Human and birds: avifauna at hunter-gatherer sites of the 6th to 3rd millennia BC (Western Dvina Lakeland)

Andrey Mazurkevich [1], Andrey Panteleev [2], Yolaine Maigrot [3], Mateusz Płóciennik [4], Piotr Kittel [5], Mikhail Sablin [2], and Ekaterina Dolbunova [1]

1 The State Hermitage Museum, St Petersburg; RU; a-mazurkevich@mail.ru, katjer@mail.ru
2 The Zoological Institute of RAS, St Petersburg; RU; pav001@list.ru, msablin@yandex.ru
3 UMR8215 – Trajectories. From sedentariness to the State, Paris; FR; yolaine.maigrot@cnrs.fr
4 University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Lodz; PL; mplociennik10@outlook.com
5 University of Lodz, Faculty of Geographical Sciences, Department Geology of Geomorphology, Lodz; PL; piotr.kittel@geo.uni.lodz.pl

ABSTRACT - *The paper presents the study of avifauna from the hunter-gatherer sites at the Dnieper-Dvina basin spanning time period from the 6th to 3rd millennia BC. A total of 669 bird bones were identified and attributed to 46 different bird taxa, representing resident and migrant birds. They belong to four habitat groups: waterfowl, forest, woodside and meadow-steppe. The dominance of waterfowl birds follows the common strategy of aquatic resources exploitation. Changes in the procurement strategies, use and symbolic meanings of birds can be envisaged. Reconstructed regional mean temperature fluctuations suggest a particular influence on breeding biology and migration patterns of different species.*

KEY WORDS – *birds; Neolithic; Dnieper-Dvina basin; mean temperature fluctuations; items made from bird bones; hunter-gatherers*

Človek in ptice: avifavna z najdišč lovcev in nabiralcev od 6. do 3. tisočletja pr. n. št. (Pojezerje Zahodne Dvine)

IZVLEČEK – *V članku predstavljamo študijo avifavne z najdišč lovcev in nabiralcev v Dnjeprovsko-Dvinskem bazenu v času med 6. in 3. tisočletjem pr. n. št. Skupno je bilo identificiranih 669 ptičjih kosti, ki pripadajo 46 različnim ptičjim taksonom. Ti predstavljajo lokalne ptice in ptice selivke. Uvrščajo se v štiri habitatne skupine: vodne ptice, gozdne, ptice z roba gozda in travniško-stepske. Prevlada vodnih ptic kaže na strategijo izkoriščanja vodnih virov. Sklepamo lahko o strategijah lova, njihove uporabe in simbolnem pomenu. Rekonstruirana povprečja temperaturnih nihanj v regiji kažejo pri različnih vrstah na določen vpliv na njihovo gnezditveno biologijo in selitvene vzorce.*

KLJUČNE BESEDE – *ptice; neolitik; Dneper-Dvina bazen; povprečna temperaturna nihanja; predmeti iz ptičjih kosti; lovci in nabiralci*

Introduction

People have had diverse economic, symbolic, social and ecological relationships with birds, with the animals used as a food supply, materials for producing items, ritual features and burial gifts (*Gal* et al. *2021*; *Mannermaa* et al. *2008*; *Lozowski 1996*; *Mannermaa 2008; 2008a*; *Zhulnikov, Kashina 2010*; *Oshibkina 1996*). Among the bird species found at archaeological sites, waterfowl birds dominate within both hunter-

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gatherer societies and those with a productive economy (*Gal* et al. *2021*; *Mannermaa 2013*; *White* et al. *2021a*; *Russell 2019*). The high percentage of bones of bird species from other habitats may be due to several factors, *e.g.,* proximity of certain landscapes to the ancient site (*Vos, Russell 2021*), functional orientation and seasonality of habitation at the site, focus on a certain seasonally rich resource (*White* et al. *2021a*), as well as a cultural choice.

Bird bones along with other faunal remains were found on Neolithic wetland sites of the 6th to 3rd millennia BC in the Dnieper-Dvina region. The studied area lies in a recently glaciated zone of the Valdai ice sheet which is characterized by high geo- and biodiversity with well-developed land relief, reach lakes, swamps and mires of different sizes and shapes. An important axis of the Western Dvina River, the valley was used for migrations of animals as well as human groups and ideas. Climate change can be seen through increases in global temperatures (*Davis* et al. *2003*), and in the occurrence of extreme events caused hydrological changes and impacted on the breeding biology and migration patterns of different species. Regional or local climatic fluctuations might have been of particular importance in this context, too (*Mroczkowska* et al. *2021; Płóciennik* et al. *2022*).

This article aims to analyse the avifauna at the hunter-gatherer sites of the Dnieper-Dvina basin from a diachronic perspective from the 6th to the 3rd millennia BC, to reveal the peculiarities of hunting strategies, range of bird species and habitats, to what extent influence of paleoclimatic conditions is visible, and the role of birds in ancient societies.

Material and methods

The avian bone assemblage represented here came from Serteya II (pile-dwelling areas excavated in 1972-1974, 1980–1989, 1993-2023 and western shore zone – 2015-2023), Serteya I (2010-2011), Serteya X (1992-1997) (Serteysky microregion), Usviaty IV (1963-1966) (Usviaty microregion), Naumovo (1970-1975) (Zhizhitsky microregion), Dubokray V (1983-1991) and VII (1991) (Sennitsky microregion) (Fig. 1). The materials from excavations undertaken in the 1960-1990s were recorded within the squares and horizons, and no sieving was applied. The finds, including faunal assemblage, at the Serteya II and I sites were recorded in a three-dimensional coordinate system. The entire layer was washed through a 0.5cm sieve, the finds were labelled according to lithological layers and squares, and further attributed to the distinguished chronological horizons (*Mazurkevich* et al. *2020a*).

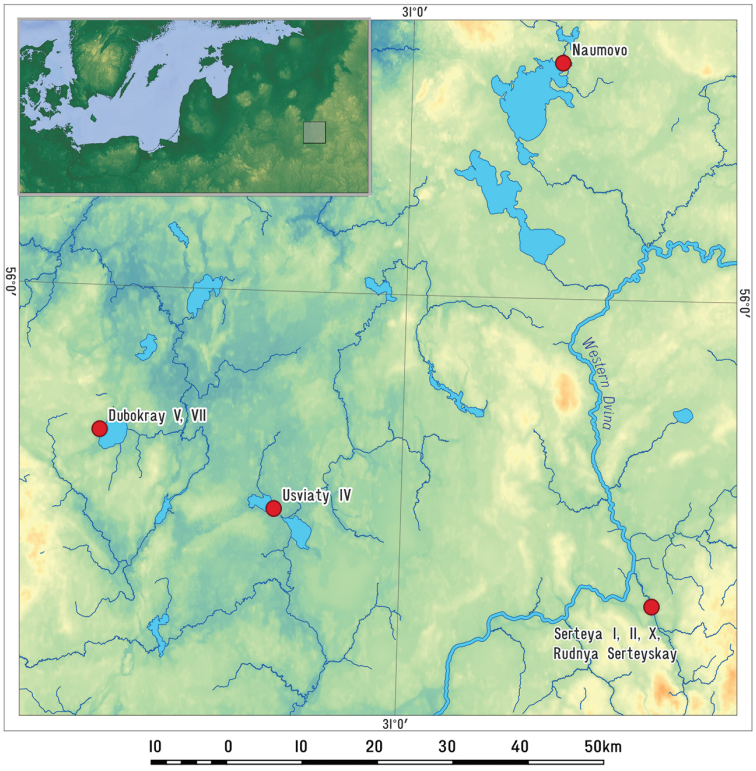

Fig. 1. Location of the Serteya I, II, X, Rudnya Serteya), Naumovo, Usviaty IV, and Dubokray V, VII sites.

Of the total 757 bird bones that were found, 669 were identified using the comparative bird collection housed in the Laboratory of Ornithology of the Zoological Institution of the RAS (Tab. 1). This makes up from 13.8 to 15.2% of the total animal bone material at different sites (fish assemblage not included).

The results of Chironomidae-inferred mean July air temperature from Serteya II (*Płóciennik* et al. *2022*; *Kittel* et al. *2021*; *Wieckowska-Lüth* et al. *2021*) were compared with alkenone-inferred temperature reconstruction from the western Mediterranean following Marta Rodrigo-Gámiz *et al.* (*2014*) and Darrell Kaufman *et al.* (*2020*).

Traceological analysis of bone items was applied with comparison to a reference collection, a surface study was made with a Leica EZ4 and Olympus BHMJ

with augmented LED lighting and lenses x10 / 0.30 UMPlanFI x20 / 0.40 LMPlanFI based on acetate prints taken from the artefacts.

Sites: chronological and functional context

The bird bone assemblage can be attributed to different time periods – 6th to early 5th millennia BC (Serteya II (western section), layer of coarse-grained grey sand, Rudnya Serteyskaya (*Sablin* et al. *2011)*), second half of the 5th millennium BC (Serteya II (western section), layer of black gyttja); 4th millennium BC (Serteya II (western section), upper part of black, olive gttja), Serteya I, X, Naumovo (layer B), Usviaty IV (layer B), Dubokray V, VII); middle of the 3rd millennium BC (Serteya II (western section, brown gyttja), Serteya II (eastern section, pile settlement)); and late 3rd millennium BC (Usviaty IV (layer A and α), Naumovo (layer A)) (Tab. 1).

The remains of bird bones are confined to different functional contexts at sites. Short-term usage of a shore line zone can be reconstructed for the 6th to early 5th millennia BC at the Serteya II and Rudnya Serteyskaya sites. Between 4150 and 3250 cal BC intense anthropogenic activity was observed at the Serteya II site, when the water level was relatively high and this was a place used for fishing, as testified by a number of different wooden fishing structures. The regressive-transgressive regimes of the ancient lake in the Serteya basin at the end of the 5th to 4th millennia BC coincided with the appearance in the region of various groups from the forest-steppe, steppe Don River and the left bank of the Dnieper River. The Serteya I site can be interpreted as a place used for a specialized fishing, synchronous to several phases of occupations of the Serteya II site (pile-dwelling section of the 3rd millennium BC, and western shore section of the 4th millennium BC) (*Mazurkevich* et al. *2020b*). Bird bones are mainly discrete finds from the archaeological layers of the sites, which complicates their precise dating. However, date modelling for the Serteya II site has made it possible to suggest shorter periods of occupation, which can also be extrapolated for dating birds (*Mazurkevich* et al. *2020a*). Given the small number of identified species, it can be assumed that these faunal remains were deposited just before site abandonment.

Narrow time periods of occupation can be suggested for the complexes uncovered in pile-dwelling sites Serteya II (eastern section), Usviaty IV and Naumovo sites (Tab. 1). At Naumovo (layer B) and Usviaty IV (layer B, 3 building horizons) remains of bird bones were found in the dwelling horizons of pile structures dated to the end of the 4th millennium BC. During this time period, around 3250 to 2500 cal BC, water level fluctuations and the possible disappearance of the lake basin in dry seasons are noted in the Serteya microregion (*Kittel* et al. *2020, 2021*), when only the western section of the Serteya II site was inhabited. Since *c.* 2750 cal BC a significant regression accompanied by seasonal fluctuations (*Wieckowska-Lüth* et al. *2021*) led to the formation of the Zhizhitsa culture pile-dwelling site, inhabited all year round with several dwellings (no. 1-6 with five construction phases distinguished within dwelling no. 1) in the eastern section of the Serteya II site and household areas, with zones of butchering on the shore line in the western section.

Bird assemblage: species, element representation and modifications

Species description. A total of 46 species of birds from 16 families were identified (Tab. 1). The difference in the number of bird remains at the sites can be due to the size of excavated areas, excavation techniques, but also to the specifics of the ancient societies' economies. The faunal collection is represented mainly by adults, the number of young birds is small – from 5 to 23%, and on average about 10% (Serteya II) or 6% (Usviaty IV layer B); one young bird was recorded at each of the Dubokray VII, Naumovo (layer B), and Usviaty IV (layer A) sites, and only adults were recorded at the other sites.

The largest collection of birds – 21 species from nine families – was recorded at the Serteya II site (Tab. 1). The dominance of aquatic bird species was noted for all chronological periods, with more than half (55.8%) represented by *Anas platyrhynchos*. Of particular importance could have been species of *Pelecanus crispus, Anser sp., Fulica atra, Gavia sp*., and *Podiceps sp.*, procured in part for their tough skins covered with dense plumage.

At Usviaty IV (layer B) 20 species from nine families were recorded, while at Naumovo settlement (layer B) six species from five families. In later layers a much smaller set was recorded – three (layer A) and one species (layer α) at Usviaty IV, four species at Naumovo (layer A).

Burned bones were recorded only at the Serteya II site, where they make up to 10% of all identifiable bones. They are mainly distributed within the sandy platform used for fire-places in pile-dwellings and on the household platform in the western section.

Element representation. At the Serteya II site almost all skeletal elements of *Anas platyrhynchos* are represented, with the humerus and coracoid predominating (Fig. 2.a,b). Cranial axes are rather rare, long bones are the most abundant, especially coracoids, ulnae and humeri. Other taxonomic groups are represented by a few or single fragments, or a slightly major presence of bones associated with meat-rich parts, such as humeri, coracoids and leg bones (tibiotarsi), can be noted. At other sites birds are divided within two groups – represented by almost complete skeletons and single bones. At Usviaty IV (layer B) site humerus (range between 28% and 36% (*Anas platyrhynchos),* coracoideum (14%), tibiotarsus (12%) and ulna (11%) made up to 65 % of all bones (Fig. 2.c).

Modifications. Anthropogenic marks are very rare, and include peeling and cutting marks related to the process of disarticulation. The cutting marks found on humerus and ulna (Fig. 3) are probably a consequence of the disarticulation of wings.

Bird assemblage: bones used for items and depictions of birds

All items come from the dwelling areas of pile settlements of the late 4th millennium BC (Usviaty culture, Dubokray V and Usviaty IV (layer B) sites) and mid-3rd millennium BC (Zhizhitsa culture, Serteya II site), except for one point found in the layer attributed to the second half of the 6th millennium BC (Serteya II site). This point was made of an ulna with a preserved proximal epiphysis (Fig. 4.17). The diaphysis was segmented and sharpened by longitudinal scraping. Such points are very rare, and only single items are known from the circum-Baltic area and Eastern Europe (*Lozowski 1996; Mannermaa 2013, 2008; Vankina 1999*).

At the Serteya II site 16 items are known, including three tools, six ornaments, seven production wastes and blanks; at the Usviaty IV site (layer B) there are two items with birds depictions, four tools, and one blank, and at the Dubokray V site there are two flutes. *Anatidae sp.* bones were mainly used, and single items were made from grey heron bones and the bones of large birds of prey. Only long bones were worked: humerus, radius, ulna and tarsometatarsus.

At the Serteya II site tools include two items with circular grooves. One piece was made from the radius (or humerus) of a large predator, the two epiphyses of which had been sawn and separated. The proximal part was sawed with a thin rope/tendon (U-shaped groove), and the distal part with a flint tool (V-shaped groove) (Fig. 4.16 A-E, H-D). The diaphysis shows a series of grooves perpendicular to the longitudinal axis, less often oblique, irregularly incised along the circumference, mostly U-shaped in cross-section, indicating repeated contact with a soft, thin material. At the bottom of the grooves traces of flint sawing can be seen (Fig. 4.16 B-F), which were mainly erased during further operations (Fig. 4.16 C-G). These tools may have been used to soften thin strips of skin, tendon fibres or plant fibres. The second was made from the humerus of a large waterfowl, and the epiphyses were preserved. The grooves on the diaphysis, U-shaped in profile, are more numerous, much shallower, and have a more regular organization. Similar items with grooved depressions with a 'U'-shaped profile were found at the Usviaty IV (Fig. 4.11,14,15,18) (*Miklyaev 1971; Malyutina, Sablin 2014*) and Dubokray VIII sites.

The most widespread category is pendants, all attributed to the Zhizhitsa culture. Five of them come from the pile-dwelling area of the Serteya II site (4 from dwelling no. 1, 1 from dwelling no. 3 (Fig. 4.1-4,6), one from the western shore part of the Serteya II site (Fig. 4.5). Pendants are short segments of the diaphysis of a long bird bone. Their cross-section (5 to 8mm) suggests the use of relatively thin bone. The edges of these pendants are so blunted by wear that the traces of manufacture are often completely obliterated. However, some have small transverse V-shaped incisions which suggest that they were made with a flint tool. Six items can be attributed as blanks/waste from the manufacture of such pendants (Fig. 4.7-13). These are fragments of diaphyses (mainly of the humerus or radius, and also of the tarsometatarsus), often epiphyseal, of rather thin long bones (cross-section 5-8mm), corresponding to the morphometric standards of the pendants described above. The diaphyses are segmented by sawing and breaking off. Two sawing techniques can be distinguished. The first, characterized by a V-shaped groove obtained by working with a flint tool (Figs. 4.7,8,10). These

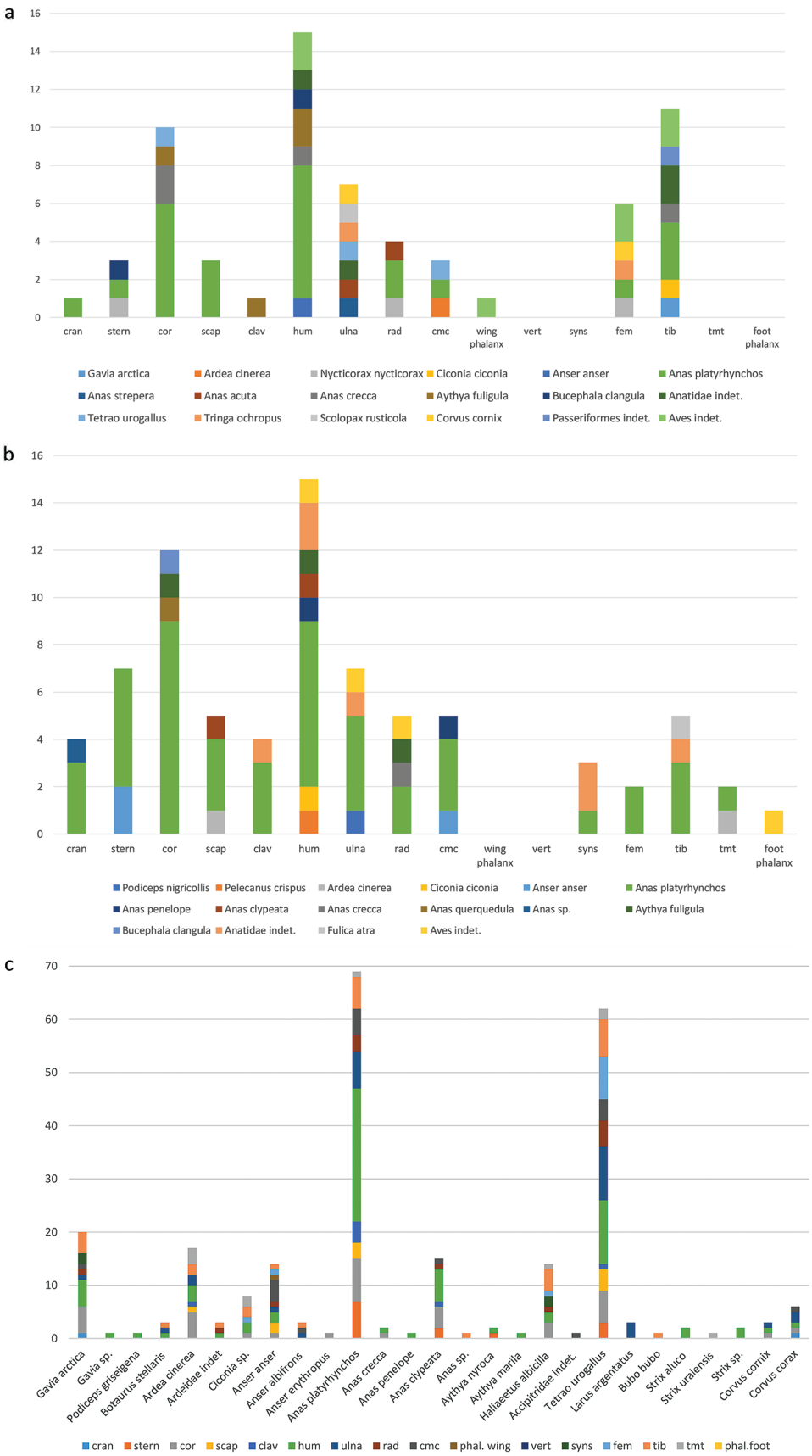

Fig. 2. Distribution of bird skeletal elements at Serteya II, western section, 4th millennium BC (a), eastern section, pile settlement (dwelling no. 3, second half of the 3rd millennium BC) (b); and Usviaty IV (layer B) site (c).

originate from dwelling no. 3 (Serteya II site). The second technique relates to rope/tendon sawing, as evidenced by the 'U' profile of the groove (Figs. 4.9,12,13). These production wastes may have other grooves, the distance between which is similar to the size of the pendants, which suggest that pendants were produced on site. All of them come from the western shore part of the Serteya II site, and can be attributed to the Usviaty culture. One possible similar item is also known at the Usviaty IV (layer B) site (Fig. 4.11), but no finished pendants were found for the Usviaty culture. Pendants made from bird bones are quite common both in the Mesolithic, Early Neolithic (Narva I site (*Gurina 1967*) and Late Neolithic (Abora I site (*Lose 1979*) and Asaviec 2, 7 sites (*Charniauski, Charniauski 2010*).

At Dubokray V site two flutes (Fig. 5.1,2) were found made from tubular bones of large swamp birds. They are straight and oblique open flutes with four side holes. The first one has worked playing holes and circular grooves left from secondary use (Fig. 5.1). The second is covered with geometric ornamentation (Fig. 5.2). They were made to the same musical standard, which might show the existence of an elaborate musical tradition. Dubokray flutes, according to Feliks Ravdonikas (*1997*) possess a sound order combining a very narrow and wide interval, which can be compared with ancient Greek enharmonic harmonics.

Several bird images are known: a pendant with a stylized image of a waterfowl (Fig. 6.2) (Serteya II site); a long spatula made of an elk rib with an image of a

Fig. 3. Cut marks on bird bones (*1, 2, 4, 5, 7, 8 *Serteya II;* 3, 6, 9 *Usviaty IV (layer B)):* 1 *Anas platyrhynchos, humerus;* 2 *Pandion haliaetus, ulna;* 3 *Haliaeetus albicilla, tarsometatarsus;* 4 *Anser anser, sternum;* 5 *femur;* 6 *Gavia arctica, tibiotarsus;* 7 *Anas platyrhynchos, coracoid;* 8 *Pelecanus crispus, humerus;* 9 *Haliaeetus albicilla, humerus (scale 1 cm).

bird's head (presumably a crow) (Fig. 6.1) (*Mazurkevich 2009*), a spatula with a bird's head (presumably a grouse) (Fig. 6.3), a wooden paddle with carved heads of birds (Fig. 7) (Usviaty IV, layer B). A pendant with a stylized image of a waterfowl was found in the pile-dwelling no. 3 of the Serteya II site. The blank of this pendant was made of a long bone of a large mammal. The entire contour was worked with flint to give it a serrated edge. The biconical perforation was made by rotary pressure with a flint cutter. Similar iconography can be found in the materials of Sakhtysh I sites in the Upper Volga region (*Kostyleva, Utkin 2009*) and sites of the Belarusian Dvina basin (*Charniauski, Charniauski 2010*).

Fig. 4. Pendants* (1-6)*, blanks for pendants* (7-13)*and tools* (14-18)*(*1-10, 12, 13, 16, 17 *Serteya II site;* 11, 14, 15, 18 *Usviaty IV, layer B site:* 17 *Early Neolithic,* 9, 11-16, 18 *Usviaty culture;* 1-8, 10 *Zhizhitsa culture).

Habitats and palaeoecological conditions

Birds identified in the Neolithic layers of wetland sites of the Dnieper-Dvina basin belong to four habitat groups: waterfowl, forest, woodside and meadow-steppe (Tab. 1), including nine sedentary species and others that are migratory.

The group of waterfowl birds (25 species at Serteya II site, 75.8%; 18 species at Usviaty IV (layer B) Fig. 8, Tab. 1) includes species that are not systematically related to each other, but are closely associated with water in their way of life, and these make up to 92.6% of the identifiable bones (at the Serteya II site). *Anas platyrhynchos* bones were particularly common at Serteya II (55.8%), and less common at other sites (Tab. 1). A set of waterfowl bird species testifies to the existence of open water bodies with abundant vegetation in the coastal zone and adjacent forest areas. In the 3rd millennium BC, species inhabited shallow water reservoirs (*Anas clypeata, Anas penelope*) can be documented; finds of *Anser anser* indicate hunting in marshes or reservoirs with standing water, *i.e.* outside these micro-regions or during the migration of these birds. At this time (2500-2100 cal BC) in the Serteya microregion a change in the water body regime can be traced, a lowering of the water level with seasonal fluctuations (*Kittel* et al. *2020*). The lake system may have been replaced by a river system. While birds with an aquatic habitat dominated at all pile-dwelling settlements, a different set of birds should be noted for the Usviaty IV and Serteya II sites (Fig. 8). At Usviaty IV (layer B) there is a smaller number of waterfowl species, and significantly higher number of subdominant species (*e.g., Gavia arctica, Ardea cinerea, Anser anser,* and *Haliaeetus albicilla* (Fig. 8) which settled near much larger water bodies than species at the Serteya II site. The latter (*Haliaeetus albicilla)* was also found at sites of Sennitsa and Zhizhitsa microregions.

The woodside group includes nine species (15.2% at Serteya II). Finds of *Scolopax rusticola* and *Tringa ochropus* are attributed to the 4th millennium BC, when climate warming and moistening were recorded (Fig. 9). They may point to the existence of dense deciduous or mixed forests with moist soil in the surroundings of the Serteya II site. Finds of bones of the *Columba palumbus* with a habitat area in floodplain deciduous forests with shrub undergrowth, and *Cerchneis tinnunculus* – in open dry spaces near forests, are dated to the 3rd millennium BC.

Fig. 5. Flutes (Dubokray V site).

The forest group includes nine species. Only two species were recorded on the Serteya II site: *Accipiter gentilis* and *Tetrao urogallus* (6.1%). The increase in the number of *Tetrao urogallus* in the pile-dwelling Serteya II site may be related to palaeoclimatic changes during 2550-2475 and 2150-2000 cal BC, which led to a change in forest composition: dominant *Alnus* species within wetland areas and mixed forest nearby were replaced by *Pinus* and *Picea* (*Kittel* et al. *2020; 2021*; *Wieckowska-Lüth* et al.

2021). This correlates with *Tetrao urogallus* habitat area – shrubby green-mossy pine, spruce-pine and other mixed forests with the participation of pine alternating with areas of upland bogs (*Piminov 2020*). A much more diverse set of birds of forest habitats can be noted for the Usviaty IV (layer B) site (seven species).

Within the meadow-steppe group only *Perdix perdix* was recorded at the Naumovo, Serteya I and Setreya X sites, where there were dry open habitats nearby inhabited by this species. The absence of *Perdix perdix* in the materials of other sites and only single bones may evidence occasional hunting.

Fig. 6. Bone spatula with an image of a raven's head (1) and grouse (3) (Usviaty IV, layer B site), an image of a waterfowl (2) (settlement Serteya II, dwelling no. 3).

Long- and short-term climatic changes and avian population dynamics

Climatic changes, both global and regional, strongly affected lake, mire as well as local fluvial environments. Generally shallow regimes were partly replaced by mires or fluvial system during water level lowering phases (*Kittel* et al. *2020; 2021*; *Wieckowska-Lüth* et al. *2021*; *Płóciennik* et al. *2022*). Species associated with different breeding habitats responded differently to changes in climate suitability and hydrological fluctuations. Species associated with inland wetlands may be more responsive to environmental changes than forest areas (*Mason* et al. *2019*). The proportion of a population that is migratory may be influenced annually by local conditions; adverse weather can encourage the movement of more birds to milder environments and *vice versa* (*Lehikoinen, Sparks 2010*). The population dynamics of water birds was suggested to be affected by the North Atlantic oscillation by impacting the availability and extent of the habitat and influencing dispersal decisions of individuals. It could have played an important role in the observed advance of arrival dates during the spring in Europe (*Gordo* et al. *2011*). Mean summer temperature reconstruction applied for Serteya microregion (Fig. 9) might explain records of southern birds which fall within warm periods during the 4th and 3rd millennia BC, which are currently absent in avifauna of the region.

A comparison with the modern ecology of bird species shows changes in their migration patterns and areas of distribution. *Gavia stellata, Pelecanus crispus, Nycticorax nycticorax, Ardeola ralloides* and *Oxyura leucocephala* are not nesting nowadays in this region. *Gavia stellata* tends to occupy northern areas, and the modern southern border

Fig. 7. Wooden paddle with the heads of ducks on the top of the handle (Usviaty IV site, layer B).

of its range runs through South Karelia (*Panteleev, Khrabry 2020*). In the 19th to early 20th century this bird was commonly nesting on the Karelian Isthmus, and in the 1960s it penetrated into Leningrad Oblast, Latvia and Estonia (*Malchevsky, Pukinsky 1983*). Certain climatic conditions might have influenced its southern boundary, resulting in possible stop-over in Dnieper-Dvina area in Neolithic during migrations. The modern distribution of the *Pelecanus crispus* is very fragmentary, with breeding areas scattered from Eastern Europe to Mongolia (*Matsyna, Matsyna 2011*). At present, in the European part of Russia the nesting area covers the Black Sea-Caspian region. Finds of subfossil bird bones at different sites in northwestern and central Europe shows that birds of the genus *Pelecanus (Pelecanus crispus*), occurred far out of their present range during mid-Holocene, which coincided with climate parameters (*Nikulina, Schmölcke 2015*). The nearest nesting sites of *Ardeola ralloides* are located in the Northern Black Sea coast, the Lower Don and the Volga Delta. There are vagrant birds documented in Europe, up to Finland (*Rusev 2011a*). *Nycticorax nycticorax* has a wider range, breeding in the Azov-Black Sea region, in the Lower Volga region, northwards to the Middle Don and Oka Rivers. Vagrants were documented in the Baltics and in central European Plain (*Rusev 2011b*). The main range of *Oxyura leucocephala* is in Lower Volga region, extending eastwards to Tuva, Kazakhstan and Central Asia (*Dementiev* et al. *1952*). Some time ago *Oxyura leucocephala* was breeding in Western Europe and the Azov-Black Sea region and had a vast unified habitat, which is now fragmented.

Discussion

Single finds and a small number of bones of waterfowl species can be attributed to the Early Neolithic (6th millennium BC). This may be explained both by the rate of preservation of materials from this time at Serteya II site, as some of them were apparently washed away during the subsequent rise in water level (*Mazurkevich* et al. *2020b*), and the short period of habitation at this site on the shore of shallow lake-type water bodies with seasonal floods which sustained for a long period (*c.* 5500–4150 cal BC) (*Kittel* et al. *2020*; *Mroczkowska* et al. *2021*). Finds of lost arrowheads along the shore zone may evidence bird hunting here (*Mazurkevich* et al. *2020b*). The small number of bird bones for the 4th millennium BC may be due to the specificity of the Serteya II site used mainly for fishing activity. The capture of birds in nets and fishing structures was most likely accidental or as a result of occasional bird hunting during fishing. Some of the birds, predominantly waterfowl species, were found at a household platform at the Serteya II site along with other faunal remains.

The greatest number of birds was recorded in the dwellings of the pile-settlements of the late 4th millennium (Usviaty IV (layer B)) and 3rd millennium BC (Serteya II site). At Serteya II site bird bones were found in dwellings no. 1 and 3. In dwelling no. 1, the avifauna was recorded in the lower horizons (4-5) (birds of aquatic and forest biotopes nesting in the region) and horizon 1 (birds of all biotopes nesting in the region, also migratory and passer-by birds). In dwelling no. 3 only the remains of birds of aquatic habitats nesting in the area and migratory birds were found. The absence of avifauna in the second and third building horizons of dwelling no. 1 may reflect the season of habitation and/or minimal number of birds during this period at this location due to high anthropogenic pressure and natural conditions (*Kittel* et al. *2020*).

The range of waterfowl species indicates the existence of open water bodies with abundant vegetation along the shore zone and adjacent forested areas over a long period of time for the Serteysky microregion, and large open water bodies for other microregions. For the 3rd millennium BC, palaeoecological changes and the appearance of species-inhabited shallow water bodies are noted. While birds of aquatic habitats are undoubtedly dominant, different sets of waterfowl species were recorded at different pile-dwelling settlements (Fig. 8). The number of birds from forest habitats is also significantly higher at Usviaty IV site (layer B), and only at the sites of the

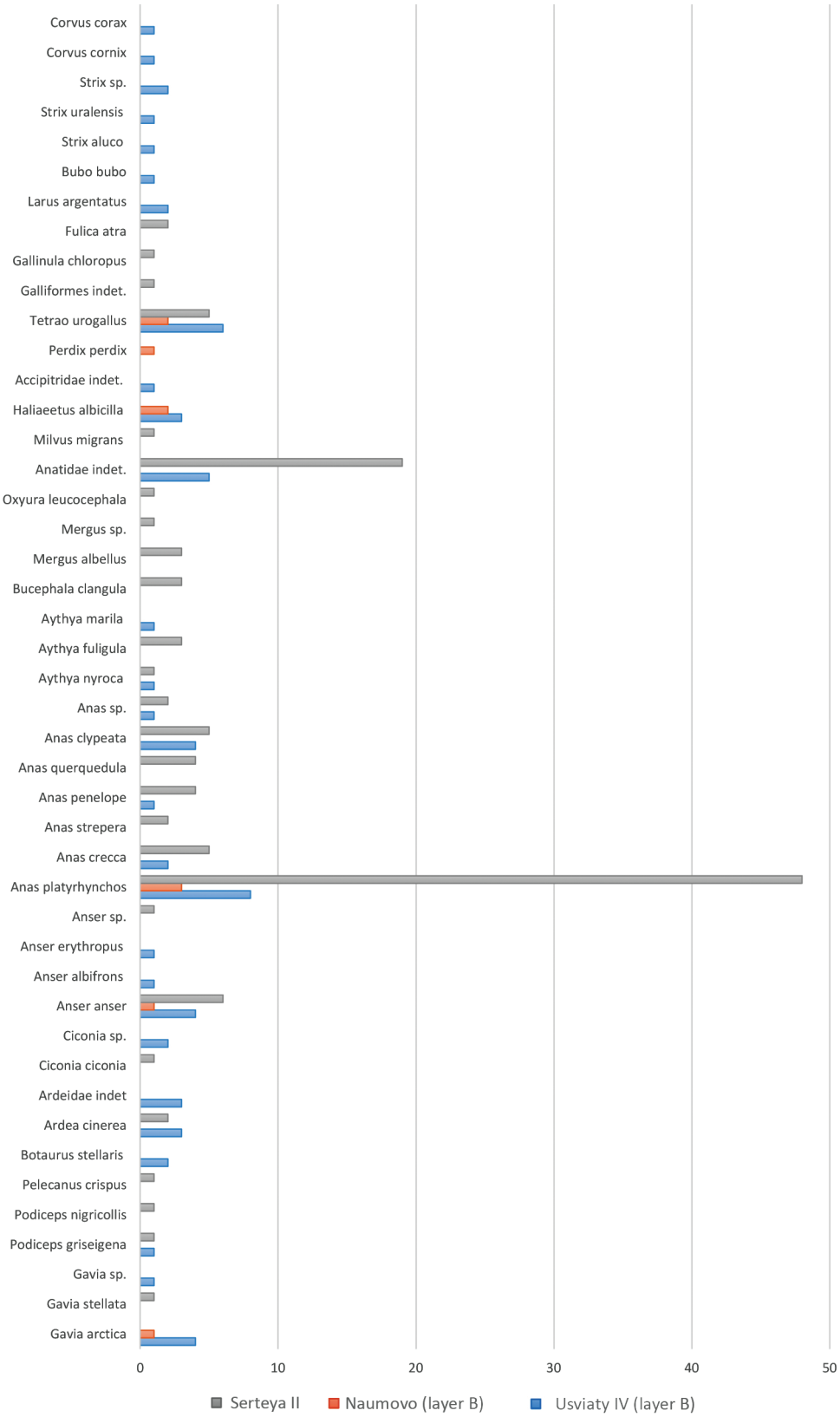

Fig. 8. Ratio of bird species and number of individuals from the dwelling horizons of the pile settlements Naumovo (layer B), Usviaty IV (layer B), and Serteya II (dwellings nos. 1 and 3).

Sennitsa, Usvyatsky and Zhizhitsa microregions *Haliaeetus albicilla* was recorded. Species from the forest habitat (Fig. 8; Tab. 1) at Usviaty IV suggest the presence of high-stemmed old mixed forests in the immediate vicinity. Records of a range of southern birds might fall within warm periods during the 4th and 3rd millennia BC reconstructed based on mean temperature modelling (*Mroczkowska* et al. *2021; Płóciennik* et al. *2022*).

The composition of bird bones indicates that many birds were brought entirely to the settlement and cut up on site. The minimal number of cutting traces (Fig. 3) can be noted, which is typical for many bird assemblages (*Mannermaa 2013*) and may be related to the preparation of whole birds or to the peculiarities of bird cutting, when traces remain only on a certain set of bones (*White* et al. *2021b*). Birds were mainly procured for meat, but particular types of birds, as well

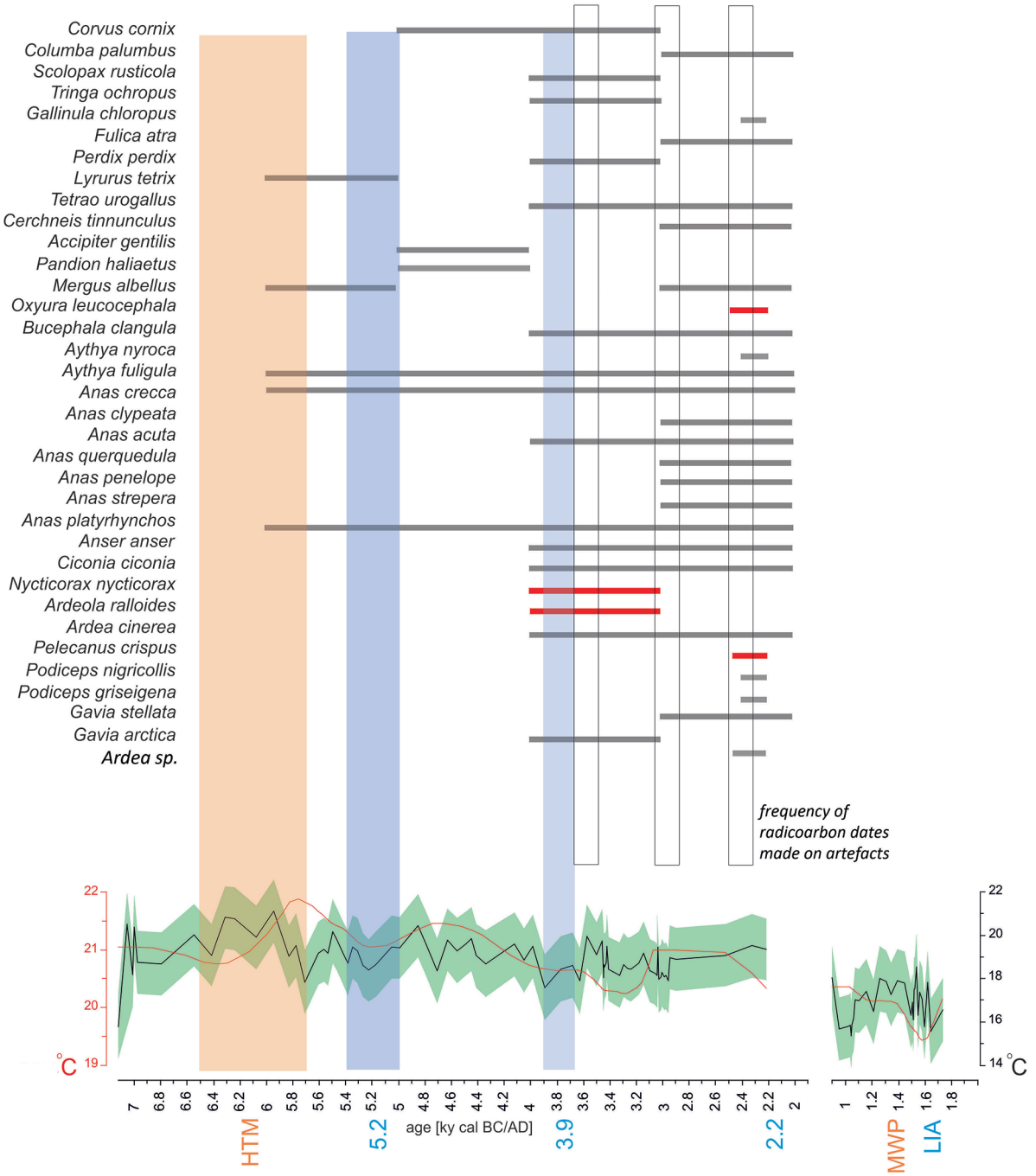

Fig. 9. Bird species and palaeoclimatic reconstructions of mean summer temperatures during the 6th to 3rd millennia BC for the Serteya II site (for Serteya microregion (black line) according to* Mateusz Płóciennik *et al.* 2022*, for the Mediterranean region (red line) according to* Rodrigo-Gamiz 2014*), (periods of frequency of radiocarbon dates were reconstructed based on* Andrey Mazurkevich *et al.* 2020a*).

as sets of bones and cutting marks, show evidence of also hunting for skins and plumage.

The dominance of bones of migratory birds and a small number of bones of juveniles may indicate spring and autumn as a potential hunting time. The latter could indicate that during the mass appearance of immature young birds (from July to early August) the hunting of birds was less common. Adult *Tetrao urogallus* could be hunted most likely either in late autumn or early spring, and young birds at the end of July-August (*German 1957*).

The peculiarity of the structure and morphology of bird bones determined the choice of this material for a certain set of items in different ancient cultures (points, beads, flutes) (*e.g., Scheinsohn 1997; Christensen 2016; Lozowski 1996*; *Mannermaa 2008*; *Gal* et al. *2021*). However, despite the widespread practice of making tools and ornaments from animal bones and teeth at Neolithic sites of the Dnieper-Dvina basin (*Mazurkevich* et al. *2020b*), bird bones were used rather rarely, and mainly for beads or tools for softening fibres. Bird images can testify to the special place of certain bird species in the culture of ancient societies of this region in the late 4th and 3rd millennia BC.

Conclusion

Hunter-gatherer strategies would have implied the procurement of a range of natural resources, highly dependent on their accessibility and variety, also influenced by climatic fluctuations, creating a particular system both economic and symbolic where they could have been incorporated. This could be envisaged through depictions of birds, strategies of their procurement, and a range of birds recorded at sites. Similar landscapes and habitats could determine similar hunting strategies and bird species in different cultures (*Zhilin, Karhu 2002*; *Mannermaa 2008; 2013; Tomek, Gumiński 2003*; *Kuzmina, Kasparov 1987; Skorobogatov* et al. *2016*). Specialization on a particular abundant seasonal resource may be part of the economic model of a number of ancient communities, both hunter-gatherers and communities oriented towards a productive economy, such as hunting migratory birds, fishing during the spawning of particularly valuable fish species (*Bondetti* et al. *2021*; *Cramp* et al. *2019*).

The focus on a single habitat resulted in the overwhelming dominance of waterfowl birds at the Serteya II site (mainly nesting) as well as Usviaty IV (layer B) and Naumovo (layer B) (nesting and migratory birds). A high variety of waterfowl species can be attributed to hunting along the shore zone for any incidentally caught birds and net fishing with incidental catches of diving species. The most birds were apparently captured on migration during the warm season, spring or autumn. Birds of some other habitat groups (*e.g., Perdix perdix*) may have resulted from occasional hunting.

A change in water body types and the climatic fluctuations of the 6th to 3rd millennia BC in the Dnieper-Dvina basin (*Kittel* et al. *2020, 2021*; *Wieckowska-Lüth* et al. *2021*; *Mroczkowska* et al. *2021*; *Płóciennik* et al. *2022*; Fig. 9) could lead to a change in bird species, caused by the formation of new habitats and bird migration routes. The differences in bird species and their number found on the sites of the Dnieper-Dvina basin may be due to micro-regional paleoclimatic and habitat variations, various forms of specialization of the sites (specialized fishing sites, household areas, zones of shore activity, dwelling structures of the pile settlement), the food preferences of ancient communities, and the role which birds played in different groups of hunter-gatherers.

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