



Research Article

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Fishing Nets and String at the Final Mesolithic and Early Neolithic Site of Zamostje 2, Sergiev Posad (Russia)

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Abstract: The site Zamostje 2, located in Sergiev-Posad district of Moscow (Russia) on the west bank of the Dubna River, has provided two Mesolithic and one Early Neolithic occupations dated from 7000 to 5400 cal BC. Thanks to the waterlogged environment, the site has an exceptional preservation. The site has yielded fishing screens, fishing fences, wooden fishing traps, and several small cordage remains elaborated with plant fibres, pine bark floats, fragments of paddles, and other wooden objects. In this work, we present the study of the fragments of cordage and fishing nets with the objective of providing new insights into the production and use of implements made of plant fibres. We have characterized the production process by analysing the morphological and technical characteristics by carrying out experimentation with plant fibres in order to obtain reference material to recognize them at an archaeological level. The analysis of 82 knots and 23 fragments of strings has allowed to determine that they were elaborated with single threads from 0.5 to 1.5 mm thick, which is noticeably smaller than most examples from other sites. All of them were elaborated with woody bast fibres.

Keywords: plant fibres, archaeobotany, prehistoric handicraft, fishing nets, experimental archaeology

1 Introduction

Plant fibres and the production of cordage were crucial for past societies, and hence, their study is essential to fully understand their organization. In the first place, we must consider the great importance that ropes have as a tool. Ropes and cords would be present in all domains of daily life: clothing, housing, hunting, fishing, and gathering, as well as in the creation of compound tools and means of transport. To produce all these objects and tools, plant fibres have been traditionally the preferred material, they are widely available, and their properties make them a very suitable material for this purpose. Only recently have these

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natural fibres been replaced by nylon and other modern materials in the string-making industry. Second, the ropes belong to perishable technologies (Hurcombe, 2014) made with what have been called the forgotten or missing resources. Their perishable nature means that they are only rarely preserved in the archaeological contexts and, therefore, everything related to their production is ignored, including the importance of the labour force of the social group that carries out this work, which, according to ethnography, is often made up of women and children. Therefore, in order to know and understand the economic organization of any society it is important to document all the resources exploited, and among them are the plant raw materials or fibres in cordage production and their production processes.

According to Hardy (2008) string production is a never-ending process. This author has remarked the amount of work involved in cordage production among the Wala of Papua Nueva Guinea, where string making took up well over 50% of women's manufacturing time and 45% of all manufacturing time when men's time was also included. String manufacture may well have been the single most time-consuming activity undertaken by the manufacturing group throughout their lives as they were completely tied to the ongoing demand for string and the need to produce. However, when it comes to archaeology, the reduced amount of string findings does not allow us to get a direct and accurate evidence of how string manufacturing was. To do so, we must turn elsewhere for help, and ethnography is one of our most reliable tools (Carr & Maslowski, 1995; Connolly, Kallenbach, & McCabe, 2017; Hardy, 2008; Kerfant, 2022; Wickens & Lowe, 2008).

Many plants can provide fibres for rope production, their availability is the main limitation for their use. In prehistoric times, some of the plant fibres more frequently documented to produce ropes are the inner bark of linden, elm, oak, juniper, and willow (Altorfer & Médard, 2000; Bender Jørgensen, 1992; Miettinen *et al.*, 2008; Myking, Hertzberg, & Skrøppa, 2005). But it is also documented the use of fibres from the stalks of nettle (Salls, 1989), blackberry, flax, hemp, hop, reed, and willow herb (e.g., Médard, 2003; Piqué *et al.*, 2018).

In the case of fishing societies, such as the one we study in Zamostje 2, which we will present later, cordage became a crucial tool (Myking *et al.*, 2005), being the basis for fishing, both for hanging a hook or making a net. From an archaeological point of view, there are some fishing related tools (e.g., sink weights and hooks) dated to the Palaeolithic. However, the first evidence of fishing nets dates from the Mesolithic, with several sites where the remains of fishing nets or ropes made from raw plant materials have been recovered, such as Antrea (Carpelan, 2008; Pälsi, 1920), Narva (Kriiska, 1996), or Vis 1 (Burov, 1966). This tradition continues in the Neolithic, with findings at Sárnate in Latvia (Rimantienė, 1991), Šventoji 2B in Lithuania (Vankina, 1970), Usvyaty IV, Serteya I and Serteya II in Russia (Kolosova & Mazurkevich, 1998; Vasilyeva, 2014), Friesack 4 (Kernchen & Gramsch, 1989), or Satrup-Förstermoor in Germany (Feulner, 2012). The aim of this work is to present the technological analysis of the remains of fishing nets recovered at the site of Zamostje 2 (Russia). The fishing net remains of Zamostje 2 have been the object of previous publications, focused mainly on the morphological descriptions and contextualization (Lozovskaya, 2019; Lozovski *et al.*, 2013). In this article, we present the technological analysis and a first approach to the raw material used for making the fishing nets. The results are contextualized in the frame of the Mesolithic fishing nets.

1.1 The Site of Zamostje 2

Zamostje 2 is an archaeological site located on the banks of the current Dubna River, about 100 km north to Moscow (Russia) (Figure 1). Since 1989, successive excavation campaigns have been carried out to establish a cultural sequence and chronology for the site. Environmental studies seem to show that in the past it was on the shore of a lake (Lozovski, Lozovskaya, Mazurkevich, Hookk, & Kolosova, 2014). The excavations have documented evidence of occupations at the riverbank as well as fishing structures in the river.

Thus, five levels have been identified and dated (Lozovskaya, Clemente Conte, Ershova, & Kulkova, 2020). The two first levels are attributed to the late Mesolithic, the older is dated between 6600 and 6400 cal BC and the upper one, which is where most of the archaeological materials concentrate, between 6300 and 5900 cal BC. Next, appears a level that corresponds to the Final Mesolithic (with provisional dates between 5900 and 5750 cal BC). Finally, the two upper levels correspond to an Early Neolithic (dated between 5700 and 5300 cal BC) and Middle Neolithic (ca. 4900–4300 cal BC).

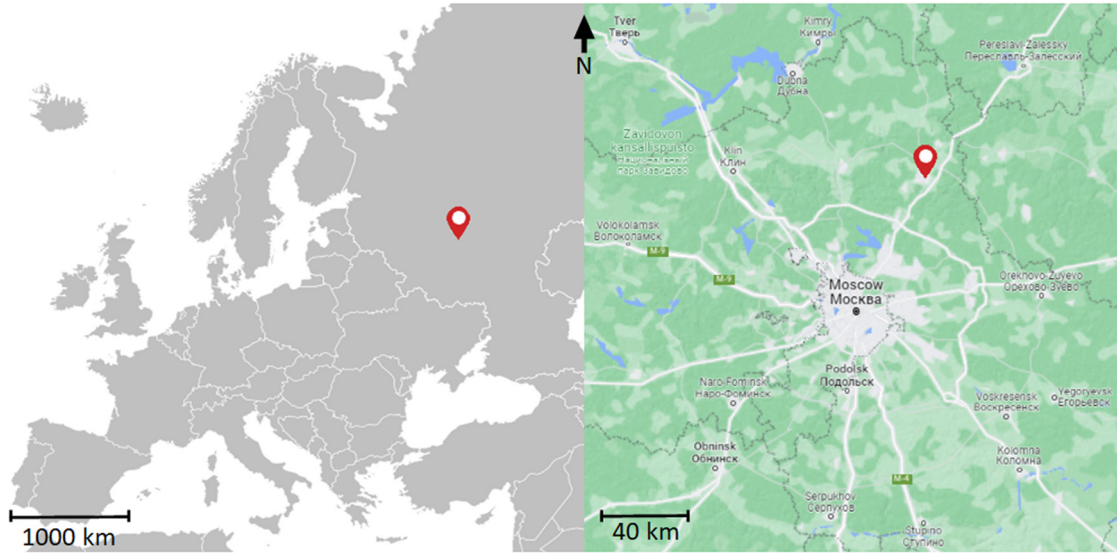


Figure 1: Location of the site Zamostje 2.

The oldest four levels have an extraordinary preservation of the organic remains, due to the constant presence of water, while the upper level has remained for a period of time above the water table, and therefore many remains have deteriorated.

Thanks to the archaeological interventions, we know that the inhabitants of Zamostje 2 were engaged in economic activities based on elk and beaver hunting, as well as harvesting of wild plants, and that fishing was crucial (Lozovskaya & Lozovski, 2018). Without doubt, fishing activities played an important role: many thousands of fish remains belonging to up to 11 species have been recovered and studied (Radu & Desse-Berset, 2013). Hooks, harpoons, and traps, as well as fragments of fishing nets, are also some of the very abundant finds (Lozovski et al., 2013).

The archaeobotanical study of macroremains, wood, and charcoal has allowed the characterization of the vegetal landscape and to draw a picture of the plant resources exploited. Pollen, charcoal, and wood remains have documented the presence of woodlands in the surroundings, where riparian taxa are very well represented (Alexandrovskiy, 2018; Ershova, 2013; Ershova & Lozovskaya, 2018). In all layers the presence of *Alnus* sp., *Salix-Populus*, *Tilia* sp., *Pinus sylvestris-nigra* type, *Prunus* sp., *Ulmus* sp., *Betula* sp., and *Acer* sp. is documented. Moreover, over 3,800 remains of seeds and fruits, corresponding to 51 taxa, have been identified (Berihuete-Azorín, 2018). The results of their study show that fruits and berries were systematically gathered, and their use extends along all the occupation sequence. Regarding water plants and lakeshore species, they are ubiquitous along time, although their presence decreased over time (28 taxa in the Late Mesolithic and 12 in the Neolithic phase).

2 Materials and Methods

The knots and fibre remains were recovered in different sectors of the site during the wash-over and water sieving of sampled sediments (Figure 2). Sediments samples were taken in two different sectors of the site. One in a column of sediment from the profile, and the other near three fishing traps that were attached to vertical stakes fixed to the bottom of the river.

In the 2013 excavation campaign, a column of sediment was taken from one of the profiles (Test pit AA18) to obtain a high-resolution record of the archaeobotanical remains and sediments (Lozovskaya & Lozovski, 2018). This column included all the Mesolithic and Neolithic archaeological levels. Once in the laboratory, we excavated the column following the natural strata, except when the layers were too deep. In

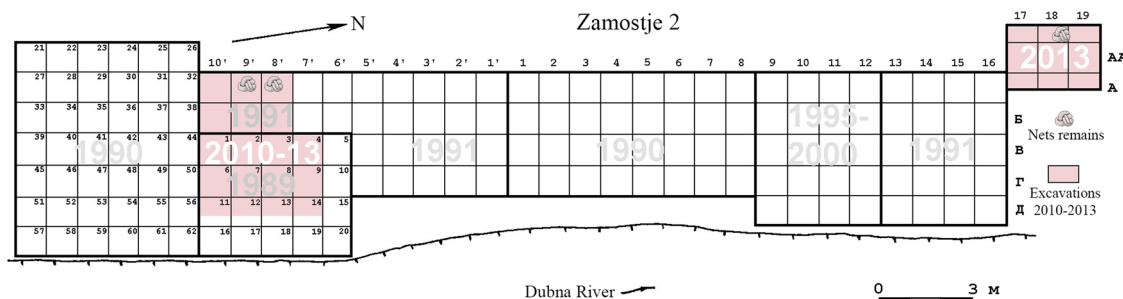


Figure 2: Plan of the excavated sectors of Zamostje 2 with location of fibre remains.

these cases, we excavated artificial layers with a thickness of 5 cm. In total, the column was divided into 25 samples. The sediment of each was processed by wash-over and the remains were recovered in sieves with a mesh size of 2 and 0.315 mm.

In addition, sediments around three fishing traps that were attached to vertical stakes fixed to the bottom of the river were also sampled. The area around the traps was characterized by additional evidence from fishing, in particular a layer of fish mummies (bones and scales in anatomical sequence), and the accumulation of large stones or net sinkers (Lozovskaya *et al.*, 2020). In this case knots and fibres were recovered during the water sieving (5 mm) of two squares (A8' and A9') near the traps.

The knots of these two locations have yielded a total of 82 items, including cordage remains. An accumulation of knots was recovered near the western fishing trap located at the contact of the two layers of Late Mesolithic (LM-UL) and Early Neolithic (EN) on squares A8' (50 specimens) and A9' (6 specimens). In the case of the Test pit AA18 26 knots and various fibre remnants were found, as well as a piece of rope with two strings. Seven knots were found in the Neolithic layer, the rest (19) were associated with deposits of the upper Late Mesolithic layer.

The aim of the technological analysis was to determine the number of strands and the direction of the torsion of the fibres and strands (Hurley, 1979). Moreover, the type of knotting of the fishing nets has been analysed. This analysis is based in previous proposals (e.g., Lozovskaya, 2019) and in our own experimental materials described below. The first stage of experiments aimed at creating a working reference base for determining the material and plausible processes from which the nets were made. That included the preparation of plant fibres from fresh and dry nettle, dry fireweed (*Chamaenerion angustifolium*) stems, soaked linden bast, willow bark boiled in ashes, and fresh hops (*Humulus lupulus*). For visual comparison, single and twisted double thin threads were obtained experimentally (Figure 3) and sheet bend knots were made (Figure 4).



Figure 3: Strings produced with (a) nettle, (b) linden, (c) willow, and (d) fireweed.



Figure 4: Knots produced with experimental strings made of willow (left) and nettle (right).

Taxonomical identification of raw materials used in knots and cords production was based on the microscopic observation of the anatomical features of fibres. A transmitted light bright field–dark field (BF–DF) is usually used to observe the appearance, shape, and anatomical features of fibres when the samples are relatively consistent. This is possible when they are conserved by dehydration or carbonization. In the case of Zamostje 2, the samples were preserved by waterlogging so the use of this type of microscope was not as resolutive as thought, as the transferred light reflects, and no specific features were visible. The rapid drying of the materials was damaging, so this procedure was discarded. Then, thin sections of two samples (a knot and a cord) were made in radial, transversal, and tangential directions to visualize the samples under a reflected light microscopy Olympus BX51 linked to an Olympus DP26 camera and using the Olympus cellSens software. The visualized features were compared with modern specimens as reference material and specialized literature (Schweingruber, Börner, & Schulze, 2011a,b).

3 Results

3.1 Morphological and Technical Characteristics

The general characteristics of the findings clearly point out towards being a part of fishing nets. Due to preservation constrains, in general only the places where the strands were knotted have been retrieved (Figure 5). However, four of them preserved very short pieces of strings attached (up to 3.5 mm). The knots are small-sized, ranging from 2.3×2.1 (No. 106) to 6×4.5 mm (No. 6), but on average, they have 3–4 mm.

According to the number of strands, two types of knots have been identified. Most of the knots consist of two single strands (67%) with straight (Figure 6a) or slightly twisted fibres (Figure 6b). The strands have a thickness of 0.3–1.5 mm, on an average 0.7–1.2 mm. Straight single fibres are the most common (64%) although some of them show a weak S twist. Some two stranded plied string fragments have also been recovered (Figure 6c). In fact, 19 knots have two double strands and almost all of them present an S twist.

In Prehistory we find a variety of solutions applied to net-making. The nets from Antrea Korpilahti (Finland) were made of double strands with a S twist (Pälsi, 1920, p. 16, Taf. V; Carpelan, 2008, p. 99). In contrast, for the fishing net from Peat Bog Vis 1 (Burov, 1966, p. 162, Figure 5), the unique knotted fishing net from Friesack 4 (layer 23) (Kernchen & Gramsch, 1989, p. 24, Taf. 6.1,2) and the net from Satrup-Förstermoor (Feulner, 2012, p. 168) they used strings, 1.5–2 mm thick, twisted in the Z direction from strands with an S twist (ssZ).

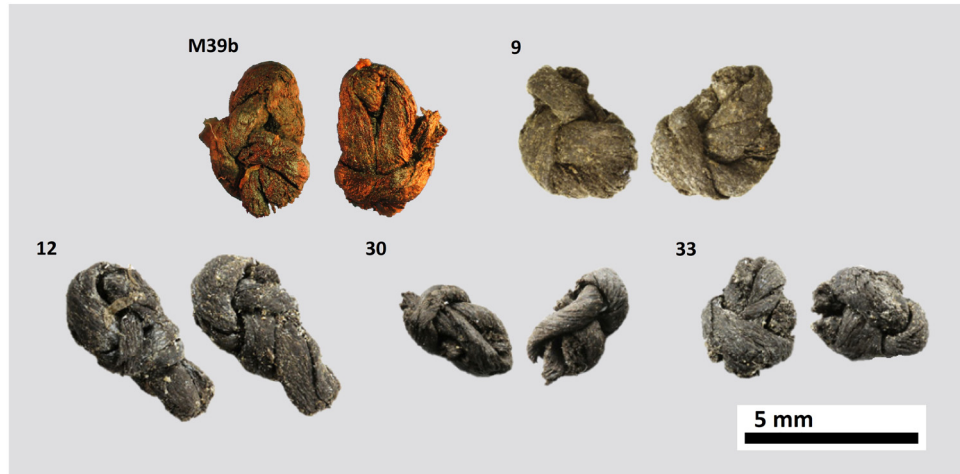


Figure 5: Detail of some archaeological knots.

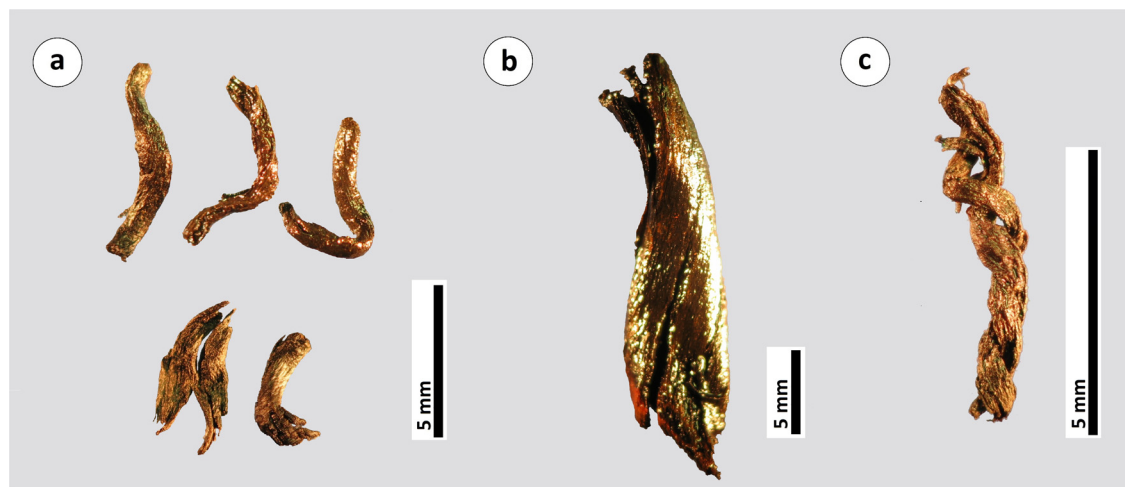


Figure 6: Fibres from Zamostje 2: (a) straight fibres, (b) slightly twisted fibres, and (c) two-strand cord.

Regarding the knot type, almost all identifiable knots (68 specimens) correspond to the type “sheet bend” (Figure 7). This knot is traditionally used in net making (netting) up to the present day (von Brandt, 1984). Also known as fisherman’s knot, it has been recorded as the main technique for weaving fishing nets since the ninth millennium cal BC. For instance, the above-mentioned Antrea net, the oldest net found, dated to the Mesolithic (ca. 9300–9200 BP), also displays this knot (Pälsi, 1920, p. 16, Abb. 7; Carpelan, 2008, pp. 99–100, Figure 5.13). The Vis I net was also woven by this knot, traced in 14 cases (Burov, 1966, p. 162, Figure 5). The six remaining knots are of other types, possibly used to tie together, for example, floats or weights, or to hold threads together.

The choice of plant species for comparison with Zamostje 2 fibres is associated with the identification of their presence at the site in the Mesolithic–Neolithic periods through different archaeobotanical proxies. Since fireweed and hops have not been yet identified, special attention has been paid to linden, willow, and nettle as source of raw materials. From the finished fibres, thin single and double twisted threads with a thickness of about 1 mm were obtained. Simple sheet bends were made from threads. In visual comparison, knots of a single weakly twisted willow thread (slightly smaller from nettle) seem to have the greatest similarity with archaeological specimens, although rare knots with a single double twisted thread are also present.



Figure 7: Variety of sheet bend knots identified at Zamostje 2. Drawing by O. Lozovskaya.

In addition, some fragments of cordage have also been recovered. Three of the fragments have 2–3 cm long and are made of threads of 1.2–1.9 and 3 mm in thickness. Other 18 are S-twist threads of a large rope, each thread 2–3 mm thick. This second type of strings presents torsion in both directions, Z and S. All these remains are found in the Final Mesolithic layer, which dates back to ca. 5850–5700 cal BC, but their specific adscription is unclear. Another two additional remains of cordage come from the Neolithic horizon of Test pit AA18.

3.2 Plant Material Identification

Identification of plant fibres is a major challenge in archaeobotanical research, very few times it is possible to determine the taxa due to the lack of reference collections and the loss of features that allow the taxonomic identification as a consequence of processing. However, the analysis of a sample of a bigger rope dated to the Final Mesolithic, carried out by Prof. M. Kolosova, documented the use of willow bast (Lozovskaya & Lozovski, 2018).

In contrast, the analysis of fragments of cordage from the Neolithic levels unfortunately, did not permit the specific adscription of the materials with certainty due to the unsatisfactory preservation of the plant fibres. Notwithstanding, the microscopic observation of plant fibres allowed to identify some anatomical features. In radial section, vessels have distinct spiral thickenings (Figure 8a); moreover, it has been possible to identify ray cells (Figure 8b). Cross-sections presented a strong deformation with respect to

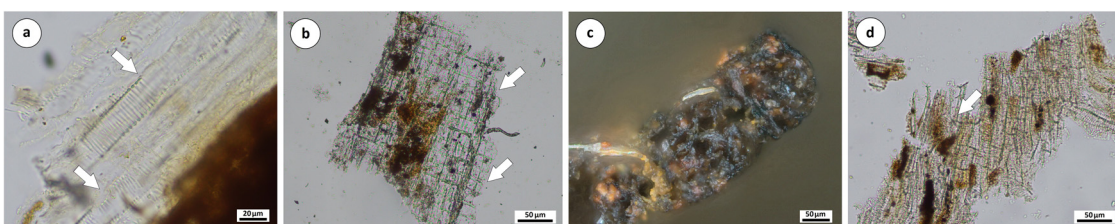


Figure 8: Optical microscopy images showing raw materials features: (a) spiral thickenings in vessels in radial section, (b) ray cells in radial section, (c) cross-section deformation (string samples), and (d) spiral thickenings in vessels (knot samples).

the shape of the vessels; however, the samples show small vessels (Figure 8c). Finally, tangential section was quite degraded, and no rays were observed. The bad state of preservation impeded a further adscription to a particular taxon, but the anatomical features observed are coherent with a dicotyledonous family.

With respect to the knots, only one sample has been analysed. As in the case of cordage, the state the conservation of the fibres is poor, and a taxonomical identification was not possible. In Figure 8d spiral thickenings in vessels are visible as in the case of the twisted fibres mentioned before. The anatomical features are also consistent with dicotyledonous features.

4 Discussion

Considering their distributions at the site (Test pit AA18 and the fishing zone with fishing traps) the knots are probably part of different fishing nets. The knots in the test pit were distributed over several archaeological layers: seven knots were found in the Neolithic layer, the rest (19) were associated with deposits of the upper Late Mesolithic layer. In contrast, the knots associated with the fishing traps were concentrated in a small area of one stratigraphic horizon, what allows us to assume that they originate from the same fishing net. The radiocarbon date of 7087 ± 45 BP (Ua-50259)/6052–5885 cal BC (Lozovskaya, 2019) obtained for two knots (Nos. 13 and 21, both poorly preserved and disintegrated) corresponds to the period of the Final Mesolithic, accompanied by transgression of the reservoir. The distribution of the knots along all the chronological sequence confirms the continuity of fishing practices during long time, as well as the same tradition in the techniques of net making.

The nets recovered at Zamostje 2 are clearly associated to fishing activities. Besides the remains of the fishing nets in the site a significant number of fish remains of at least 11 species have been recovered, the most important of which were *Esox lucius*, *Perca fluviatilis*, *Rutilus* sp., *Carassius carassius*, and *Leuciscus idus* (Radu & Desse-Berset, 2013). Moreover, different archaeological materials related to fishing have been documented, among them are fishing hooks, harpoon heads, barbed points, fish scaling knives made of elk ribs, paddles, and bark floats. Finally, we should mention the stationary fishing structures made of wood and represented by fish traps, screens, and fences (Lozovski *et al.*, 2013).

The use of fishing nets made of plant fibres was widespread among Mesolithic and Neolithic north European groups. They were documented at Antrea (Carpelan, 2008; Pälsi, 1920), Narva (Kriiska, 1996), Vis 1 (Burov 1966), Usvyaty IV, Friesack 4 (Kernchen & Gramsch, 1989), or Satrup-Förstermoor (Feulner, 2012).

The nets of Zamostje 2 are similar to those documented at Antrea or Vis I with respect to the type of knot. Concerning the employed raw materials, a variety of them have been identified for other archaeological cases, being usually species that are widely available in the local landscape. Some examples are the Antrea Korpilahti net, where multistage studies were carried out to finally identify the material as willow bark bast (Miettinen, 2008, pp. 83–84). On another note, the raw material for the net in Vis 1 consisted of twisted roots and leaves of sedge, according to the definition of Prof. S.N. Tyuremnov (Burov, 1966, p. 162), while the Förstermoor net, according to F. Föllner, was made of nettle fibres, like a similar rope from the Early Neolithic Kongsted site (Feulner, 2012, pp. 168–169; Hartz & Kraus, 2009, p. 218). Finally, a knotless net from Sventoji 2B was woven from nettle fibres (Rimantienė, 1991, p. 74, Figure 2). At the Neolithic settlement of Usvyaty IV, the use of juniper roots is supposed, and at Serteya II, blueberry (*Vaccinium* sp.) rhizomes (Kolossova & Mazurkevich, 1998, p. 54). At the same time, new finds of wickerwork at Serteya II also showed the standard use of willow fibres (Vasilyeva, 2014, pp. 233–235).

With respect to the fibres used in net production in Europe only few times have been identified and mainly general attributions to the type of fibre or genus have been done. However, several plants have been recognized: the net of Antrea was identified as willow bast (Bender Jørgensen, 1992, p. 93), in the case of Wis-Moor I the plant used was a type of *Carex* (Bender Jørgensen, 2013, p. 359), bast was used in Friesack 4, Germany (Bender Jørgensen, 1992), bast of willow or poplar in Tybrind Vig, Denmark. Bast of trees is usually identified as raw material, but other plant parts, such as stalks and leaves were also used for

this purpose. For the manufacture of nets in the past some of the most frequent plants were willow branches, linden bark, and stalks of nettle (Rimantienė, 1991, pp. 72–73).

The species used in Zamostje 2 have so far not been identified but based on the species recorded by palynology (Ershova & Lozovskaya, 2018), charcoal analysis (Alexandrovskiy, 2018) and plant macroremains (Berihuete-Azorín, 2018) of many different species were available for obtaining fibres. In fact, a variety of possible plant fibres grew in the surroundings, among them were nettles, sedges, blackberries, willow, raspberry, and lime bark. Hemp and flax appeared in this area later and have not been found within the remaining archaeobotanical assemblage (Berihuete-Azorín, 2018).

Regarding the used techniques, our aim was learning which techniques were involved, to assess possible changes along time. The purpose of knots is to tie together a piece of string, cord, or rope. This bonding can be performed in many ways, responding to a variety of necessities, and resulting in different shapes and strength qualities. Knots have been a basic advance, allowing to further develop in the construction of tools and implements. In the case of Zamostje 2, we have already explained that the fibres used are slightly twisted, and most of the remains correspond to the knots that had formed the net. As explained before, the main type for all periods is the sheet bend knot. In fact, this is coherent with the historical evolution of fishing nets making, the materials have been changing over time, but this type of knot is still employed nowadays for the same purpose. Its main advantages are that it is fast to tie, allows to join two ropes or strings of different diameters, does not slip under load, on the contrary, it gets stronger when more pressure is applied, and it is also easily untied if needed.

Finally, concerning the experimentally created knots, they were helpful to get a better understanding of how the work with those kinds of fibres was. In the future, different types of plant processing such as maceration of fat or retting with water will be undertaken and recording of changes in the microstructure of the fibres will be documented.

5 Conclusions

Strings and ropes must have been of great importance for the fishing, hunting, and gathering societies, in which the demand for this material had to be constant. Therefore, one would have to imagine that its elaboration would involve a significant part of the labour investment of some people in the group, or perhaps of specialized groups within a society. For a fishing society like this whose economical activities are represented at Zamostje 2, string was a key tool and therefore, string production should constitute a very important activity. Its character makes it a very time-consuming activity, which involves a large investment of work, energy, and time. The demand for this material was so big, that it is thought that string production should constitute a daily or quotidian activity. We would like to insist the importance of studying this type of material, despite all the difficulties that have been glimpsed, since both technical and botanical information are crucial for understanding the economy of a particular group of people.

In the case of Zamostje 2, the study of the fibres and knots has allowed to determine similarities with other prehistoric societies with respect to the net production technique, as is the case of Antrea or Vis I. Moreover, this study confirms the continuity in the net production technique for long time, as the type of knot documented has continuity until modern times. Unfortunately, the raw material could not be determined beyond a rough classification of dicotyledonous plant, which impeded to go further for the moment with respect to the plant used.

The research in Zamostje 2 also demonstrates the necessity of accurate methods of sampling and recovering of plant remains. Likewise, it is important to improve plant identification protocols and methods, especially regarding manufactures such as fibre artifacts.

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