Russian J. Theriol. 23 (1): 73–82

Bird of prey nest sediments as a source of data on the modern fauna and flora of northern taiga in the European Russia

Dmitry V. Ponomarev*, Inna V. Kryazheva, Tatiana I. Marchenko-Vagapova, Vladislav A. Isakov & Lyudmila A. Selkova

ABSTRACT. The study examined rodent bone remains, spore-pollen assemblages, and the granulometric composition of sediments found in a bird of prey nest in the northern taiga of the Middle Timan in the Komi Republic. The data obtained was compared to previous research on contemporary flora and fauna. The sediments consist of silty clays and loams formed by surface water, which removed sediments and weathered bedrock carbonate products from the slope. Sediments accumulated approximately for 30 years, as shown by the discovery of a bird ring in the top layer of the nest sediment. Among the rodent remains, 12 species typically found in the fauna of the northern taiga of Eastern Europe have been identified. The predominance of remains belonging to riparian species in the sub-fossil assemblage is due to the raptor's hunting specialization. Compared to the data obtained through trapping small mammals using trenches, the nest materials lack only shrews. Nevertheless, there are still rare and elusive species that go undetected by traps due to their size or lifestyle present in the materials. The spore-pollen assemblages discovered in the sediments of bird nests offer a reliable depiction of the current vegetation in the surrounding area, which encompasses both the zonal vegetation category and even the existence of uncommon forest-tundra combinations within the research zone. The data obtained demonstrate the capability of using bone remains as well as spores and pollen found in nests of birds of prey to analyze recent flora and fauna.

How to cite this article: Ponomarev D.V., Kryazheva I.V., Marchenko-Vagapova T.I., Isakov V.A., Selkova L.A. 2024. Bird of prey nest sediments as a source of data on the modern fauna and flora of northern taiga in the European Russia // Russian J. Theriol. Vol.23. No.1. P.73–82. doi: 10.15298/rusjtheriol.23.1.08

KEY WORDS: small mammals, bone remains, spore-pollen assemblages, vegetation, northern taiga, north of European Russia.

Dmitry Ponomarev [dvponomarev@inbox.ru], Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya str. 54, Syktyvkar 167982, Komi Republic, Russia; Inna Kryazheva [innageologi@mail.ru], Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya str. 54, Syktyvkar 167982, Komi Republic, Russia; Tatiana Marchenko-Vagapova [timarchenko@geo.komisc.ru], Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya str. 54, Syktyvkar 167982, Komi Republic, Russia; Vladislav Isakov [isakovvlad94@gmail.com], Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya str. 54, Syktyvkar 167982, Komi Republic, Russia; Lyudmila Selkova [laselkova@mail.ru], Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya str. 54, Syktyvkar 167982, Komi Republic, Russia.

Отложения гнезда хищной птицы как источник сведений о современной фауне и флоре севера таежной зоны Европейской части России

Д.В. Пономарев*, И.В. Кряжева, Т.И. Марченко-Вагапова, В.А. Исаков, Л.А. Селькова

РЕЗЮМЕ. В статье приводятся результаты изучения костных остатков грызунов, спорово-пыльцевых комплексов и гранулометрического состава отложений гнезда хищной птицы в северной тайге Среднего Тимана (среднее течение р. Пижмы, Республика Коми) и сравнение полученных данных с материалами исследований рецентных фауны и флоры. Отложения, представленные алевритовыми глинами и суглинками, сформировались в результате смыва со склона рыхлых осадков и продуктов выветривания коренных карбонатных пород поверхностными водами. Осадки накапливались примерно 30 лет, о чем можно судить по

* Corresponding author

находке кольца птицы в верхней части разреза отложений гнезда. В комплексе остатков грызунов определены 12 лесных и околоводных видов типичных для фауны восточно-европейской северной тайги. Преобладание в субфоссильном сообществе остатков околоводных видов объясняется охотничьей специализацией пернатого хищника. По сравнению с данными отловов мелких млекопитающих ловчими канавками в материалах из гнезда отсутствуют только мелкие виды насекомоядных, но присутствуют редкие виды и виды, которые из-за размеров или образа жизни не попадаются в канавки. Спорово-пыльцевые комплексы из отложений гнезда довольно точно воспроизводят современную растительность окрестностей, в том числе зональный тип растительности и даже существование в районе исследований относительно редких лесотундровых ассоциаций. Полученные данные показывают перспективность использования субфоссильных материалов из отложений гнезд хищных птиц для исследований современных фауны и флоры.

КЛЮЧЕВЫЕ СЛОВА: мелкие млекопитающие, костные остатки, спорово-пыльцевые комплексы, растительность, северная тайга, Европейский Север.

Introduction

The birds of prey pellets and sediments formed with pellets are a reliable source of information on the modern vertebrate fauna. Studies have shown that bone assemblages from these pellets are an accurate representation of prey species population composition in nature, especially for small mammals like rodents. This accuracy is comparable to or even better than capture data, as illustrated by a meta-analysis conducted by Heisler *et al.* (2016). The accumulation of bone remains in pellets is subject to selectivity due to the raptor's specialization, fluctuations in the abundance of its prey, and the varying habitats of its domain. These

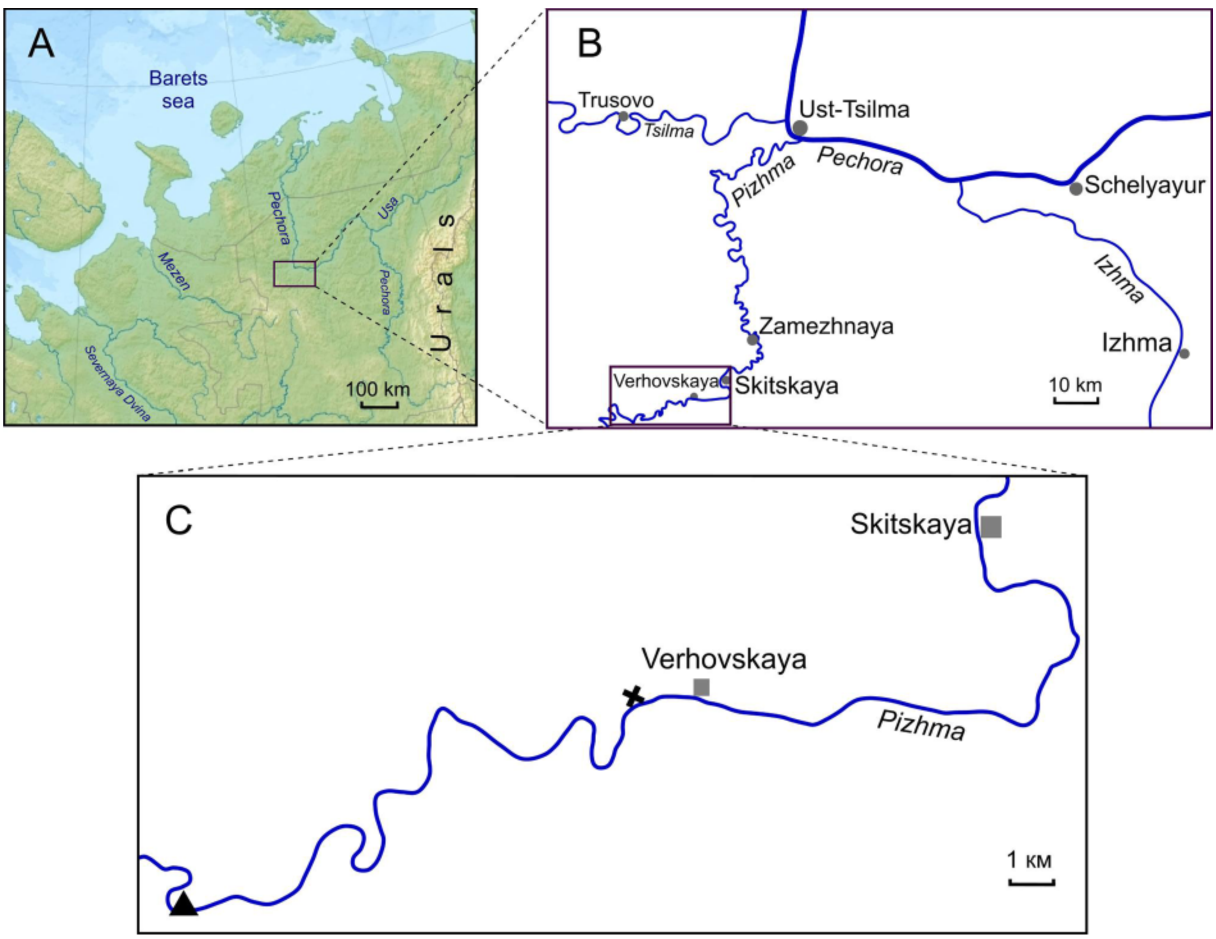

Fig. 1. Schematic map of the study area, with the cross indicating the position of the nest and the triangle representing the location of small mammal captures conducted by Bobretsov (2020). A, B and C show correspondingly small, medium and large scale maps.

Fig. 2. Photo of a bird ring retrieved from nest sediments at a depth of 5–10 cm.

factors create a margin of error for faunal reconstructions based on pellet materials (Smirnov and Sadykova, 2003). This paper presents findings from analyses of rodent remains, spore-pollen associations, and granulometric composition of sediments extracted from an abandoned bird of prey nest in the northern taiga subzone near the Pizhma River, a tributary of the Pechora River, located in the Ust-Tsilma District of the Komi Republic, Russia (Fig. 1). An intriguing aspect of this site is the discovery of a ring in the sediment layer (5–10 cm), as depicted in Figure 2. This ring was utilized to tag a first-year male northern pintail (*Anas acuta*) in the United Kingdom at the end of November 2005. By analyzing the tagging information, the precise time of sediment deposition can be established.

It should be noted that Bobretsov (2020) conducted long-term surveys of micromammals using trap ditches, which were executed merely 10 km away from our study area. Similarly, an extensive investigation of the recent vegetation along the banks of the Pizhma River has been carried out by Lashchenkova (1959), Lashchenkova & Nepomilueva (1982), Teteryuk *et al.* (2002) and Bobretsov (2020).

The objective of this study is to determine the species composition and ecological structure of the modern rodent fauna of the study area, as well as the accumulation rate of nest sediments and the main lithological features of the sediments. To achieve this, we examined the species composition of rodent remains found in nest sediments, analyzed spore-pollen spectra, and studied sediment grain size distribution. Additionally, the modern biota data of the middle reaches of the Pizhma River offers a chance to compare our findings on rodent fauna with those of small mammal captures in nature. This also allows us to ascertain the extent to which spore-pollen spectra from the nest sediments reflect the vegetation in its proximity.

Materials and methods

Unconsolidated sediments were excavated using conditional horizons with a thickness ranging from 2–5 cm. Following excavation, bone remains were passed through 1 mm mesh diameter sieves and subsequently dried before being manually collected. For species identification purposes, the first lower molar was used to identify the remains of root voles and field voles. In the case of all other molars in the "*Microtus*" genera, species were assigned according to the distribution of the first lower molars. Red-backed voles (genera *Clethrionomys* and *Craseomys*) were identified using the method developed by Borodin *et al.* (2005).

The work uses the voles' systematics as proposed by Abramson & Lissovsky (2012), except for the bank and northern red-backed voles, where *Clethrionomys* should be used as the valid name (Kryštufek *et al.*, 2020).

Samples for palynological studies were processed following established methods (Grichuk & Zaklinskaya, 1948; Pokrovskaya, 1950; Erdtman, 1992). A digital biological microscope "Motic BA 300" was used to study spores and pollen at 420 magnification. Each sample was studied using over 250 pollen grains. Program "TILIA" was employed to construct spore-pollen diagrams. Interpretation and calculation of spore-pollen analysis (SPA) results were conducted using a group method. Spores and pollen were grouped into tree and shrub pollen, grass pollen, and spores. The percentages of spore species and pollen grains from the marked forms were then determined.

The laboratory work to determine the granulometric composition of sediments was carried out based on the method of Kachinsky (1958). The clay-silt fraction smaller than 0.1 mm was analyzed using the Microsizer 201C laser particle analyzer located at the "CCU Geonauka" Institute of Geology, Komi Science Center, Ural Branch of the Russian Academy of Sciences (Syktyvkar). The resulting data was used to calculate the mean grain diameters (d_m) and material sorting coefficients (S_c). The sorting coefficient increases from zero to one in the direction of increasing sediment sorting. S_c=0 represents the poorest sorting of sediments, whereas S_c=1 signifies individual-fraction sediments, as stated by Belkin & Ryazanov (1972). The classification of clayey-silty-sandy rocks by Rukhin (1969) is used to name the rocks.

Ringing information was obtained by contacting the Russian Bird Ringing Center (http://www.ringcenter.ru).

Results

The locality

The abandoned nest is located on the left bank of the Pizhma River, which is a left tributary of the Pechora River, in the Ust-Tsilma District of the Komi Republic. The nest rests on a ledge of a rock outcrop predominantly composed of Carboniferous limestones (64.9215° N and 51.6663° E). This rock outcrop can be found approximately 2 km upstream of the uninhabited village of Verkhovskaya. According to some oral reports, it is known as "Efremov Zagrad". We conducted excavations at the end of June 2021. Almost at the very top of the 90-meter-high rock lies a small crack filled with unconsolidated sediments (Fig. 3). Adjacent to the fissure and to the side, a rocky ledge is present, covered in light sediments and overgrown with grass. A depression on the rocky ledge forms the nest of a bird of prey (Fig. 4). A trench measuring 60 by 60 cm was excavated within the nest. The sediment thickness was 20 cm, with vertebrate bone remains found in the topmost 15 cm of the sediment.

The sediment section from top to bottom:

0–5 cm. Silty loam with a high concentration of limestone non-rounded pebbles, up to 27.5%, and gravel, up to 4.6%. The rock volume contains 15.6% of bone remnants.

5–10 cm. Silty clay with a high proportion of non-rounded limestones, up to 16.5% of gravel, and up to 5.9% of pebbles.

10–15 cm. Silty clay. Non-rounded limestone gravel content is 2.1%.

15–20 cm. Silty loam has a high percentage of non-rounded limestone pebbles up to 12.5% and 6.4% of gravel.

The silty loams and clays are light brown in color and fine-grained, which easily float in water and are poorly wet when washed. The sediments comprise numerous bones of vertebrates, with a primary presence of mammals and birds. Additionally, it contains a plurality of plant roots, decomposed remnants of bird excreta, and fragments of limestone. The cementing agent of the rock is the bird droppings, mainly in the upper part of the section.

The study conducted a granulometric analysis of sediments from various conventional horizons, as shown in Table 1. Results demonstrated that the granulometric composition exhibited considerable variability, with low sorting coefficient values and a high degree of sediment carbonation. The sediment formation can be attributed to the washing of unconsolidated sediments and weathering products from bedrock Carboniferous carbonate rocks on the slope by surface rain and snowmelt water, with simultaneous accumulation of bird droppings and pellets. These conclusions were derived from the analysis of pertinent data and observations on the peculiarities of the site structure.

Finding a ring in a 5–10 cm layer enables estimation of the age and accumulation rate of the nest sediments. Considering a male northern pintail ringed in November 2005 may have been present in the nesting area since 2006, the excavations conducted in June 2021 serve as a reference point. It is challenging to determine the precise location of the ring within the sedimentary layer as it was discovered in droppings-cemented sediment that was removed by plates and soaked in water.

Fig. 3. A general view of the outcrop of Carboniferous limestone at the Pizhma River with an arrow marking the location of the nest.

Table 1. Granulometric composition of nest sediments.

Sample	Carbonate content, %	Bone remains, %	Content of grain size fractions (mm), %														*d_m, mm	**S_c
			Pebbles		Gravel		Sand					Aleurite			Clay			
			50–25	25–10	10–5	5–2	2–1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.03	0.03–0.01	0.01–0.005	0.005–0.001	<0.001		
0–5 cm	16.7	15.6	16.3	8.3	2.9	4.4	0.2	0.3	1.7	2.0	2.8	5.1	13.4	10.5	14.7	1.9	0.228	0.12
5–10 cm	15.2	–	–	3.6	2.3	16.3	0.2	0.3	0.8	2.3	2.4	3.6	13.5	17.4	31.4	6.0	0.025	0.14
10–15 cm	18.4	–	–	–	–	1.9	0.2	0.2	0.3	0.1	0.1	2.6	25.7	28.5	36.8	3.5	0.006	0.38
15–20 cm	42.9	–	–	9.7	2.8	5.8	0.6	1.0	1.2	1.9	1.7	3.8	19.6	22.2	27.4	2.3	0.028	0.14

* d_m — mean grain diameter; ** S_c — sorting coefficient

Table 2. The percentage of remains and the total number of rodent teeth from nest sediments, as well as the total number of individuals and dominance index of small mammals, based on trapping data (Bobretsov, 2020).

Species / conventional horizon	0–2 cm	2–5 cm	5–10 cm	10–15 cm	D*
Sorex araneus — common shrew	–	–	–	–	25.7
Sorex isodon — taiga shrew	–	–	–	–	1.7
Sorex tundrensis — tundra shrew	–	–	–	–	0.7
Sorex caecutiens — Laxmann's shrew	–	–	–	–	28.1
Sorex minutus — Eurasian pygmy shrew	–	–	–	–	3.7
Sorex minutissimus — Eurasian least shrew	–	–	–	–	0.7
Neomys fodiens — Eurasian water shrew	–	–	–	–	0.4
Talpa europaea — European mole	+	+	+	–	1.3
Pteromys volans — Siberian flying squirrel	1.2	0.9	0.3	0.4	–
Sciurus vulgaris — red squirrel	1.9	1.4	1.4	1.3	–
Tamias sibiricus — Siberian chipmunk	–	0.1	–	–	–
Sicista betulina — northern birch mouse	–	0.3	–	–	3.1
Ondatra zibethicus — common muskrat	–	0.4	0.1	0.2	–
Craseomys rufocanus — gray red-backed vole	1.6	4.0	1.1	–	–
Clethrionomys glareolus — European bank vole	4.7	6.6	3.5	3.9	5.7
Clethrionomys rutilus — northern red-backed vole	2.3	3.3	4.3	1.7	14.7
Myopus schisticolor — wood lemming	1.3	0.6	0.8	–	0.2
Arvicola amphibius — water vole	34.6	29.2	38.2	35.5	–
Alexandromys oeconomus — root vole	36.2	44.4	40.9	49.8	9.9
Microtus agrestis — field vole	16.3	8.7	9.4	7.3	4.1
Total number of molars / individuals**	391	703	803	414	1208**

*D — the species dominance index indicating the ratio of each species' abundance to the total abundance of all species present.

Notably, the ring could have been situated within either the top 5cm or lower 10cm of the horizon. The upper 5 cm of the horizon could have emerged in the period spanning from 2006 to 2021 or even faster, which is not over 15 years. Additionally, the accumulation duration of the upper 10 cm is no longer than 30 years. Assuming a constant sediment formation rate of 5–10 cm in 15 years, the sediment section formed no more than 60 years ago. It is worth noting that the previous calculations were made assuming that the ring entered the sediments in 2006, the year following its ringing. Pintails can survive up to 20 and even 27 years in the wild (Fransson *et al.*, 2017). If a pintail dies 10–15 years after ringing, the nest sedimentation time could potentially be reduced to literally one or two years.

By averaging all the calculations above, assuming convenience (in terms depth of the ring and date of pintail death), we can assume that the upper 10 cm of sediment was formed in 15 years and the entire section in 30 years.

Rodent fauna

Only half of the washed sample volume was utilized to identify mammal remains in the uppermost conditional horizon (0–2 cm). With a total of 2311 cheek teeth from 12 rodent species, the four conditional horizons were examined. In addition to rodents, remains of mole (*Talpa europaea*), hare (*Lepus timidus*), weasel (*Mustela nivalis*), and stoat (*Mustela erminea*) were found. Table 2 and Fig. 5 summarize the species composition and proportion of rodent remains. To compare with the nest's local taphocenosis, the trapping results between 2014 and 2020 were used to create the species dominance index (Bobretsov, 2020).

The preservation of bone remains is good, with bones displaying a range of colors including white, light yellow and light beige. There is evidence of digestive enzyme processing on a substantial portion of bones and teeth, and many vole teeth show signs of partially dissolved enamel, rough surface, matte color, and round shape. Notably, whole skulls are absent, as are complete mandibles of rodents, and there is a nearly complete lack of insectivore remains, except the mole. The features of the material suggest that diurnal birds of prey participated in bone accumulation, rather than nocturnal ones, as indicated by prior researches (Mayhew, 1977; Andrews, 1990). Furthermore, a clear preference emerges for relatively large mammalian species within the assemblage, including squirrel, water vole, muskrat, hare, and various types of bird such as pintail, the males of which can weigh up to 1300 g. The raptor specializes in hunting in riverine habitats, which is supported by the predominance of remains from prey near-water species such as water vole, root vole, and waterfowl.

Overall, the composition of the bone assemblage includes typical forest species (Siberian flying squirrel, red squirrel, Siberian chipmunk, red-backed voles, wood lemming, and field vole) found in zonal forests, as well as intrazonal near-water species (water vole, root vole, muskrat). The prevalence of near-water species and lack of shrews can be attributed to the raptor's hunting specialization.

Spore-pollen data

The palynological method was used to investigate sediments from a nest. Four samples were analyzed at depths of 0–5 cm, 5–10 cm, 10–15 cm, and 15–20 cm. It was observed that spores and pollen were not present in the samples taken from depths of 0–5 cm and 5–10 cm probably due to the prevalence of bird excrement in the upper sections. These samples contained a significant amount of hyphae and mycelium of fungi.

Fig. 4. General view of the nest excavation.

Samples retrieved at depths of 10–15 and 15–20 cm comprised abundant spores and pollen, displaying varying levels of preservation. Alongside, the presence of fungi's hyphae and mycelium, green algae, and arthropod cuticle remains were also detected.

The spore-pollen spectrum consists mostly of arboreal pollen, making up 91.2% of the total composition (Fig. 6). Grasses and spore plants were only found in small quantities, making up 6–13% and 2.5–3.5%, respectively. Among the tree pollen, conifers were the predominant representatives, with *Pinus sylvestris* and *Picea* sp. comprising 46% and 22% respectively. Small-leaved species, predominantly from the genus *Betula*, occupy a subordinate position, with *Betula* sect. *Fruticosae* accounting for up to 11%, *Betula* sect. *Albae* approximately 8%, and *Betula nana* making up 4%. Pollen from *Alnus* sp., *Alnaster* sp., and *Salix* sp. is found singularly.

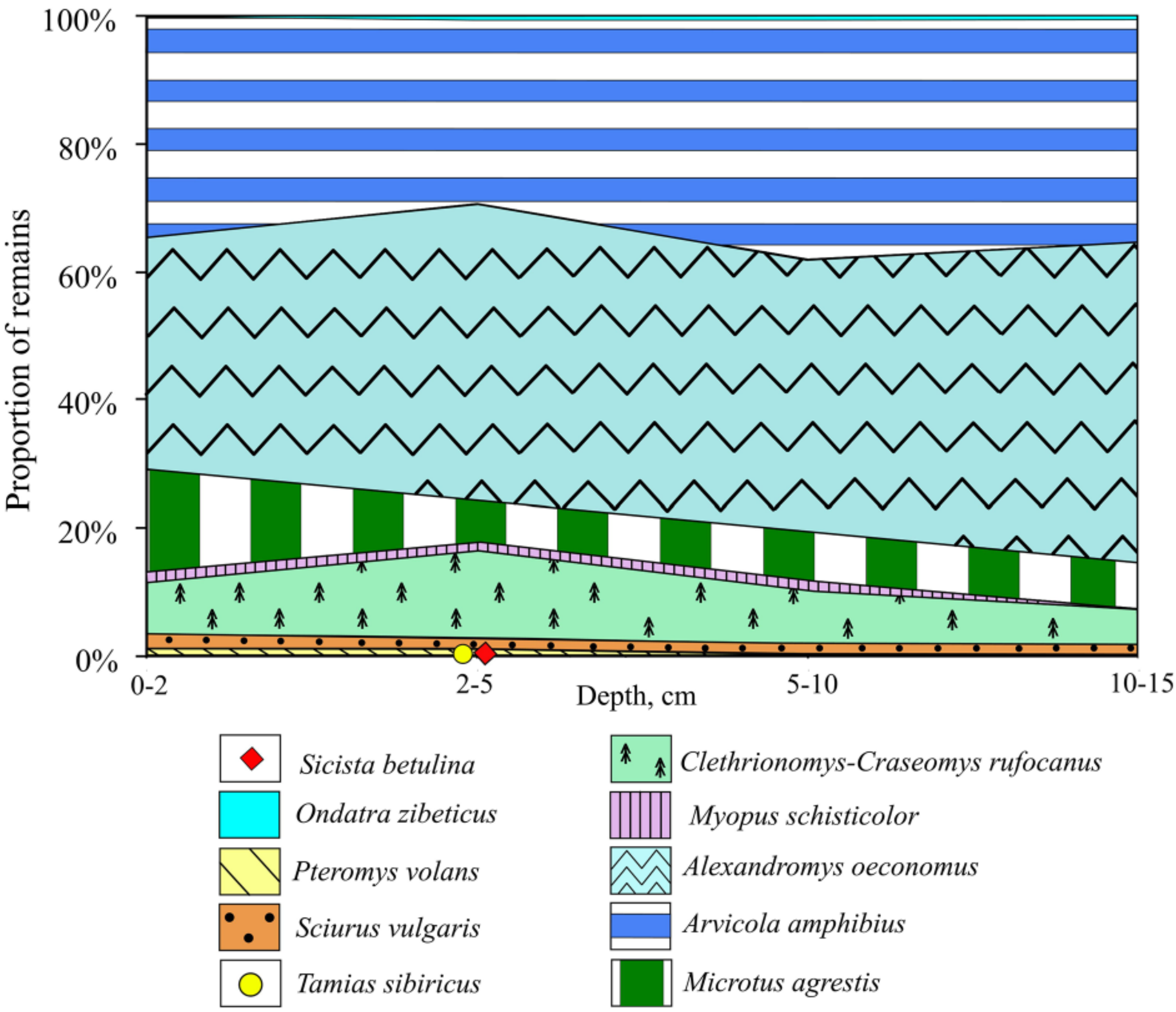

Fig. 5. Faunal composition and percentage of rodent remains in the nest sediments.

The herbaceous plant community is limited in diversity and consists primarily of grasses (over 4%), wormwoods, Chenopodioideae, Ericaceae, various herbs from families such as Polygonaceae, Ranunculaceae, Caryophyllaceae, Apiaceae, Asteraceae, and others. Additionally, *Sphagnum* mosses, Polypodiaceae ferns, lycopods *Lycopodium clavatum*, *L. pungens*, *L. annotinum* are present.

Palynological spectra provide insight into the distribution of spruce-pine forests also with birch, alder, and willow trees in the area surrounding the nest. In the forest understory, there are dwarf birch and representatives of the Ericaceae plant family. Herbaceous communities occupy small open areas. Overall, the spectrum's composition suggests a highly favorable climate for forest vegetation.

Our field observations and neontologists' data (Lashchenkova, 1959; Lashchenkova & Nepomilueva, 1982; Teteryuk *et al.*, 2002; Bobretsov, 2020) provide a detailed description of the current vegetation surrounding the nest and in the middle reaches of the Pizhma River. Various vegetation associations exist in this area.

1. Herbaceous-moss-lichen pine-aspen-birch forests with alder participation occupy steep limestone slopes.
2. Rare forests with pine and birch trees with mosses and lichens grow on the northern slopes, accompanied by exotic forest-tundra associations. An assortment of arctic, arctoalpine, and boreal-montane species grow here, including *Dryas octopetala*, *Salix reticulata*, *Minuartaria verna*, *Papaver lapponicum*, *Saxifraga caespitosa*, *Hedysarum arcticum*, *Valeriana capitata*, *Arctostaphylos* (*Arctous*) *alpina*, *Thalictrum alpinum*, *Libanotis condensate*, and *Carex glacialis* together with dwarf birch and *Ledum*. Rock plants, including *Cystopteris dickieana*, *C. fragilis*, *Woodsia glabella*, and *Asplenium viridae*, are present in the area. In addition to the "northern" species, there are also "southern" species like *Anemone sylvestris*, and *Thymus serpyllum* (*taljievii*?).

3. The elevated zonal landscapes are occupied by various types of forests, such as fern-blackberry spruce forests, larch-spruce-blackberry-aconite and lingonberry-herb forests, as well as mixed prostrate shrub-green-moss birch-spruce-larch forests.
4. Willow forests with hydrophilic herbs and grasses, *Carex acuta* communities, *Petasites*, and horsetail occupy the floodplain of the Pizhma River. Herbaceous meadows with *Thalictrum minus*, aconite, meadowsweet, garden speedwell, *Angelica*, chives, various types of grasses, and Apiaceae dominate here.
5. Strips of mixed herbaceous and large herbaceous birch-spruce or birch forests with pine and spruce are present in some places along the river.

Discussion

A comparison of our faunal data collected from the excavating nest with the trapping data presented by Bobretsov (2020) highlights the selectivity of the two sources. The trapping data represents a seven-year average of counts in several main habitats, including spruce and two types of birch forests, as well as a meadow. On the other hand, our nest excavation materials present the results of hunting a relatively large raptor, averaged over periods of approximately seven years (one five-centimeter horizon) over the past 30 years. The primary hunting zone of the raptor was situated predominantly above the Pizhma River valley comprising willow forests and meadows with near-water vegetation in the floodplain. Besides these habitats, the area surrounding the nest is occupied by spruce forests, pine-aspen-birch forests, rare pine and birch forests with unusual forest-tundra associations, and birch forests with pine and spruce.

Sixteen mammal species were identified from nest sediments, including 12 rodent species, as well as a mole, a hare, and two species of small mustelids (ermine and least weasel). Fourteen species of shrews and rodents were recorded using trap trenches. Larger and/or stronger animals such as the Siberian flying squirrel, red squirrel, chipmunk, muskrat, gray red-backed vole, water vole, hare, ermine, and least weasel were not caught in the trap trenches. Using traps, various species of shrews were captured including common shrew, taiga shrew, tundra shrew, Laxmann's shrew, Eurasian pygmy shrew, Eurasian least shrew, and Eurasian water shrew. These species were not discovered in nest deposits as they were not preyed upon by raptors. Although the traps were set in different habitats, traditional trapping with trap trenches yielded the anticipated domination of soricids. To increase the number of small mammal species in the study area, it is required to systematically place various trap types, such as crush traps and cones, during different seasons for many years. The prolonged use of trap trenches demonstrated that in forest habitats of the area, the northern red-backed vole, European bank vole, and field voles are the most common rodents, while in floodplain meadow habitats, the root vole, field vole, and northern birch mouse predominate (Bobretsov, 2020).

The micromammalian fauna from the nest sediments shows a more diverse composition, with small

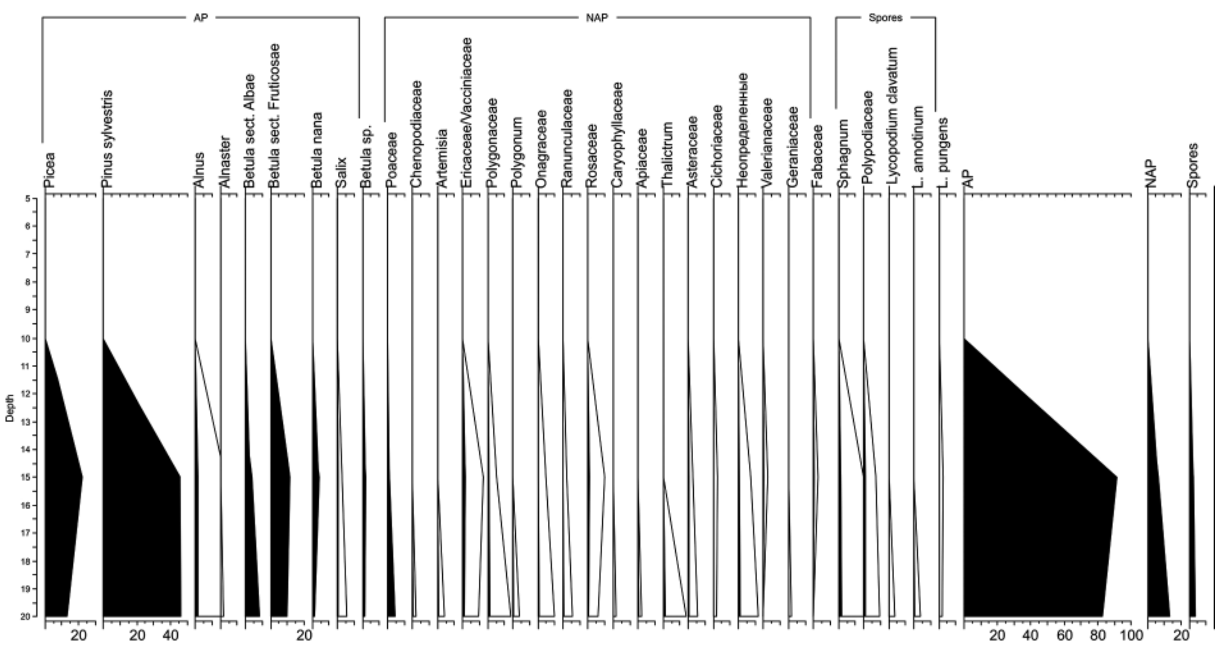

Fig. 6. Spore-pollen diagram of the nest sediments.

mammals from the middle-size group, including water vole, red squirrel, chipmunk, and muskrat, dominating. However, there is an almost complete absence of shrews, except for moles. These species were not found in the nest sediments because they were not prey for the raptor. However, several small rodent species, including the rare wood lemming for the study area, were present in the taphocenosis. These findings suggest that surveying raptor nests holds promise as a method for monitoring changes in small mammal populations over at least the past century. To ensure the presence of both rodents and soricids in nest bone assemblages, it is essential to analyze nest deposits of both diurnal and nocturnal raptors. Owls have a high number of shrews in their diet, while these prey items are rare in diurnal raptors (Andrews, 1990).

The data collected through both survey methods reveal the existence of mammalian species that are characteristic of the northern taiga zone in the middle reaches of the Pizhma River. The composition of the species in trapping materials varied depending on their habitats: taiga shrews and voles were more prevalent in mossy forest habitats, whereas forest-meadow species dominated in grassy habitats (Bobretsov, 2020). Subfossil data reveals the distribution of closed forests and the presence of near-water habitats. However, near-water species' dominance is explained by taphonomic reasons rather than the wide distribution of these biotopes due to predator specialization.

A comparison of modern vegetation descriptions with palynological materials from nest sediments demonstrates that spore-pollen data accurately reflects the zonal vegetation type. This data shows the presence of not only forest associations (pine on slopes and spruce on plateaus) with an abundance of birch, *Vaccinium*, and other Ericaceae and herbaceous communities but also intrazonal floodplain communities. Additionally, it shows the development of unusual forest-tundra associations with dwarf birch. It is clear from this analysis that spore-pollen data is an effective tool for accurately describing vegetation.

Conclusions

Excavations at an abandoned bird of prey nest in the northern taiga (Middle Timan, middle reaches of the Pizhma River, Ust-Tsilemsky District of the Komi Republic) yielded fascinating information about the local flora and fauna. The nest sits on a rocky ledge comprised of Carboniferous limestones. The sediments within the nest consist of dusty silty clays and loams that contain a high amount of limestone fragments and vertebrate bones. These sediments formed due to the erosion of unconsolidated sediments and weathering products from the carbonate bedrock on the slope by surface water, along with the addition of bird excrement and other products of bird activity in the upper layers. Discovery of a ring used to tag a northern pintail in 2005 in Great Britain, located within the 5–10 cm interval of a 20 cm sediment section, provides an estimate for the sediments' age. Due to the impossibility of determining the exact year at which the ring arrived at the nest, it can be hypothesized that the approximate time for accumulation of all sediments (20 cm) is estimated to be around 30 years.

The bone remains recovered from the nest sediments allowed for the identification of 16 modern mammal species, consisting of 12 rodent species, as well as mole, arctic hare, least weasel, and ermine. The subfossil assemblage reveals the presence of typical northern taiga mammalian fauna including forest, intrazonal near-water, and meadow species. The hunting specialization of the diurnal raptor influenced prey selectivity, resulting in larger species such as muskrat, red squirrel, Siberian flying squirrel, and water vole being present in the rodent population, with a significant predominance of species from meadow and near-water habitats, notably water vole and root vole.

Compared to the data from trapping small mammals, only various species of shrews are missing from the nest materials. There are several species not caught in the traps, including red squirrel, Siberian flying squirrel, chipmunk, muskrat, gray red-backed vole, water vole, hare, least weasel, and ermine. Furthermore, the nest's material contains uncommon species for the research region, namely wood lemming, which has been observed in the area infrequently and not consistently each year.

The spore-pollen assemblages from the nest sediments accurately replicate the current vegetation in the nest area, representing the northern taiga zonal vegetation. The palynocomplex represents the growth of dark coniferous forests, pine-birch forests with mosses on slopes, *Vaccinium* communities with *Ledum*, floodplain landscapes with willow and herbaceous meadows, and even uncommon forest-tundra associations with dwarf birch.

In general, it is worth noting that the bone remains retrieved from the bird of prey's nest can be used to complement studies on the population, fauna, and biotope distribution of small mammals as well as on the species composition and ecological structure of modern flora.

ACKNOWLEDGMENTS. The authors would like to express their gratitude to V.P. Bobretsov, S.P. Bobretsov and A.A. Kryazhev for their assistance during fieldwork in the Ust-Tsilma district of the Komi Republic over multiple field seasons. We thank T.V. Fadeeva, Pirozka Pazonyi, and an anonymous reviewer for providing valuable feedback that helped improve this article.

The study was conducted as part of the research topic "Evolution of biota and its environments as a basis for stratigraphy and geological correlation of the sedimentary cover of the Pechora plate and its folded frame" with reference No. 122040600008-5.

The authors confirm that there is no conflict of interest.

References

Abramson N.I. & Lissovsky A.A. 2012. Subfamily Arvicolinae // Pavlinov I.Ya. & Lissovsky A.A. (eds.). Mammals of Russia: a Taxonomic and Geographical Reference. Moscow: KMK Scientific Press. P.220–276.

Andrews P. 1990. Owls, caves and fossils: predation, preservation and accumulation of small mammal bones in caves, with an analysis of the Pleistocene cave faunas from Westbury-sub-Mendip. Somerset, UK: University of Chicago Press. Chicago. 231 p.

Belkin V.I. & Ryazanov I.V. 1972. [Concept and measures of granulometric sorting and homogeneity] // Materials of V Komi Republican Scientific Conference. Syktyvkar: Geoprint, Vol.5. P.184–185 [in Russian].

Bobretsov A.V. 2020. [Small mammals of the middle reaches of the Pechorskaya Pizhma River: structure and population dynamics] // Bulletin of IB Komi SC Ural Branch RAS. Vol.3–4. P.2–9 [in Russian].

Borodin A.V., Kourova T.P. & Markova E.A. 2005. [Dimensional characteristics of molar teeth in *Clethrionomys* (*Craseomys*) *rufocanus*, *Cl.* (*Clethrionomys*) *glareolus*, *Cl.* (*Cl.*) *rutilus* (Arvicolinae, Rodentia) and their use for species identification] // Zoologicheskii Zhurnal. Vol.84. No.2. P.236–244 [in Russian].

Erdtman G. 1992. Erdtman's Handbook of Palynology. 2nd ed. Nilsson S. & Praglowski J. (eds.). Copenhagen. 580 p.

Fransson T., Jansson L., Kolehmainen T., Kroon C. & Wenninger T. 2017. EURING list of longevity records for European birds. Stockholm, Swedish Museum of Natural History, EURING. https://euring.org/data-and-codes/longevity-list

Grichuk V.P. & Zaklinskaya E.D. 1948. [Analysis of Fossil Pollen and Spores and its Application in Paleogeography]. Moscow: OGIZ GEOGRAFGIZ. 224 p. [in Russian].

Heisler L.M., Somers C.M. & Poulin R. G. 2016. Owl pellets: a more effective alternative to conventional trapping for broad-scale studies of small mammal communities // Methods in Ecology and Evolution. Vol.7. P.96–103.

Kachinsky N.A. 1958. [Mechanical and microaggregate composition of soil, methods of its study]. Moscow: AN SSSR. 192 p. [in Russian].

Kryštufek B., Tesakov A.S., Lebedev V.S., Bannikova A.A., Abramson N.I. & Shenbrot G. 2020. Back to the future: the proper name for red-backed voles is *Clethrionomys* Tilesius and not *Myodes* Pallas // Mammalia. Vol.84. No.2. P.214–217.

Lashchenkova A.N. & Nepomilueva N.I. 1982. [Rare plant communities of the Middle Timan in need of protection] // Trudy Komi filiala Akademii nauk SSSR. Vol.58. P.28–36 [in Russian].

Lashchenkova A.N. 1959. [Note on the flora of limestones of the Pizhma River] // Proceedings of the Komi Branch of All-Union Geographical Society. Vol.5. P.107–110 [in Russian].

Mayhew D.F. 1977. Avian predators as accumulators of fossil mammal material // Boreas. Vol.6. No.1. P.25–31.

Pokrovskaya I.M. 1950. [Laboratory processing of samples for pollen analysis] // Pollen Analysis. Moscow: State Publishing House of Geological Literature. P.29–45 [in Russian].

Rukhin L.B. 1969. [Fundamentals of Lithology. The Doctrine of Sedimentary Rocks]. Leningrad: Nedra. 778 p. [in Russian].

Smirnov N.G. & Sadykova N.O. 2003. [Sources of errors during faunistic reconstructions in Quaternary paleozoology] // Ushakova K.I. (ed.). [Quaternary Paleozoology in the Urals]. Ekaterinburg: Izdadelstvo Uralskogo Universiteta. P.98–115 [in Russian].

Teteryuk B.Yu., Teteryuk L.V., Kanev V.A. & Syamtomova A. 2002. [Commanded to preserve: flora, vegetation and condition of rare species of the Reserve "Svetly"]. https://ib.komisc.ru/add/old/t/ru/ir/vt/02-61/07.html [in Russian].