanovoye 4 (layer III, trench 3). Drawing: M.G. Zhilin.

1. Needle-shaped, often massive arrowheads with a round or slightly flattened cross-section and conical or pyramid-like bevel. The thickest part of the artefact is at the border between the stem and the bevel; the point narrows very gently toward the tip (Fig. 2:3–4). Their point is conical or flattened, sometimes with a small cone (Fig. 2:8) or a step (Fig. 2:10). The length of most arrowheads is over 20 cm, with a diameter of 7–9 mm, although in some rare cases shorter artefacts occur. Such arrowheads were found at Ivanovskoye 3 (stuck in a lake bottom), Ivanovskoye 7 (layer IV), Berendeyevo 18, Stanovoye 4 (layer III, trench 3), and Sakhtysh 9 and 14 (layer IV). A needle-shaped arrowhead with a wedge-like bevel (Fig. 2:9) was encountered in Stanovoye 4 (layer III, trench 3). Single long needle-shaped arrowheads with a relief belt running around their stem (Fig. 2:5, 7, 12) were found at Ivanovskoye 3 (stuck in a lake bottom), Ivanovskoye 7 (layer IV), and Stanovoye 4 (layer III, trench 3). One short item with a thickened biconical base (Fig. 2:13) comes from Stanovoye 4 (layer III, trench 3). Preforms of long needle-shaped arrowheads were found at Sakhtysh 9 (Fig. 2:1–2) and Ivanovskoye 7 (bottom layer) (Fig. 2:6). Needle-shaped arrowheads with one long slot for inserts (Fig. 2:14–5) were found at Ivanovskoye 7 (layer IV); Stanovoye 4 (layer III, trench 3), and Sakhtysh 14 (layer IV).
2. Arrowheads with a thickened biconical head with a conical point, sometimes with a relief belt or a step running around the thickest part of the head. The stem is long and the bevel conical or pyramid-like (Fig. 3). Arrowheads of this type were found at Ivanovskoye 7 (layer IV), Stanovoye 4 (layer III, trench 3), and Sakhtysh 14 (layer IV). One arrowhead with biconical head and an additional biconical thickening on the stem (Fig. 3:7) and another with three such thickenings (Fig. 3:9) were found at Stanovoye 4 (layer III, trench 3).
3. Narrow flat symmetric arrowheads, long or medium long, with a flattened conical base without a tang (Fig. 4:1, 7) come from Stanovoye 4

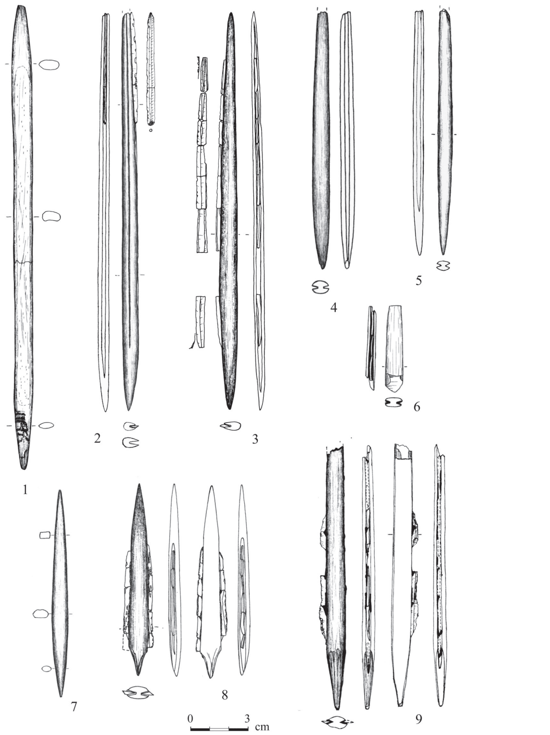

Fig. 4. Narrow flat arrowheads. 1–5 – Stanovoye 4 (layer IV); 6–7, 9 – Stanovoye 4 (layer III, trench 3); 8 – Ivanovskoye 7 (layer IV). Drawing: M.G. Zhilin.

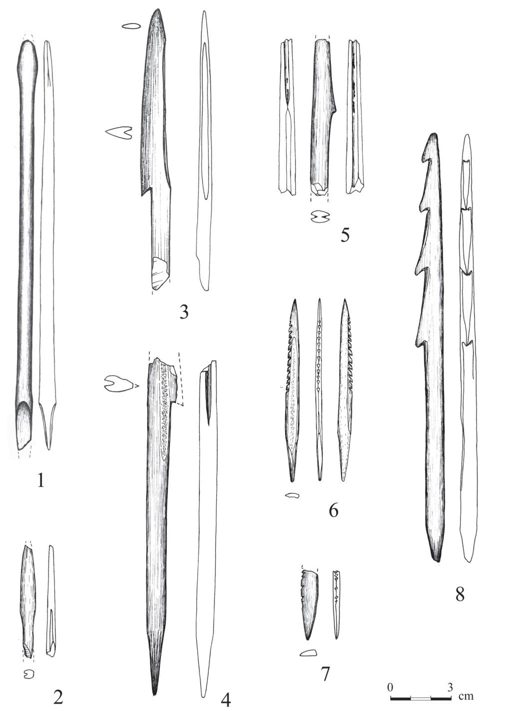

Fig. 5. Paddle-shaped, slotted one-winged, and barbed arrowheads. 1, 2, 5, 7–8 – Stanovoye 4 (layer III, trench 3); 3–4, 6 – Ivanovskoye 7 (layer IV). Drawing: M.G. Zhilin.

(layer IV and layer III, trench 3). Similar arrowheads but with a long slot for inserts along one side (Fig. 4:2–3) were found at Stanovoye 4 (layer IV and layer III, trench 3), Ivanovskoye 7 (layer IV), and Sakhtysh 14 (layer IV). Similar arrowheads with long slots along both sides (Fig. 4:4–5) come from Stanovoye 4 (layer IV). Narrow flat symmetric arrowheads with a short tang and a long slot for inserts along one side were found at Stanovoye 4 (layer III, trench 3). Similar arrowheads with slots along both sides (Fig. 4:8–9) are also known from Ivanovskoye 7 (layer IV) and Stanovoye 4 (layer III, trench 3).

4. Paddle-shaped arrowheads with a short blade and long stem are scarce. One such artefact with a wedge-like bevel (Fig. 5:1) was found at Stanovoye 4 (layer III, trench 3), accompanied by a fragment of similar item with a slot along one side of the stem (Fig. 5:2).
5. One-winged arrowheads with a barb at the end of the wing and a slot for inserts at the opposite side. The cross-section of the stem is round or oval, bevel is conical, and the wing is less than half of the length of the artefact (Fig. 5:3–4). Such types were found at Ivanovskoye 7 (layer IV), and a fragment of similar arrowhead was found at Stanovoye 4 (layer III, trench 3), although it has slots along both sides of the wing (Fig. 5:5).
6. A long arrowhead with large unilateral triangular barbs, long stem and a conical bevel, features typical of arrowheads both in terms of shape and size (Fig. 5:8), was found at Stanovoye 4 (layer III, trench 3). This artefact as well as the following type was tightly hafted in the shaft and has no devices for attaching a line, both facts indicating that they cannot be harpoon heads.
7. A small flat arrowhead with dense small unilateral barbs and flattened pyramid-like bevel (Fig. 5:6) comes from Ivanovskoye 7 (layer IV), and a fragment of another one was found at Stanovoye 4 (layer III, trench 3) (Fig. 5:7).

TECHNOLOGY OF MANUFACTURE OF BONE ARROWHEADS

Traces of various operations preceding the final treatment and overlapping each other were discovered at several places in many of the artefacts. Such 'technological stratigraphy' – accompanied by the presence of various kinds of blanks, preforms and refuse in the find material – made it possible to establish the sequence of operations and to reconstruct different stages of production of the arrowheads with a sufficient degree of certainty.

First, elk long bones were soaked in water for softening, as indicated by a cache of three long bones of an elk buried in a pit, encountered in the lowest layer of the Ivanovskoye 7 site (layer IV). It had been dug below the ancient water level, and the bones placed there were resting in sand and water. One of the bones featured shallow longitudinal straight lines along both sides, made with a sharp burin in places where grooves would later be made (Zhilin et al. 2002). When the bones had softened, shallow transverse grooves running across the perimeter of the bone were made near one or both of the epiphyses, which were broken off along this groove. Such a groove was usually made with the help of a chisel or an adze with an unpolished cutting edge, which left characteristic pit-like traces on the bone surface (Fig. 6:4). Such an adze still in its original position in an elk antler sleeve was found at Stanovoye 4 (layer III, trench 3) (Zhilin 2006a; 2007a; 2009). A series of 13 removed epiphyses with similar traces and breakage scars was found at Ivanovskoye 7 (layer IV).

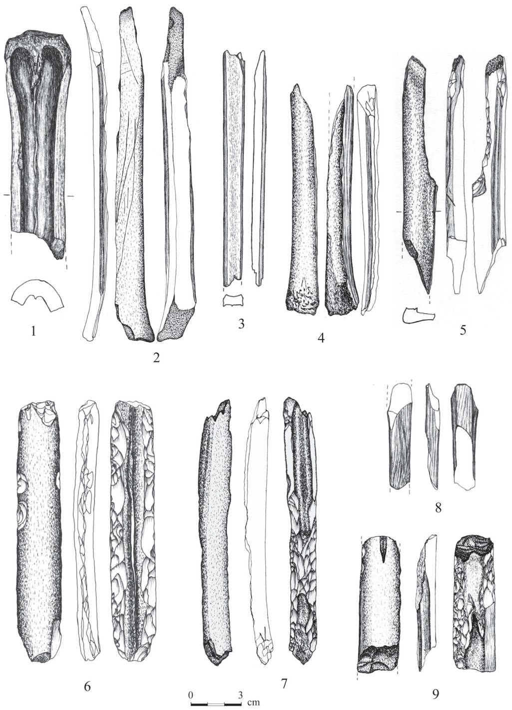

Fig. 6. Blanks made from long elk bones. 1, 5 – Ivanovskoye 7 (layer IV); 2, 4, 6–9 – Stanovoye 4 (layer III, trench 3); 3 – Stanovoye 4 (layer IV). Drawing: M.G. Zhilin.

The next step was to cut the bone diathesis into halves, after which long and narrow splinters were extracted with the use of the 'groove and splinter' technique. In some cases the long bones were cut into halves with preserved epiphyses (Fig. 6:1), or sometimes the epiphyses were removed but a part of the joint surface is visible at the end of a preform (Figs. 2:1, 6 & 6:2). Thirteen fragments of splinters without epiphyses and four similar fragments with partly preserved epiphyses were found at Ivanovskoye 7 (layer IV). The groove was usually cut to a depth of 2/3 to 5/6 of the thickness of a wall of the bone. Long parallel traces left by a burin can be seen along the sides of the groove (Figs. 2:1, 6 & 6:1–5). Such traces are sometimes visible on some parts of the finished arrowheads (Fig. 2:11), indicating the use of this technology of blank production. When the splinter was too wide it was narrowed with the help of percussion with a hammerstone. Such operation left characteristic scars like facets on lithic tools (Fig. 6:5).

Then, the splinters were turned into preforms with the help of crude scraping or whittling (Fig. 6:1). Our experiments showed that percussion technique gives good results with dry bone, but wet bone is much easier to work by scraping, carving and whittling (Savchenko 2010). When the proportions of a splinter were ideal, the secondary treatment began with sharpening the point of what would eventually become an arrowhead with longitudinal whittling and shaping its surface in the same manner. Preforms of long needle-shaped arrowheads from Ivanovskoye 7 (layer IV) and Sakhtysh 9, abandoned at this stage (Fig. 2:1–2, 6), show both the long linear traces left by a burin on their sides, which preserved on the surface of the grooves, as well as the long flat longitudinal facets with typical longitudinal linear traces left by a whittling knife on its dorsal (convex) surface. Typical cross-section and preserved outer (convex) and inner (concave) bone surfaces and parts of epiphyses indicate for sure that they were made from long bones.

The other technique used involved splitting the long bones into pieces with a hammerstone, with further modification of the selected piece into the desired shape by percussion, likewise, using a hammerstone (Fig. 6:6–7). Once the percussion was finished, the resulting preforms were shaped by longitudinal scraping (Fig. 6:8) and/or whittling (Fig. 6:9), which left characteristic traces and wiped out the percussion facets. Further whittling and scraping was used for shaping the preforms into arrowheads. At this stage various details such as barbs, grooves, slots for inserts were added by carving, grooving, sawing, fine whittling and scraping. Many arrowheads were at this point considered ready for use, as indicated by traces of glue at the base and by use-wear analysis. However, some arrowheads were decorated with engraved ornamentation (Figs. 3:1–2, 6 & 4:2), which was carried out by using a burin with a very sharp edge. Our experiments showed that a broken flint blade or flake is the most suitable tool for this purpose. Final treatment included grinding the arrowhead with fine-grained abrasive slabs and bright polishing with hide or other organic polishers. Grinding was used rather scarcely. More often, bright polishing was carried out just after fine whittling or fine scraping of the surface. It is worth noting that the tangs and bevels of the arrowheads were not polished. Ornamentation was executed after the fine treatment of the surface (by whittling or scraping) was finished, but before polishing.

Slots for inserts in composite arrowheads were grooved after fine scraping or whittling, but before polishing. A flat shelf about 2–3 mm wide was made by whittling with a knife along the edge of an arrowhead. Fragments of broken flint blades served as burins, with a very sharp working edge for cutting slots that feature a V-shaped cross-section (Figs. 2:14–5 & 4:9). Some of the arrowheads have a trapezoid-like cross-section of slots (Fig. 4:2–6, 8), which indicates that the cutting edge of the burin was formed by a very narrow burin scar. Our experiments showed that such burin scars often appear as a result of wearing out during the work, and not intentional treatment of a burin. After about half an hour of grooving, the working edge of a broken blade becomes dull, and

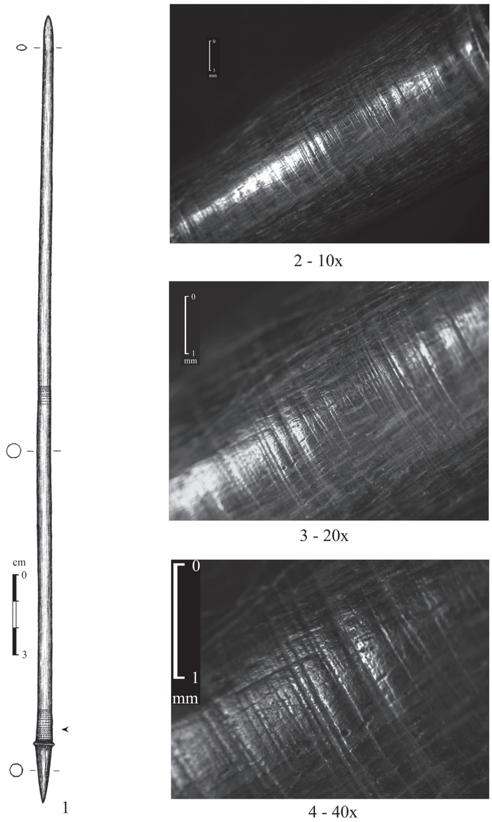

Fig. 7. Needle-shaped arrowhead, traces of turning lathe treatment; Ivanovskoye 7 (layer IV). Drawing and photo: M.G. Zhilin.

more effort is needed to work the artefact. This typically results in removing a very narrow burin spall from the working edge and formation of a burin scar. When this happens, the burin works much better, but the shape of the cross-section of the groove changes from V-shaped into trapezoidal. When the slots were finished, the shelf was removed by fine longitudinal whittling, and only small remaining parts of the shelf could be observed under a microscope. Finally, some of the slotted arrowheads were polished, and inserts were mounted into the slot.

A detailed study of the edges of inserts preserved in slots in one of the arrowheads from Ivanovskoye 7 (layer IV) (Fig. 4:8) and experimental data indicate that the grooves were first filled with glue, after which the artefact was heated over hot charcoal or a very small fire until the glue became soft. Then inserts were then put into each slot, resulting in the extra glue flowing off from the slot. The glue covered the sides of the inserts and was removed by longitudinal shaping, which produced long striations on the remains of the glue that cover the side surfaces of inserts (Fig. 10:1–2, 6). Tiny drops of glue, which set and were preserved on some facets of retouch in the inserts, prove that the trimming of these inserts was done before they were mounted into the slot. When the glue became hard the arrowhead was ready for use.

Special attention was paid to the firm placement of inserts in order to obtain a straight and even cutting edge. The row of inserts for each side of an arrowhead was composed in advance. If needed, intact microblades were broken into parts as indicated by the glue covering the breakage between the fragments of a single microblade (Skakun et al. 2014). Inserts were placed so that on one side of the arrow, all of them were mounted with the dorsal face up, while on the opposite side all were mounted with the dorsal face down (Figs. 4:8 & 10:1–2). A similar way of mounting inserts was also observed by S.V. Oshibkina at the Veret'ye 1 site (Oshibkina 1989; 1999) and by the author at Stanovoye 4 (layer III, trench 3) (Fig. 4:9). In our experiments, we put two rows of inserts for each slot on a horizontal surface (with their dorsal surface up) before filling the slot with glue. When the glue melted, one slot was filled with inserts, and the arrowhead was turned to fill the second slot. After the glue had hardened, I observed that the inserts were unintentionally placed in the described pattern. It was simply the easiest way to place the inserts into the slots.

The treatment of some of the artefacts is of special interest and deserves to be described separately. One long needle-shaped arrowhead from Ivanovskoye 7 (layer IV) (Figs. 2:7 & 7:1) has a relief belt at the border between the stem and tang of the arrowhead. This belt was first marked with circular grooves, which were removed by further whittling, with only the deepest parts visible under the microscope. Ornamentation in the shape of a very dense and fine spiral running over the stem, carved with a burin with a very sharp working edge, can be observed in the middle of the stem and at its bottom near the relief belt. It can be clearly seen under the microscope that traces of the burin are mostly parallel to each other, but some are crossing at very acute angles (Fig. 7:2–4). It is also worth noting that elevations of micro-relief of the artefact surface are altered with this treatment, while micro-depressions are not affected. Such traces are characteristic of various round artefacts worked with the help of a turning lathe, with the worked item rotating and the burin slowly moving along its surface. That some of the lines cross each other indicates that the burin was not firmly fixed as in modern turning lathes, but was most probably hand-held. After ornamentation was finished, the arrowhead was brightly polished, most probably using hide or some other organic polisher. Similar treatment is observed on two other needle-shaped arrowheads from Early Mesolithic sites, namely Ivanovskoye 3 (found stuck in a lake bottom) (Fig. 2:3) and Berendeyevo 18 (Fig. 2 4) (Zhilin 1993; 2001).

USE-WEAR TRACES ON BONE ARROWHEADS

Arrowheads from Ivanovskoye 7 (layer IV) and Stanovoye 4 (layer IV and layer III, trench 3), including fragments with a preserved point, displayed more or less pronounced signs of use-wear under the microscope. In the majority of the artefacts this included rounding, smashing or chipping of the tip; small or larger flat or semi-flat facets, running from the tip along one or two (and sometimes several) sides of the point; 'hide' polishing, beginning from the tip and gradually disappearing; fine and sometimes also coarse striations, running from the tip along the axis of the arrowhead and/or at an acute angle to it. Similar traces were also observed on the points of our experimental arrowheads when they had been shot at a target made of peat and covered with fresh wild boar skin. At most of the arrowheads studied, use-wear was not well developed, indicating a rather short period of use, but some of them displayed very good use-wear patterns which deserve a separate description.

The point of a fragment of a long, needle-shaped arrowhead from Ivanovskoye 7 (layer IV) (Figs. 2:10 & 8:1) was supplied with a gentle step. It is rounded and smoothed, and a bright polishing runs from the tip of the arrow towards the stem, becoming gradually duller. Within this polishing, some fine striations and coarse grooves running from the tip at an acute angle to the artefact axis are clearly visible (Fig. 8:2–3). These fine striations resulted from multiple hits on some type of a soft material covered by fine mineral particles

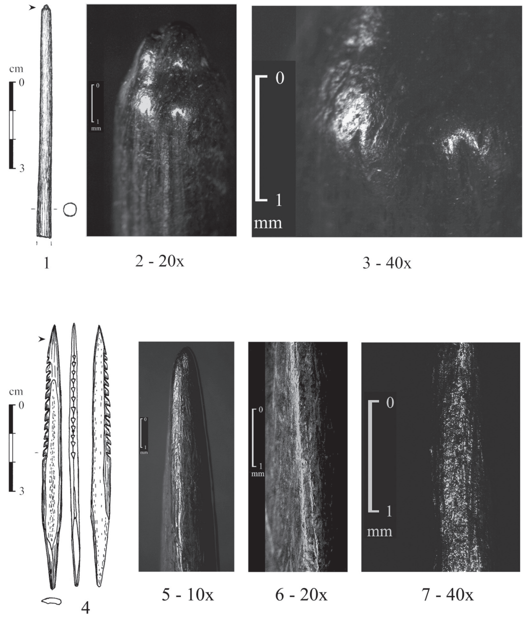

Fig. 8. Needle-shaped and barbed arrowheads, use-wear traces; Ivanovskoye 7 (layer IV). Drawing and photo: M.G. Zhilin.

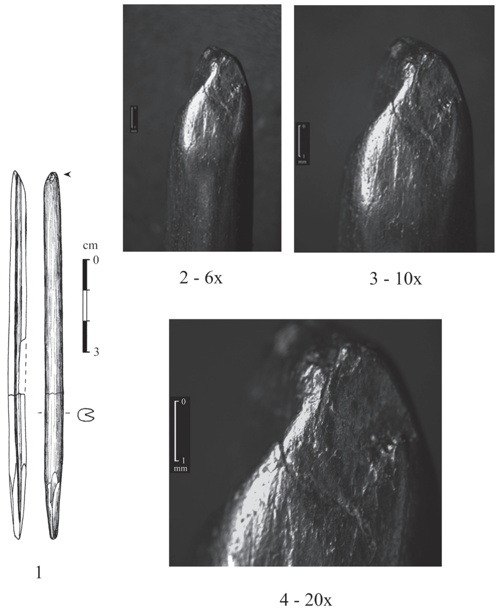

Fig. 9. Needle-shaped slotted arrowhead, use-wear traces; Ivanovskoye 7 (layer IV). Drawing and photo: M.G. Zhilin.

(e.g. animal skin, clothing), while the grooves indicate hitting the ground during the long use-period of this particular arrowhead.

The point of a slotted, needle-shaped arrowhead from Ivanovskoye 7 (layer IV) (Figs. 2:14 & 9:1) was smashed as a result of hitting some hard material, and flat facets running from the tip can be observed at one side of the point of the artefact. An oblique breakage scar accompanied by chipping facets, polishing, grooves and fine striations running from the tip along the axis of the arrowhead are seen on its other side (Fig. 9:2–4). This arrowhead was clearly used for a long time, hitting both the hunted animals and the ground when it missed the target. Traces of repair (or several repairs?) partly removed the slot for inserts, both in its point and bevel. Finally, it was broken in two pieces, which were found at a distance of several metres from each other.

A small barbed point (Figs. 5:6 & 8:4) was found at Ivanovskoye 7 (layer IV) stuck in the lake bottom near the ancient shoreline at an angle of about 70°. The small tang of this artefact is identical to tangs of other small arrowheads and indicates similar hafting and use of this point as an arrowhead. The position of the artefact indicates that it was shot into the water from a very close distance. The tip of the point is rounded, and a dull matt polishing runs from the tip towards the shaft, gradually disappearing. Within this polish, multiple long fine striations can be observed, with illegible sides running from the tip (Fig. 8:5–7) up to the first barb and some even further. Such traces are characteristic of bone leisters and fishing spearheads and indicate multiple hits on a silty and sandy lake bottom while stabbing or shooting fish. Pike (*Esox lucius*) is the dominating fish species in this layer of Ivanovskoye 7, which was inhabited during the warm season (Zhilin et al. 2002). During warm weather, pike gather in shallow water in order to warm itself near the surface, making it an easy target for fishermen. The use-wear traces observed and the position of this arrowhead, stuck in the lake bottom, most probably indicate that it was used for shooting pike, but missed the target.

Rounding, chipping and small pits are observed at the tip of the point of a slotted narrow flat arrowhead with flint inserts found at Ivanovskoye 7 (layer IV) (Figs. 4:8 & 10:1–2). Dull polishing

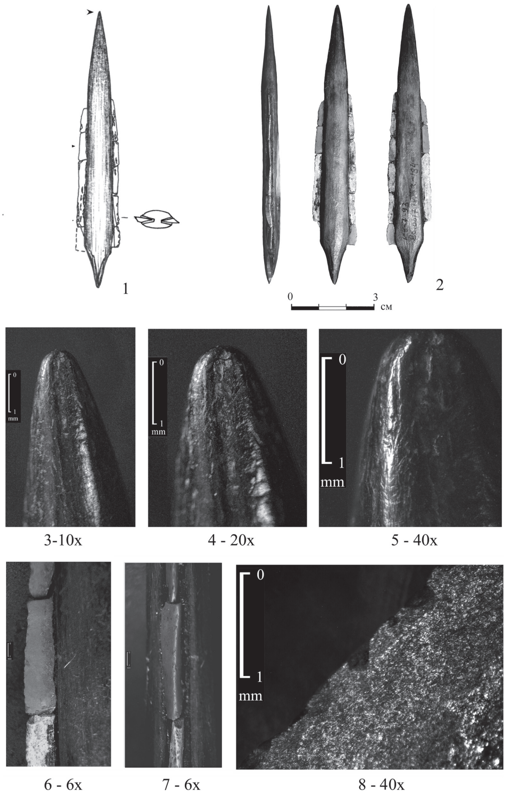

Fig. 10. Narrow flat slotted arrowhead, use-wear traces; Ivanovskoye 7 (layer IV). Drawing and photo: M.G. Zhilin.

running from the tip and gradually disappearing covers the point of the arrowhead. Furthermore, within this polish two types of linear traces can be observed (Fig. 10:3–5). The first one is represented by straight thin striations and, in some cases, grooves running from the tip along the axis of the arrowhead. The second type consists of linear traces or thin short striations running from the tip in a screw-like pattern at an acute angle to the axis of the artefact. Some of the latter overlap the straight striations of the first type. Traces on the point of the arrowhead indicate multiple penetrations into a soft material covered by fine mineral particles, and also occasional hits into the ground. The latter is indicated by grooves at the tip and nearby, while and the absence of such grooves beyond 2 cm from the tip suggests that the points did not penetrate very deep in the ground.

In addition to the marks described above, various deformations caused by a long history of use and by natural damage resulting from post-depositional processes can be seen. The microscopic study of inserts shows that their edges are rounded and smoothed and that they bear traces of abrasion (Fig. 10:6–7). Such features are probably related to storing the arrow in a quiver together with other arrows, with multiple arrowheads in close contact with each other. Furthermore, the inserts display utilisation chipping on their edges, and some also display micro-scars resembling burin scars on their angles. Thin strips of oriented polishing running from the point of the arrowhead at an acute angle to the edge of an insert, sometimes almost parallel to it, were observed at some inserts, especially at the second insert from the left (Fig. 10:8) and the third insert from the right side. A few thin scratches running in the same direction were also visible there. Such traces probably resulted from multiple sliding contacts with bones, sinew, cartilage and dirty skin of animals when the arrowhead hit the target. As a result of such contact, the edges of the inserts bear evidence of chipping, and the linear traces left by tiny flint chips sliding across the surface of other inserts could also be observed under a microscope.

TRACES OF GLUE

Three types of glue were recognised on surfaces of bone arrowheads from Ivanovskoye 7 (layer IV) and Stanovoye 4 (layer IV and layer III, trench 3). The first one was observed in the slot of a one-winged arrowhead from Ivanovskoye 7 (layer IV) (Fig. 5:3). It is brown and looks like resin, semi-transparent and shiny in places where the surface is fresh, with a characteristic wavy surface in facets resembling glass or flint. Imprints of three microblades were observed in the glue, the first and the second ones being unretouched, while the last one opposite to the barb on the other side of the arrowhead bore traces of several facets of steep retouch, representing the obliquely truncated end of the insert. Similar glue was produced in our experiments by melting pure pine and spruce pitch without any admixtures. It was rather fragile and not strong enough, but could still be used to fix inserts in the arrowheads.

A different type of glue was observed in slots of arrowheads from Ivanovskoye 7 (layer IV) and Stanovoye 4 (layer III, trench 3) (Fig. 4:6, 8–9). Under the microscope this glue looks like a matt greyish-brown micro-granular substance with a lot of tiny charcoal particles visible at points of fracture. In our experiments similar glue was made by mixing pitch from coniferous trees (pine or spruce), beeswax and charcoal dust. It turned out to be very good for fixing projectile inserts. Similar-looking glue was also made by melting pine pitch on a hot stone encircling a camp fire and adding ash from the hearth until the glue became sluggish but not solid. This glue was inserted into the slot of an arrowhead and microblades were mounted into it. The extra portion of glue that was pressed out from the slot was removed by a longitudinal movement as in the arrowhead found at Ivanovskoye 7. This glue was also very good when hardened, and inserts remained in their position in the slot even after several shots hitting the target had been fired. Remains of similar glue were observed on the bevels of several arrowheads from Stanovoye 4 (layer III, trench 3).

A third type of glue was observed on the bevel of a long and flat narrow arrowhead (Fig. 4:1) from Stanovoye 4 (layer IV). It is dense black, with the outward appearance of black birch tar. The arrowhead was broken in the middle, and traces of the same glue cover an area up to 2–3 cm from the breakage. Traces of binding with a thin plant material are visible under the microscope on the surface of the glue remains, possibly indicating an attempt to repair this arrowhead. Analyses of similar-looking glue from two Early Mesolithic sites – Starr Carr (Clark 1954) and Pulli (Vahur et al. 2011) – showed that it was birch tar. The same substance was most probably used in hafting and repairing the arrowhead from Stanovoye 4 (layer IV).

At the time of writing, the chemical composition of glue samples from Ivanovskoye 7 and Stanovoye 4 are being analysed at the University of Tartu in Estonia, and we are waiting for the results.

DISCUSSION

Analogies and development

In order to determine the wider context of the arrowheads from Early Mesolithic sites from the Volga-Oka interfluve, we have to make comparisons with synchronous sites with bone arrowheads from northern Eurasia. Only a few needle-shaped points have been found at Pre-boreal sites of western and northern Europe such as Starr Carr in England (Clark 1954), Friesack in northern Germany (Gramsch 1990; 2000; 2004), and Lundby in Denmark (Henriksen 1980; Hansen 2003). Early Mesolithic sites from northeastern Poland with preserved faunal remains and bone artefacts dated to the Pre-boreal period have produced no bone arrowheads at all (Brzozowski & Siemaszko 1996; Sulgostowska 1996).

By contrast, a number of similar types of arrowheads and sequences of their production have been observed at Early Mesolithic sites ranging from the eastern Baltic (Jaanits & Jaanits 1975; 1978; Zagorska 1980; Zagorska & Zagorskis 1989) through the Volga-Oka interfluve (Zhilin 2001), and all the way to the Trans-Urals (Chairkin & Zhilin 2005; Savchenko, 2014), even if these finds bear evidence of a number of local technological solutions and types of bone arrowheads. Needle-shaped arrowheads were found in Pulli, Zvejnieki 2 (bottom layer), Sūļagals and Beregovaya 2 (layer IV), as well as in Shaytanskaya and Lobvinskaya caves. It is worth noting that needle-shaped arrowheads with a wedge-like bevel were spread in Trans-Urals during the Early Mesolithic, but only singular cases can be found in the Volga-Oka interfluve and they are not encountered in Early Mesolithic bone assemblages of any other region. However, during the final Palaeolithic massive needle-shaped points with wedge-like bevels made from reindeer antler were found in a region ranging from northeastern Poland to Kaliningrad and western Lithuania (Gross 1937; 1940). Most probably, this variant emerged in the eastern Baltic and Trans-Urals independently, because there are no traces of any links between these regions during the final Palaeolithic and Early Mesolithic.

An arrowhead with a smooth thickened head is among the finds from Pulli, and narrow flat arrowheads without a tang or with a short tang have been found at both Pulli and Sūļagals. Similar artefacts with a long slot for inserts along one or both sides come from Pulli, Zvejnieki 2 (bottom layer), Sūļagals, Shigir peat bog (Savchenko et al. 2015), and the caves of Shaytanskaya and Lobvinskaya. A fragment of a paddle-shaped arrowhead was found at Zvejnieki 2 (bottom layer), and ten artefacts of this type are included in the find assemblage of Beregovaya 2 (layer IV). Such types as one-winged slotted and barbed arrowheads are not known from Early Mesolithic sites of the eastern Baltic, while, on the other hand, points of Lubana type have not been found at Early Mesolithic sites of the Volga-Oka interfluve. Still, similarities in types of Early Mesolithic arrowheads in the two regions are greater than differences, which indicates regular communication and existence of social networks among the populations of these regions. This is also confirmed by contemporary flint artefacts, especially tanged arrowheads and retouched inserts, some of which were made from Cretaceous flint (Zhilin 2003a; Jussila et al. 2012).

Narrow flat bone arrowheads, both without and with one or two slots for inserts, are the oldest type found in the Volga-Oka interfluve. During the first half of the Pre-boreal period they are supplemented by needle-shaped non-slotted and slotted arrowheads, points with a thickened biconical head, one-winged slotted arrowheads, and arrowheads with fine unilateral barbs. In the second half of the Pre-boreal period, paddle-shaped non-slotted and slotted arrowheads are added to the repertoire. During the first half of the Boreal period, we observe further development of bone arrowheads in Mesolithic cultures of eastern Europe, but differences between them become more pronounced. On the other hand, the presence of single finds of typical Lubana type points in Veret'ye 1 and Ivanovskoye 3 indicates that contacts between the populations of different regions of this territory were still active (Zhilin 2001).

Pretreatment of bone

As indicated above, once bone has been softened, it is much easier to work it by scraping, grooving, carving, whittling, sawing or drilling. Based on archaeological and ethnographic data, researchers have suggested that the bone was softened by soaking (Zhilin 2001; Savchenko 2010), soaking and heating (Gurina 1956; Semenov1965), and/or chemical treatment (Malinova & Malina 1988). The best results were achieved by soaking the bone in water mixed with ash for two months. Following that, preforms made from cattle long bones could be easily worked by whittling with an iron knife, as if one was whittling wood (Serikov & Tupikov 2015). Our experiments were conducted in summer 2015 and involved soaking long bones of an elk for one month in water mixed with ash from a campfire. The experiment demonstrated that it is much easier to process bone with flint tools after such treatment. Long regular traces of whittling, observed on some preforms and finished arrowheads suggest that similar treatment of bone could also have been used at Early Mesolithic sites in the Volga-Oka interfluve.

It is worth noting that the employment of direct percussion technique requires dry bone, which is more fragile and rather easy to knap using a hammerstone. Fragments of long bones were probably dried after the marrow had been extracted, and then shaped into preforms by percussion. But once the preforms were ready, they also were put into water, as indicated by the preform made by percussion from a long elk bone at Ivanovskoye 7 (layer III), found in gyttja near the shoreline (Zhilin et al. 2002: Fig. 29). The preform was 43 cm long, and it is hard to loose such a large object. It was intact and very carefully treated, so it is unlikely that it was thrown away. Preforms from Stanovoye 4 (layer IV and layer III, trench 3) (Fig. 6:9) display long regular traces of whittling, which have removed percussion facets, indicating most probably that the preforms were softened after percussion. Our experiments showed that it took about 3–4 hours to produce the majority of the studied arrowheads with flint tools similar to those found at the studied sites.

Operation sequence

The following operation sequence in the manufacture of bone arrowheads in the Early Mesolithic of the Upper Volga was established: preparing a long elk bone by soaking (for grooving) or drying (for breaking by percussion) → obtaining a blank either by the 'groove and splinter' technique or by percussion → shaping the preform by coarse scraping or whittling → carving details, grooving slots (for slotted arrowheads) → fine longitudinal whittling or scraping → engraving ornamentation → fine abrasive grinding → bright smooth polishing → placement of inserts (for composite arrowheads). This operation sequence was not always carried out in full, as a number of studied artefacts had been used but did not feature ornamentation and/or polishing.

In just one case some kind of a pattern composed of very fine crossing lines was engraved over the brightly polished surface on the stem of an arrowhead (Figs. 3:1 & 11:1), while ornamentation of its head was done before polishing, following the standard scheme for Mesolithic bone arrowheads of the forest zone of eastern Europe (Zhilin 2001). This arrowhead was found in an unusual position – deeply vertically stuck up to its tang in the sandy lake bottom near the ancient shoreline (Zhilin et al. 2002). The use-wear is in its initial stage and includes chipping and rounding of the tip of the point and only several short grooves and striations running from the tip along the arrowhead axis (Fig. 11:2–3). Such use-wear most probably resulted from a single shot from a very short distance into the sandy lake bottom. Other studied arrowheads of this type from Early Mesolithic sites from European Russia and Trans-Urals displayed usual use-wear traces, described above. These facts (very careful treatment, rich ornamentation, additional engraving, unusual position and the evident use of the artefact for a single shot) combined may indicate that the arrowhead carried a special meaning, probably connected to some kind of ritual activity.

The use of turning lathe

The use of a turning lathe for decorating the bone arrowheads also deserves special attention. On the Upper Volga this kind of arrowheads are scarce and were found, in addition to the lower layer of Ivanovskoye 7, also in the lower layer of Ivanovskoye 3 (Oshibkina et al. 1992), Berendeyevo 18 (Zhilin 1993), lower layer of Ozerki 16 (Zhilin 2006b) and as a stray find from the Dubna River near Moscow (Zhilin 1993). The lower layers of Ivanovskoye 7 and Berendeyevo 18 are dated to the Pre-boreal period, where as that of Ozerki 16 is dated to the early Boreal period. The arrowhead from the Ivanovskoye 3 site was found deeply stuck in the lake bottom under a Late Mesolithic layer, which indicates that it belongs to Early or Middle Mesolithic, i.e. Pre-boreal or Boreal periods. After Middle Mesolithic such treatment and the use of a turning lathe are not known in central Russia before the Middle Ages.

It is worth noting that turning lathe treatment was not used for shaping arrowheads, but only for decoration of already finished artefacts before final bright polishing. The rarity of such finds and a very specific treatment may also indicate a special meaning of these arrowheads, or special care of their makers. It is interesting to note that during the Late Neolithic and Eneolithic similar decoration of bone arrowheads was used in Trans-Urals (Serikov & Tupikov 2015: Fig. 1). This technology was similarly used for decoration only, and it was applied only to short biconical arrowheads, which

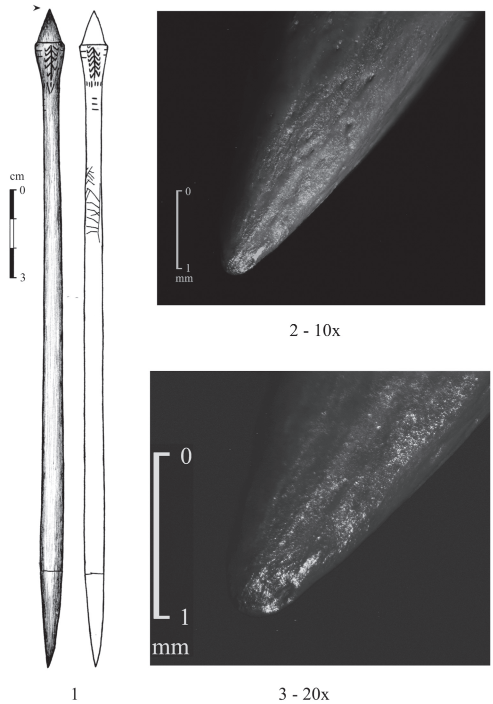

Fig. 11. Arrowhead with biconical head, use-wear traces; Ivanovskoye 7 (layer IV). Drawing and photo: M.G. Zhilin.

were produced in large numbers. Yu. B. Serikov made an experimental reconstruction of a horizontal turning lathe supplied with a bow and operated by two persons – one was pulling and pushing the bow, while the other was holding a burin fixed in a handle (Serikov & Tupikov 2015: Fig. 2). This lathe and method of use worked quite well in the decoration of arrowheads. Probably a similar turning lathe was also used in the Early and Middle Mesolithic on the Upper Volga, although it is not possible to exclude other possible types of lathe.

Linear traces and rotation of an arrow

Two types of striations were observed on arrowheads from Early Mesolithic sites. Straight striations, running along the artefact axis emerge when the arrow is not turning round its axis when it hits the target. Screw-like traces, by contrast, result when the arrow is turning as it hits the target. Our experiments showed that this is controlled by the fletching of the arrow. The coexistence of both types of traces on a single arrowhead (Fig.

10:5) most probably indicates change of fletching and, possibly, the shaft during the use-history of the arrowhead. This most probably was related to breakage and reshaping of the tang. Some screw-like traces overlap the straight ones indicating that first the arrow was not rotating, and started rotating after repair.

Duration of use

Long and slender arrowheads were rather fragile, and many of them were found broken. After breakage most arrowheads were abandoned, but some were repaired and reused. One of arrowheads from Ivanovskoye 7 (layer IV) was broken in the middle, and a new tang was made at the point where the arrow had broken, partly removing the slots, while the point and inserts remained unchanged (Fig. 4:8). A second find from the same layer was most probably repaired several times: the point was resharpened and the tang reshaped, and the slot was partly removed at both ends (Fig. 2:14). All repaired arrowheads display very well-pronounced use-wear indicating long use. From Siberian ethnography we know that arrows that have killed the hunted mammals were considered the best ones and were treated with special care (Teploukhov 1880; Serikov 2009). The same probably applies to arrowheads from Early Mesolithic sites.

CONCLUSIONS

Several types of bone arrowheads were produced and used during the Early Mesolithic in the Volga-Oka interfluve. Microscopic and experimental research of the arrowheads made it possible to determine how they were made and used. All of the studied arrowheads were rather well-made, employing a standard operation chain, and some rare artefacts were treated with special care. The technology of manufacture was rather sophisticated and made possible the production of various different types of artefacts. The development of bone arrowheads, their production and use followed the general pattern characteristic of Butovo culture, which existed in the Volga-Oka interfluve from the beginning of the Mesolithic till the end of the period. Use-wear traces indicate hitting some sort of soft (occasionally hard) material covered by fine mineral particles, most probably hunted animals. Some arrowheads also display traces from hitting the ground, evidently resulting when the arrow missed the target. Only one small barbed arrowhead showed traces of hitting a silty and sandy lake bottom, and was used most probably for shooting fish.

Use-wear traces on the majority of the studied arrowheads indicate that they were used for a rather short time, but some arrowheads display very well-developed use-wear and traces of repair bearing evidence of a long history of use. The research demonstrated the good skill of Early Mesolithic inhabitants of the Volga-Oka interfluve in manufacturing bone arrowheads, which they used for hunting various animals. Numerous bones of the latter from Early Mesolithic find contexts (Zhilin 2014) together with hunting and fishing gear bear evidence of successful adaptation to the early Holocene environment.

Most types of bone arrowheads from Early Mesolithic sites of the Upper Volga and the eastern Baltic region are similar, and the technology manufacture is also similar. Previous research has pointed out similarity in the flint industry of Pre-boreal period sites in these regions as well as southern Finland (Zhilin 2002; 2003a; Takala 2004; 2009; Jussila et al. 2007; 2012; Gerasimov et al. 2010). The observed similarity of flint tanged arrowheads and inserts from Early Mesolithic sites in southern Finland, such as Lahti Ristola and Saarenoja 2, with arrowheads and inserts from contemporary sites in the eastern Baltic and the Volga-Oka interfluve leads us to suggest that bone arrowheads similar to the ones discussed in this article were probably produced and used in southern Finland and on the Karelian Isthmus as well.

The number and diversity of bone arrowheads at Early Mesolithic sites of the Volga-Oka interfluve and sites like Zvejnieki 2 (lower layer) and Sūļagals in the eastern Baltic is several times greater than flint ones. This indicates their crucial role in the hunting equipment of the Early Mesolithic population of said regions. Flint arrowheads are rare at Early Mesolithic sites in southern Finland, where oblique and transverse arrowheads made of quartz appear later in the period (Manninen & Tallavaara 2011). This makes possible to suggest that bone arrowheads played the leading role in Early Mesolithic hunting equipment of this region as well. But a confirmation to this hypothesis can be found only when Early Mesolithic sites with bone arrowheads are discovered in southern Finland and on the Karelian Isthmus.

REFERENCES

Unpublished sources

Aleshinskaya, A.S. 2001. Paleogeograficheskiye usloviya obitaniya drevnego cheloveka v mezolite Volgo-Okskogo mezhdurech'ye: Po palinologicheskim dannym. PhD dissertation. Geography, Moskovskiy Gosudarstvennyi universitet, Moscow.

Literature

Andersen, K., Jørgensen, S. & Richter, J. 1982. *Maglemose hytterne ved Ulkestrup Lyng*. Nordiske Fortidsminder, Serie B Bind 7. Det kgl. nordiske Oldskriftselskab, København.

Bronk Ramsey, C. 2003. *OxCal Version 3.9.* Oxford Radiocarbon Accelerator Unit, Oxford.

Brzozowski, J. & Siemaszko, J. 1996. Dolnomezolityczne obozowisko kultury kundajskiej w Miłukach, stanowisko 4, w świetle datowań dendrochronologicznych i radiowęglowych. Zeszyty Naukowe Politechniki – Śląskiej, Seria: Matematyka-Fizyka 80, *Geochronometria* 14: 229–38.

Chairkin, S.E. & Zhilin, M.G. 2005. Mezoliticheskiye materialy iz peshchernykh pamyatnikov lesnogo Zaural'ya. In M.G. Zhilin (ed.), *Kamennyi vek lesnoy zony Vostochnoy Evropy i Zaural'ya*: 252–73. Academia, Moskva.

Clark, J.G.D. 1936. *The Mesolithic Settlement in Northern Europe*. Cambridge University Press, Cambridge.

Clark, J.G.D. 1954. *Excavations at Star Carr*. Cambridge University Press, Cambridge.

Clark, J.G.D. 1975. *The Earlier Stone Age Settlement of Scandinavia*. Cambridge University Press, Cambridge.

Gerasimov, D.V., Kriiska, A. & Lisitsyn S.N. 2010. Colonization of the Gulf of Finland (the Baltic Sea) coastal zone in the Stone Age. In A.V. Golovnev (ed.), *III Northern Archaeological Congress: Papers: November 8–13, 2010 Khanty-Mansiysk*: 28–53. IzdatNaukaServis, Ekaterinburg&Khanty-Mansiysk.

Gramsch, B. 1990. Die frühmesolithischen Knochenspitzen von Friesack, Kr. Naumen. *Veröffentlichungen des Museums für Ur- und Frühgeschichte Potsadam* 24: 7–26.

Gramsch, B. 2000. Friesack: Letzte Jäger und Sammler in Brandenburg. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 47: 51–103.

Gramsch, B. 2004. From the Late Paleolithic to the Early Mesolithic in northeastern Germany. In: T. Terberger & B.V. Eriksen (eds.), *Hunters in a Changing World: Environment and Archaeology of the Pleistocene–Holocene Transition (ca. 11000–9000 BC) in Northern Central Europe*: 183–201. Internationale Archäologie 5. Leidorf, Rahden.

Gross, H. 1937. Der erste sichere Fund eines paläolitischen Geräts in Ostpreussen. *Mannus* 29(2): 113–8.

Gross, H. 1940. Die Renntierjäger-Kulturen Ostpreussens. *Praehistorische Zeitschrift* XXX–XXXI: 39–67.

Gurina, N.N., 1956. *Oleneostrovskiy mogil'nik*. Materialy i issledovaniya po arkheologii SSSR 47. Nauka, Moskva-Leningrad.

Gurina, N.N. 1991. Nekotorye obshchiye voprosy izucheniya drevnego rybolovstva i morskogo promysla na territorii SSSR. In N.N. Gurina (ed.), *Rybolovstvo i morskoy promysel v epokhu mezolita–rannego metalla v lesnoy i lesostepnoy zone Vostochnoy Evropy*: 5–24. Nauka, Leningrad.

Hansen, K.M. 2003. Pre-Boreal elk hunting in Denmark. In A. Bauerochse & H. Hassmann (eds.), *Peatlands: Archaeological Sites – Archives of Nature – Nature Conservation – Wise Use: Proceedings of the European Peatland Conference 2002 in Hannover, Germany*: 99–106. Leidorf, Rahden.

Hartz, S., Terberger, T. & Zhilin, M. 2010. New AMS-dates for the Upper Volga Mesolithic and the origin of microblade technology in Europe. *Quartar* 57: 155–169. Leidorf, Rahden.

Henriksen, B.B. 1980. *Lundby-holmen: Pladser af Maglemose-type i Sydsjælland*. Nordiske Fortidsminder, Serie B Bind 6. Det kgl. nordiske Oldskriftselskab, København.

Hertell, E. & Tallavaara, M. 2011. High mobility or gift exchange: Early Mesolithic exotic chipped lithics in southern Finland. In T. Rankama (ed.), *Mesolithic Interfaces: Variability in Lithic Technologies in Eastern Fennoscandia*: 11–41. Monographs of the Archaeological Society of Finland 1. Archaeological Society of Finland, Helsinki.

Jaanits, L. & Jaanits, K. 1975. Frühmesolithischen Siedlung in Pulli. *Eesti NSV Teaduste Akadeemia Toimetised, Ühiskonnateadused* 24(1): 64–70.

Jaanits, L. & Jaanits, K. 1978. Ausgrabungen der frühmesolithischen Siedlung von Pulli. *Eesti NSV Teaduste Akadeemia Toimetised, Ühiskonnateadused* 27(1): 56–63.

Jussila, T., Kriiska, A. & Rostedt, T. 2007. The Mesolithic settlement in NE Savo, Finland and the earliest settlement in the eastern Baltic Sea. *Acta Archaeologica* 78(2): 143–62.

Jussila, T, Kriiska, A, & Rostedt, T. 2012. Saarenoja 2 – an Early Mesolithic site in south-eastern Finland: Preliminary results and interpretations of studies conducted in 2000 and 2008–10. *Fennoscandia Archaeologica* XXIX: 3–27.

Kol'tsov, L.V. 1989. Mezolit Volgo-Okskogo mezhdurech'ya. In L.V. Kol'tsov (ed.), *Mezolit SSSR*: 68–87. Arkheologiya SSSR. Nauka, Moskva.

Kol'tsov, L.V. & Zhilin, M.G. 1999. *Mezolit Volgo-Okskogo mezhdurech'ya: Pamyatniki butovskoy kul'tury*. Nauka, Moskva.

Kraynov, D.A. & Khotinskiy, N.A. 1984. Ivanovskiye stoyanki: Kompleks mezo- i neoliticheskikh ozerno-bolotnykh poseleniy na Volgo-Okskom mezhdurech'ye. In A.A. Velichko (ed.), *Arkheologiya i paleogeografiya mezolita i neolita Russkoy ravniny*: 92–109. Nauka, Moskva.

Kraynov, D.A., Lozovskiy, V.M. & Kostyleva, E.L. 1990. Mezoliticheskaya stoyanka Sakhtysh 9. In A.V. Utkin (ed.), *Arkheologicheskiye pamyatniki Volgo-Klyaz'minskogo mezhdurech'ya* 3: 23–31. Ivanovo.

Loze, I.A. 1988. *Poseleniya kamennogo veka Lubanskoy niziny: Mezolit, ranniy i sredniy neolit.* Zinatne, Riga.

Lozovski, V.M. 1996. *Zamostje 2: the Last Prehistoric Hunter-Fishers of the Russian Plain*. Editions du CEDARC, Treignes.

Malinova, R. & Malina, Ya. 1988. *Pryzhok v proshloye: Eksperiment raskryvayet tayny drevnikh epokh*. Mysl', Moskva.

Manninen, M.A & Hertell, E. 2011. Few and far between: an Archive survey of Finnish blade finds. In T. Rankama (ed.), *Mesolithic Interfaces: Variability in Lithic Technologies in Eastern Fennoscandia*: 112–41. Monographs of the Archaeological Society of Finland 1. Archaeological Society of Finland, Helsinki.

Manninen, M.A. & Tallavaara, M. 2011. Descent history of Mesolithic oblique points in eastern Fennoscandia: a Technological comparison between two artefact populations. In T. Rankama (ed.), *Mesolithic Interfaces: Variability in Lithic Technologies in Eastern Fennoscandia*: 176–211. Archaeological Society of Finland, Helsinki.

Matiskainen, H. 1996. Discrepancies in deglaciation chronology and the appearence of man in Finland. In L. Larsson (ed.), *Earliest Settlement of Scandinavia*. Acta Archaeologica Lundensia, Ser. In 8:o, No 24: 251–62. Almquist & Wiksell International, Stockholm.

Oshibkina, S.V. 1983. *Mezolit basseyna Sukhony i Vostochnogo Prionezh'ya*. Nauka, Moskva.

Oshibkina, S.V. 1989. The material culture of the Veretye-type sites in the region to the east of Lake Onega. In C. Bonsall (ed.), *The Mesolithic in Europe: Papers Presented at the 3rd International (Mesolithic) Symposium, Edinburgh 1985*: 402–13. John Donald, Edinburgh.

Oshibkina, S.V. 1999. Tanged point industries in the north-west of Russia. In S. Kozłowski, J. Gurba, L.L. Zaliznyak (eds.), T*anged Points Cultures in Europe*: 325–32. Lubelskie materiały archeologiczne 13. Maria Curie-Skłogowska University Press, Lublin.

Oshibkina, S.V., Kraynov, D.A. & Zimina, M.P. 1992. *Iskusstvo kamennogo veka: Lesnaya zona Vostochnoy Evropy*. Nauka, Moskva.

Paulsen, H. 2013. From Stone Age hunting bow to medieval weapon of war: Selected examples of bows and arrows in the North. In O. Grimm & U. Schmölcke U (eds.), Hunting in Northern Europe until 1500 AD: *Old Traditions and Regional Developments, Continental Sources and Continental Influences*: 185–206. Schriften des Archäologischen Landesmuseums, Band 7. Wachholz, Neumünster.

Pälsi, S. 1920. Ein steinzeitlichen Moorfund bei Korpilahti kirchspiel Antrea, Län Viborg. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* 28:2: 3–19. Suomen Muinaismuistoyhdistys, Helsinki.

Savchenko, S.N. 2010. Experiments on manufacturing techniques of Mesolithic and Early Neolithic slotted bone projectile points from eastern Urals. In A. Legrand-Pineau, I. Sidéra, N. Buc, E. David & V. Scheinsohn (eds.), *Ancient and Modern Bone Artefacts from America to Russia: Cultural, Technological and Functional Signature*: 141–147. BAR International Series 2136. Archaeopress, Oxford.

Savchenko, S.N. 2014. Preyemstvennost' i innovatsii v razvitii kostyanoy industrii mezolita

gornolesnogo Zaural'ya. *Stratum plus* 2014(1): 181–208.
Savchenko, S., Lillie, M.C., Zhilin, M.G. & Budd C.E. 2015. New AMS dating of bone and antler weapons from the Shigir collections housed in the Sverdlovsk Regional Museum, Urals, Russia. *Proceedings of the Prehistoric Society* 81: 265–81.
Semenov, S.A. 1965. *Prehistoric technology: an Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. Cory, Adams & Mackay, London.
Serikov, Yu.B. 2009. *Peshchernye svyatilishcha reki Chusovoy*. Tagil print, Nizhniy Tagil.
Serikov, Yu.B. & Tupikov, I.N. 2015. K voprosu o himicheskom razmyagchenii kosti v drevnosti. *Tverskoy arkheologicheskiy sbornik* 10(1): 304–11. TGOM, Tver".
Skakun, N., Zhilin, M. & Terekhina. V. 2014. The history of one arrowhead from a peat bog site in central Russia (technological and use-wear studies). In J. Marreiros, N. Bicho & J.F. Gibaja (eds.), *International Conference on Use-Wear Analysis: Use-Wear 2012*: 430–40. Cambridge Scholars Publishing, Newcastle upon Tyne.
Sulgostowska, Z. 1996. The earliest Mesolithic settlement of north-eastern Poland. In L. Larsson (ed.), *Earliest Settlement of Scandinavia*. Acta Archaeologica Lundensia, Ser. In 8:o, No 24: 297–304. Almquist & Wiksell International, Stockholm.
Takala, H. 2004. *The Ristola Site in Lahti and the Earliest Postglacial Settlement of South Finland*. Lahti City Museum, Lahti.
Takala, H. 2009. The flint collection from the Ristola site in Lahti and the cultural contacts of the earliest postglacial settlement of southern Finland. In S. McCartan, R. Schulting, G. Warren & P. Woodman (eds.), *Mesolithic Horizons: Papers Presented at the Seventh International Conference on the Mesolithic in Europe, Belfast 2005*: 31–7. Oxbow Books, Oxford.
Teploukhov, A.E. 1880. O doistoricheskikh zhertvennykh mestakh na Ural'skikh gorakh. *Zapiski Ural'skogo obshchestva lyubiteley yestestvoznaniya* 6(1): 1–31.
Vahur, S., Kriiska, A. & Leito, I. 2011. Investigation of the adhesive residue on the flint insert and the adhesive lump found from the Pulli Early Mesolithic settlement site (Estonia) by MICRO-ATR-FT-IR spectroscopy. *Estonian Journal of Archaeology* 15(1): 3–17.
Zagorska, I. 1974. Vidējā akmens laikmeta zivju šķēpi Latvijā. *Arheoloģija un etnogrāfija* XI: 25–38.
Zagorska, I. 1980. Das Frühmesolithikum in Lettland. In: *Veröffentlichungen des Museums für Ur- und Frühgeschichte Potsadam* 14/15: 73–82.
Zagorska, I.A. 1991. Rybolovstvo i morskoy promysel v kamennom veke na territorii Latvii. In N.N. Gurina (ed.), *Rybolovstvo i morskoy promysel v epokhu mezolita–rannego metalla v lesnoy i lesostepnoy zone Vostochnoy Evropy*: 65–86. Nauka, Leningrad.
Zagorska, I. 1993. The Mesolithic in Latvia. *Acta Archaeologica* 63: 97–116.
Zagorska, I. & Zagorskis, F. 1989. The bone and antler inventory from Zvejnieki II, Latvian SSR. In C. Bonsall (ed.), *The Mesolithic in Europe: Papers Presented at the 3rd International (Mesolithic) Symposium, Edinburgh 1985*: 414–23. John Donald, Edinburgh.
Zaretskaya, N.E., Zhilin, M.G., Karmanov, V.N. & Uspenskaya, O.N. 2005. Radiocarbon dating of wetland Mesolithic-Neolithic archaeological sites within the Upper Volga and Middle Vychegda. *Geochronometria* 24: 117–31.
Zhilin, M.G. 1993. *Kostyanoye vooruzheniye drevneyshego naseleniya Verkhnego Povolzh'ya*. Russkaya Ravnina, Moskva.
Zhilin, M.G. 1998. Technology of the manufacture of Mesolithic bone arrowheads on the Upper Volga. *European Journal of Archaeology* 1(2): 149–75.
Zhilin, M.G. 2001. *Kostyanaya industriya mezolita lesnoy zony Vostochnoy Evropy*. URSS, Moskva.
Zhilin, M.G. 2002. K voprosu o pionernom zaselenii Yuzhnoy Karelii i Finlyandii v rannem golotsene. *Vestnik Karel'skogo kraevedcheskogo muzeya* 4: 3–15. KGKM, Petrozavodsk.
Zhilin, M.G. 2003a. Early Mesolithic communication networks in the East European forest zone. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler & A. Åkerlund (eds.), *Mesolithic on the Move: Papers Presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000*: 688–93. Oxbow Books, Oxford.
Zhilin, M. 2003b. Early Mesolithic peat bog sites on the Upper Volga. In A. Bauerochse & H. Hassmann (eds.), *Peatlands: Archaeological Sites – Archives of Nature – Nature Conserva-*

tion – Wise Use: Proceedings of the European Peatland Conference 2002 in Hannover, Germany: 48–61. Leidorf, Rahden.
Zhilin, M.G. 2006a. Das Mesolithikum im Gebeist zwischen den Flussen Wolga und Oka: einige Forschungsergebnisse der letzten Jahre. *Praehistorische Zeitschrift* 81(1): 1–48.
Zhilin, M.G. 2006b. *Mezoliticheskiye torfyanikoviye stoyanki Tverskogo Povolzh'ya*. IA RAN, Moskva.
Zhilin, M.G. 2007a. Mesolithic wetland sites in central Russia. In M. Lillie & S. Ellis (eds.), *Wetland Archaeology & Environments: Regional Issues, Global Perspectives*: 65–78. Oxbow Books, Oxford.
Zhilin, M.G. 2007b. The Early Mesolithic of the Upper Volga: Selected problems. In M. Masojć, T. Płonka, B. Ginter & K. Kozłowski (eds.), *Contributions to the Central European Stone Age*: 89–104. University of Wrocław, Wrocław.
Zhilin, M.G. 2009. Chronology and evolution in the Mesolithic of the Upper Volga-Oka interfluve. In P. Crombe, M. Van Strydonck, J. Segrant, M. Boudin & M. Bats (eds.), *Radiocarbon Chronology and Evolution within the Mesolithic of North-West Europe: Proceedings of an International Meeting, Brussels, May 30th–June 1st 2007*: 451–72. Cambridge Scholars Publishing, Cambridge.
Zhilin, M.G. 2013. Traditsii i innovatsii v razvitii kostyanoy industrii butovskoy kul'tury. *Stratum plus* 2013(1): 1–30.
Zhilin, M.G. 2014. Early Mesolithic hunting and fishing activities in central Russia: a Review of faunal and artefactual evidence from wetland sites. *Journal of Wetland Archaeology* 14(1): 92–106.
Zhilin, M.G., Kostyleva, E.L., Utkin, A.V. & Engovatova A.V. 2002. *Mezoliticheskiye i neoliticheskiye kul'tury Verkhnego Povolzh'ya: Po materialam stoyanki Ivanovskoye VII*. Nauka, Moskva.
Zhilin M.G. & Savchenko, S.N. 2015. Issledovaniye mezoliticheskikh stoyanok na Gorbunovskom torfyanike v Zaural'e v 2010–2014 gg. In N.A. Makarov (ed.), *Institut Arkheologii: Novye ekspeditsii i projekty*: 22–5. IA RAN, Moskva.