doi:10.17746/1563-0110.2024.52.1.125-133

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An Archaeobotanical Study of the Bukhta Nakhodka Fort, the Yamal Peninsula (13th to Early 14th Century)

We present the findings from an archaeobotanical study of samples from the habitation layer of Bukhta Nakhodka, a 13th to early 14th century fort on the Yamal Peninsula, Western Siberia. On the basis of a detailed analysis of the taxonomic diversity of macro- and micro-remains of plants, the vegetation around the site is reconstructed as grass, moss, and subshrub tundra. The abundance of pollen and vegetative plant parts in habitation deposits inside buildings support an earlier hypothesis that peat and turf briquettes, resulting from turf removal, were used for construction. The vegetation cover of tundra area within the site and immediately adjoining it had changed. Its integrity was disrupted during construction of the fort, after which ruderal tundra apophytes expanded rapidly, and the turf layer was partly recovered during the fort's existence. A secondary grass cover, differing from that of the natural tundra communities, formed after the fort had been abandoned. A few remains of wild food plants were found, but none of cultivated plants. On the basis of archaeobotanical data, it is concluded that the pre-Nenets people used the plant resources of the Yamal subarctic tundra mostly for construction, domestic needs, and possibly as food.

Keywords: *Plant macrofossil analysis, pollen analysis, archaeology, pre-Nenets population, subarctic region of Western Siberia.*

Introduction

The development of the Arctic regions of Northern Eurasia is associated with the medieval warm period or medieval climatic anomaly (950–1250 AD). In the 10th–14th centuries, when the climate, according to dendrochronological data, was warmer and probably drier than the average throughout our era (Shiyatov, Hantemirov, 2005), stationary settlements of both indigenous people and Europeans appeared on the Yamal Peninsula and adjacent territories (Istoricheskaya ekologiya…, 2013: 232–233; Plekhanov, 2013; Vizgalov, Kardash, Konovalenko, 2018; Kardash et al., 2018; and others). By that time, tundra communities already predominated on the peninsula, and woody vegetation occupied intrazonal landscapes along the valleys of large rivers in its southern part, gradually forming the northern border of the forest and the forest-tundra type of vegetation south of the Arctic Circle (Volkova, Bakhareva, Levina, 1989; Telyatnikov, Pristyazhnyuk, 2002; Vasilchuk, 2007: 155; and others).

Archaeological complexes of stationary settlements in the subarctic region of Western Siberia provide valuable information about the subsistence system of the population, and about the natural conditions at that time. Despite many years of research into such objects, only a few sites have been studied using archaeobotanical methods (Panova, 1998, 2008; Panova, Yankovska, 2008; Zhilich et al., 2016; Korona, 2010, 2013, 2015; Anderson et al., 2019).

The purpose of the work is to carry out a comprehensive in-depth archaeobotanical study in order to reconstruct plant communities in the vicinity of the Bukhta Nakhodka fort, and to identify anthropogenic changes caused by the economic activities of the aboriginal population living at that time.

Archaeological essay and brief results of the earlier interdisciplinary studies

The fort of Bukhta Nakhodka (67°19′N, 72°10′E) is located on the subarctic territory of the Yamal Peninsula (Fig. 1), within the moderately cold and humid subarctic climate zone, where the temperature of the coldest month (January) is –24…–26 °C, that of the warmest (July) is +8…+12 °C, average annual precipitation is ca 300–400 mm (Natsionalniy atlas…, 2008: 158–159). The site is located in the subzone of subshrub tundras, which are characterized by moss-lichen dwarf-birch communities with *Betula nana, Empetrum hermaphroditum, Carex globularis* (Ibid.: 328–330). The immediate vicinity of the fort is dominated by tundra communities without tree vegetation, but with shrub thickets (*Salix* sp., *Betula nana, Alnus alnobetula* subsp. *fruticosa*) and a coastal raised bog with *Rubus chamaemorus*.

Fig. 1. Location of a number of forts in the subarctic region of Western Siberia.
1 – Bukhta Nakhodka; *2* – Yarte VI; *3* – Tiutei-Sale-1; *4* – Polui promontory fort; *5* – Nadym; *6* – Ust-Voikary.
a – Arctic Circle; *b* – modern northern border of forest vegetation.

The archaeological study at the site in 2006–2014 has shown that this was a settlement of Sikhirtya—the pre-Nenets population of the Yamal tundra. The layout of the fort was of a mirror-symmetrical type (Fig. 2). All the studied buildings were two-chambered dwellings, each consisting of a bypass gallery and a living space with a central hearth. The gallery served as a thermal-insulation layer and was likely used for storing food, clothing, and utensils, i.e. it had an economic purpose (Kardash, 2011: 16–21).

According to the results of dendrochronological dating of the wood of the buildings, the last building-horizon uncovered by excavations dates to the 13th to early 14th centuries AD (Sidorova, Büntgen et al., 2017). Archaeozoological study of osteological material has shown that the main economy of the fort's population was hunting wild reindeer; in addition, they hunted arctic fox, and caught fish (mainly sturgeon) and marine mammals (Kardash, Lobanova, 2008; Istoricheskaya ekologiya…, 2013: 257). The site functioned in the autumn-winter period, and from May to September only a small group of people remained there (Kardash, 2011: 42–45).

Material and methods

Samples for the archaeobotanical study were collected within the 2014 excavation area (Fig. 2). The tested cultural layer, both inside and outside the buildings, is homogeneous, humic, dark brown in color, and contains a mass of wooden chips, grass, and half-decayed organic remains. Under laboratory conditions, samples (weighing ca 25 g) were taken from the soil monoliths for pollen analysis, and samples (in the volume of 300–600 ml) for the plant macrofossil analysis. From the sediments of the gallery of buildings 3 and 5, each 50 cm thick, continuous columns of 10 samples each were selected in accordance with the weight and volume of the samples indicated above.

The samples were processed and analyzed using standard methods (Grichuk, Zaklinskaya, 1948; Nikitin, 1969). Pollen and spores were determined in

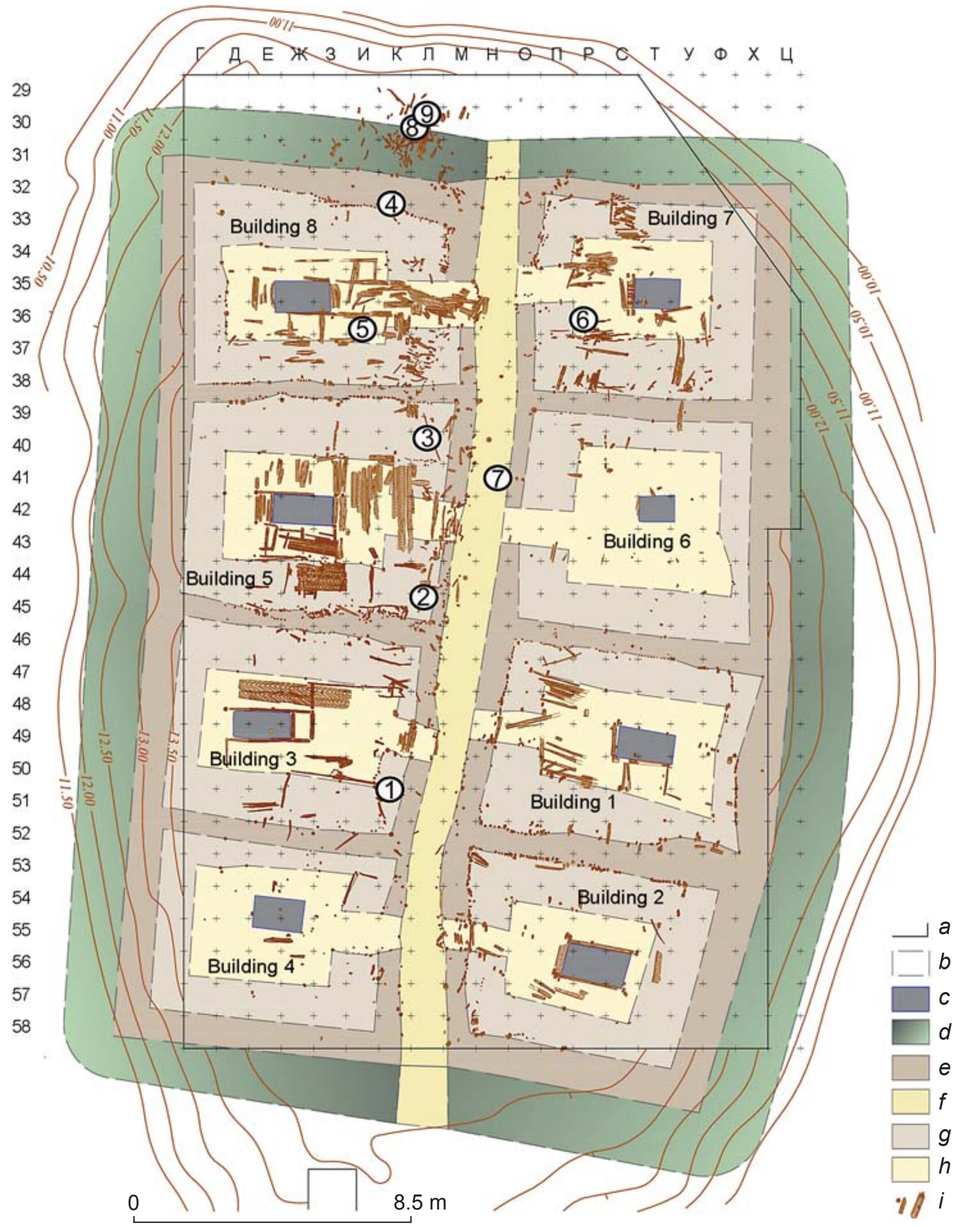

Fig. 2. Plan of the defense and residential area (DRA) of Bukhta Nakhodka and the site of sampling for archaeobotanical study.
a – boundary of the excavations; *b* – boundary of DRA; *c* – hearth; *d* – ramp slope; *e* – DRA walls; *f* – central passage of DRA; *g* – building gallery; *h* – central room of the building; *i* – remains of wooden structures. *1–9* – sample numbers.

temporary glycerol preparations using an Olympus BX51 microscope at ×400 magnification. For each sample, at least five preparations were examined, counting 100–300 pollen grains from terrestrial plants and simultaneously recording spores of higher spore-bearing plants and coprophilous fungi. The exceptions are three samples with very low concentrations of pollen, in which fewer than 100 pollen grains were counted. The material for studying plant macrofossils was sieved on a column of sieves (minimum cell diameter 0.25 mm) and viewed using a Carl Zeiss Stemi 2000-C microscope. To determine taxonomic affiliation, reference collections of pollen and spores, fruits and seeds from the Museum of the Institute of Plant and Animal Ecology, Ural Branch of the Russian Academy of Sciences and atlases were used (Dobrokhotov, 1961; Kats N.Y., Kats S.V., Kipiani, 1965; Beug, 2004). The obtained data were processed and the diagrams were constructed using the software package Tilia, v. 2.0.41 (Grimm, 2004). On the pollen diagram, the proportion of pollen of taxa of trees and shrubs, subshrubs and herbs was calculated from the total amount of pollen of woody and herbaceous plants, taken as 100 %. The

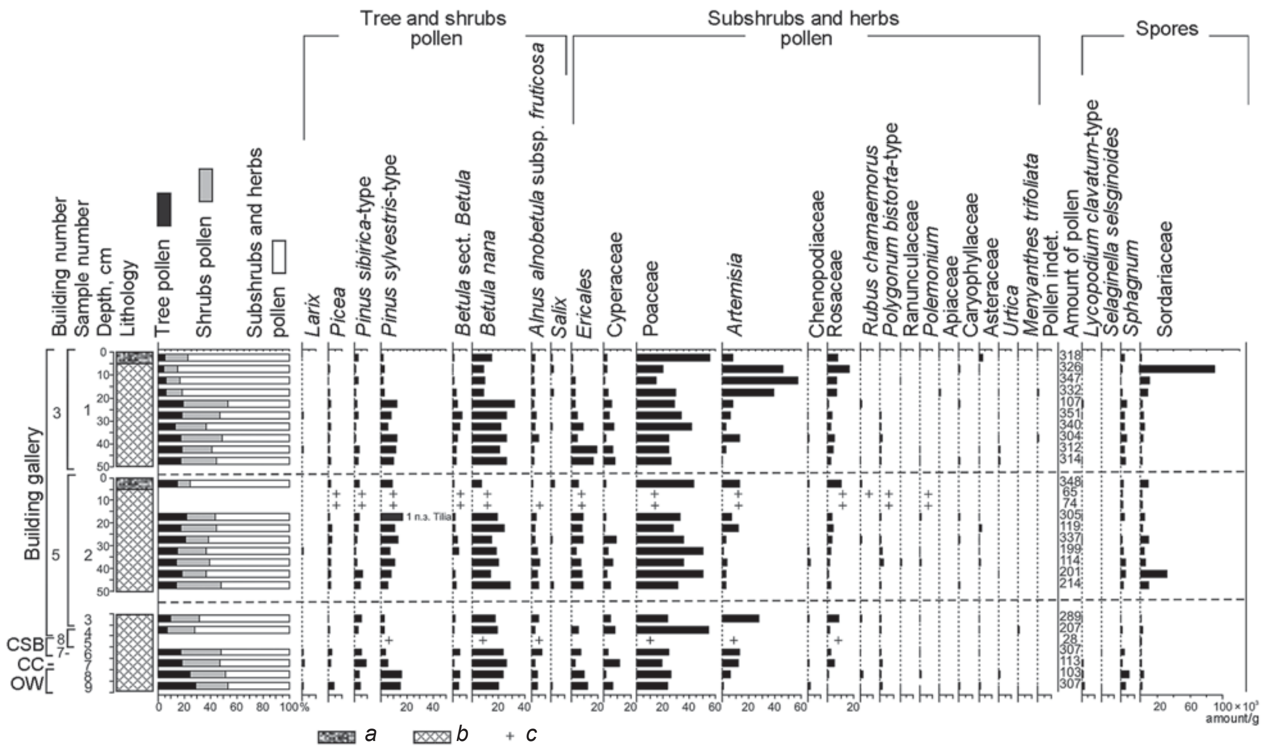

Fig. 3. Pollen diagram.
a – turf, *b* – cultural layer; *c* – single pollen. CSB – central space of the building, CC – central corridor, OW – outer wall.

content of spores of higher spore-bearing plants and coprophilous fungi is given as concentration (Fig. 3). The diagram of plant macrofossils shows the absolute amount of remains of a particular taxon in the studied volume of each sample (Fig. 4).

Results of archaeobotanical study and discussion

According to the findings of archaeobotanical study, no significant differences in taxonomic composition were found between any of the studied samples; no specific features in the species composition of micro- and macro-remains from various functional parts of the fort's buildings have been identified at this stage. The identified taxa of pollen and macro-remains of shrubs, subshrubs, and herbs correspond to the modern flora of Yamal (Poluostrov Yamal…, 2006).

The obtained pollen spectra and complexes of plant macrofossils characterize the vegetation of the southern shrub tundras: sedge-graminoid communities with tundra forbs, herbaceous-subshrub associations, thickets of dwarf birch and willows with the addition of alder, groups of wormwood and mayweed on non-turfed substrates of river slopes, peat-bog communities of sedges, Labrador tea, heather subshrubs, cloudberries, cotton grass, and sphagnum mosses. Such diversity in the vicinity of the site is still observed today. Similar tundra plant communities were reconstructed on the basis of pollen data from the deposits of the archaeological sites of Yarte VI (11th–12th centuries AD) and Tiutei-Sale-1 (the upper cultural layer dates back to the 12th-14th centuries AD), located northwest of Bukhta Nakhodka (Panova, 1998, 2008; Anderson et al., 2019: 13–15).

The obtained pollen spectra revealed a high content of pollen from grasses (Poaceae), dwarf birch (*Betula nana*), and heather subshrubs (Ericales). In plant macrofossil collections, the last two taxa, together with *Sphagnum* sp., are also abundant, while the grasses are represented by single specimens (see Fig. 3, 4). The study of the structure of the external and internal walls of buildings has shown that the space between two rows of vertical poles, beams, logs, and slabs was filled with peat and turf briquettes, waste materials, and wood chips (Kardash, 2011: 21). The revealed composition of pollen spectra and macrofossil collections likely reflects the plant communities that existed during the construction of the fort; to fill the internal space of the walls, people used tundra turf consisting of herbs, moss, and subshrubs. The noticeable difference between the amount of Poaceae pollen and macrofossils can be explained by the fact that the houses were built in mid-summer. At this time, the flowering of wild graminoids and sedges had already ended; most of the pollen rain settled on the surface; however, the seeds of

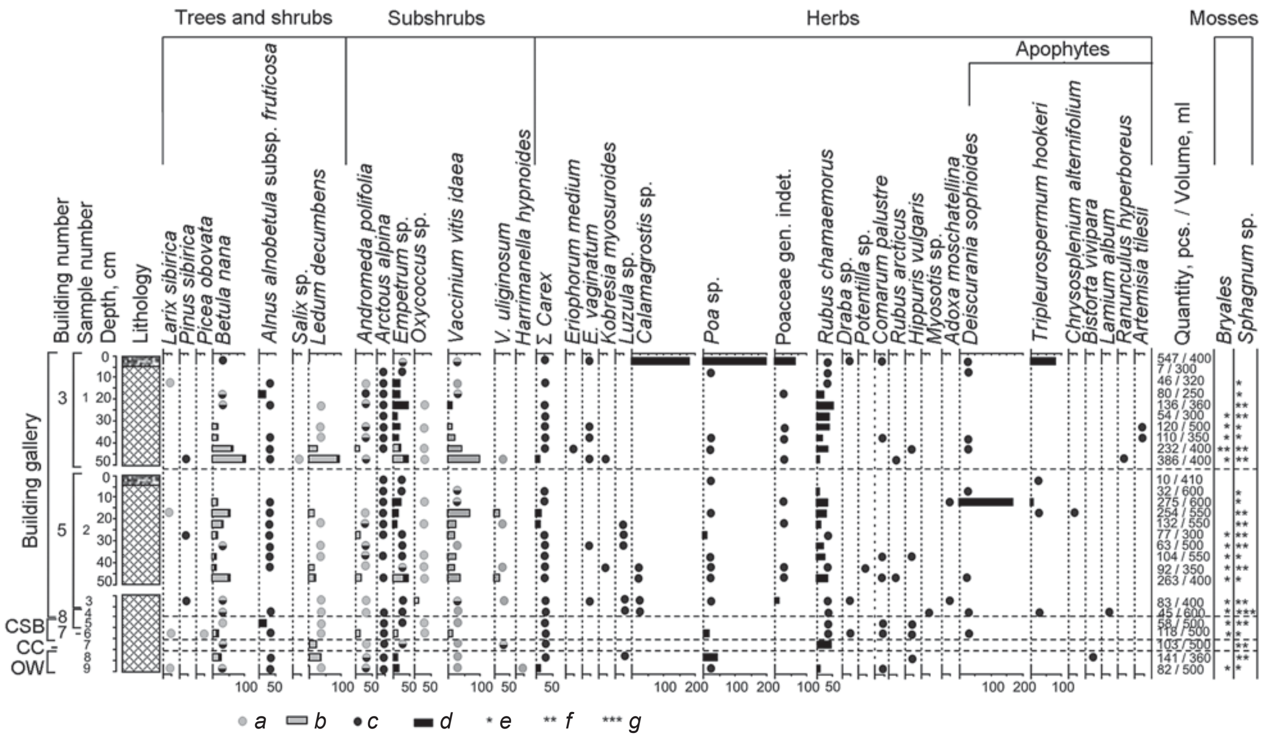

Fig. 4. Composition and content of plant macrofossil.
Vegetative parts: *a* – less than 10 spec., *b* – more than 10 spec.; fruits and seeds: *c* – less than 10 spec., *d* – more than 10 spec.; mosses: *e* – single, *f* – many, *g* – abundant. Legend to lithology and sampling sites same as on Fig. 3.

Amount of taxa and their macrofossils in cultural layers of archaeological sites of the Subarctic region of Western Siberia

Group of plants	Bukhta Nakhodka Fort (13th to early 14th century AD)		Fort Nadym (Korona, 2015) (Mid-15th to early 18th century AD)		Polui promontory fort (Korona, 2013) (late 16th to early 18th century AD)	
	Taxa	Macrofossils	Taxa	Macrofossils	Taxa	Macrofossils
Cultivated	–	–	–	–	1	2/0.01
Wild food, including	7	817/22.4	9	1574/22.5	7	2893/15.8
crowberry (*Empetrum* sp.)	1	266/7.3	1	24/0.3	1	2036/11.1
cloudberry (*Rubus chamaemorus*)	1	507/13.9	1	857/12.2	1	690/3.8
Weeds, в including apophytes	7	285/7.8	10	4335/61.8	17	13,939/76.1
Other	32	2548/69.8	26	1099/15.7	17	1491/8.1
Total	46	3650/100	45	7008/100	42	18,325/100

Note. Numerator indicates the absolute number, denominator indicates the percentage.

grasses and sedges had not yet reached their technical maturity, so these haven't been preserved.

Among the variety of discovered macrofossils, noteworthy is a group of wild food-plants (cloudberry, arctic raspberry, crowberry, lingonberry, blueberry, cranberry). Its share is more than 22 % of the total amount of macrofossils (see *Table*). Similar data were obtained from the study of the cultural layer of Fort Nadym (Nadymsky gorodok) (see *Table*), where the species diversity of food plants is higher: not only the hypo-arctic species are present, but also mountain ash (*Sorbus aucuparia*) and bird cherry (*Padus padus*) (Korona, 2015: 194). In the Polui promontory fort (Poluisky mysovoy gorodok), the remnants of this group account for ca 16 % (see *Table*). The diet of the aboriginal population of all three forts included the fruits of edible wild plants, but gathering was not significant in the nutritional structure.

No pollen or macrofossils of cultivated plants were found in samples from Bukhta Nakhodka (see Fig. 3, 4). Pollen grains of such plants are also absent in samples from Yarte VI and Tiutei-Sale-1 (Panova, 1998, 2008; Anderson et al., 2019: 13–15). In Fort Nadym, macrofossils of this group were not found (see *Table*); and in Polui, only two fragments of oat grains (*Avena* cf. *sativa*) were discovered (Korona, 2013: 368; 2015: 195), which is probably because of the proximity of Russian settlements.

Noteworthy is a group of plants that can be conditionally classified as weeds, namely apophytes. These rapidly spread in areas altered by human economic activity, but at the same time maintain their strong position in local flora. These plants constitute less than 8 % of the total amount of macrofossils found (see *Table*). In several samples, seeds of alpine bistort (*Bistorta vivipara*), arctic buttercup (*Ranunculus hyperboreus*), and golden saxifrage (*Chrysosplenium alternifolium*) were found—typical tundra plants of turf substrates growing in meadow-shrub communities in river valleys, in wet meadows, and tundra meadows. The seeds of flixweed (*Deiscurania sophioides)*, mayweed (*Tripleurospermum hookeri*), and Telesius wormwood (*Artemisia telesii*) were classified as taxa of non-turfed substrates in the tundra, including coastal outcrops, screes, and alluvial sand and pebble deposits. In the pollen spectra, pollen of *Artemisia* sp. is abundant, and pollen grains of Asteraceae are found, predominantly of the *Matricaria*-type morphological group, which also includes the genus *Tripleurospermum*. Under anthropogenic load on vegetation, the above plants become tundra ruderals, settle in secondary communities in areas with disturbed soil cover, and grow in garbage areas, near residential buildings, and along paths and trails (Dorogostaiskaya, 1972: 103, 105, 114, 132, 145; Sekretareva, 2004: 75, 102). In sample No. 4 from the gallery of building 8 were discovered single seeds of white dead nettle (*Lamium album*), which is a nemoral-boreal species of forests of the Northern Hemisphere moderate temperature zone. This species was probably introduced into the tundra by humans, and is now occasionally found in willow forests and mixed-grass meadows along the slopes of the main shore of the Gulf of Ob, reaching 69° N along river valleys (Poluostrov Yamal…, 2006: 48; Govorukhin, 1937: 433).

The share of weed seeds in Nadym and Polui forts was 62 % and 76 %, respectively (see *Table)*. The most abundant are stinging nettle (*Urtica dioica*), white goosefoot (*Chenopodium album*), and white dead nettle (Korona, 2013: 369; 2015: 195). In the Far North, these species often occur as ruderals in habitats with well-fertilized soils, near dwellings, and along paths and roads (Dorogostaiskaya, 1972: 89, 94, 132).

The species composition and the amount of macrofossils of weeds at three archaeological sites in the subarctic region of Western Siberia reflect different degrees of anthropogenic impact on the surrounding vegetation. In the vicinity to the Bukhta Nakhodka fort, because of economic activities mainly associated with the use of turf-moss layer during the construction of the site, the integrity of the vegetation cover was disturbed. As a result, tundra plants appeared near the fort, which were capable of rapidly colonizing unturfed substrates. The population of the Nadym and Polui forts had a significant impact on the surrounding vegetation, which led to the widespread distribution of typical ruderal weeds both on the territory of the settlements and in the surrounding area.

In the studied samples from the cultural layer of the Bukhta Nakhodka fort, small amounts of micro- and macro-remains of tree species were identified (see Fig. 3, 4). Single pollen-grains, stomata of needles, and shortened shoots of larch were found. Xylotomic analysis of archaeological wood samples from the ruins of buildings showed that it was Siberian larch (*Larix sibirica*) that was used during construction (Sidorova, Omurova et al., 2017: 77). According to the cutting dates, buildings 5 and 3 were erected no earlier than 1233 and 1235, respectively (Ibid.; Sidorova, Büntgen et al., 2017: 149–151). This suggests the simultaneous construction and functioning of these dwellings.

According to paleoclimatic reconstructions made using samples of subfossil wood from alluvial deposits of rivers of the Yamal Peninsula in the range from 67° to 68° N, the average summer temperature in the 11th–13th centuries AD remained consistently above the long-term average (Hantemirov, 1999: 188–189). This contributed to the growth of larch woodlands in the southern part of the peninsula, possibly in the immediate vicinity of Bukhta Nakhodka. At the same time, larch logs could have been transported to the construction site from the valleys of the larger rivers Khadytayakha, Yadayakhodayakha, Bolshaya and Malaya Kharutta, where islands of degrading larch woodlands are still found (Poluostrov Yamal…, 2006: 198).

In the pollen spectra, the pollen content of spruce (*Picea* sp.) and birch tree (*Betula* sect. *Betula*) does not exceed 5 % and 10 %, respectively. Only a few fragments of birch bark and one fragment of spruce needle (*Picea obovta*) were found in the collections of plant macrofossils. At present, these plants do not grow in the vicinity of the archaeological site. Mountain birch (*Betula tortuosa*), which belongs to the group of tree-like forms, and Siberian spruce (*Picea obovta*) are occasionally found in larch woodlands in the south of the Yamal Peninsula

(Ibid.). In the collections of subfossil wood, the share of Siberian spruce is small (ca 5 % of the total number of fossil wood cuts), birch occurs sporadically (Hantemirov, 1999: 186). This also suggests a low distribution of these tree species in historical time.

In the collections of plant macrofossils, fragments of Siberian-pine seed shells (nuts) were found; in the pollen spectra, the proportion of *Pinus sibirica*-type and *Pinus sylvestris*-type pollen is 5–15 %. The study of the subrecent pollen spectra of modern plant communities in the southern subarctic tundra of the Yamal Peninsula has shown that pine pollen is a permanent long-distance component, and its content usually does not exceed 20 %. Macrofossils of tree species were not discovered in subrecent complexes of zonal plant communities (Lapteva et al., 2013). The pine pollen found in samples from Bukhta Nakhodka was likely brought inside the closed buildings after pollen rain had settled on the daytime surface of the sod-moss layer, which was then used in construction. Single fragments of Siberian pine seed shells cannot indicate the presence of this tree species in the vicinity of the site. These finds rather suggest trade relations between its inhabitants and the population of the forest-tundra or taiga zone of Western Siberia, who still eats nuts today. Such contacts are also confirmed by the presence, in the cultural layer of the fort, of bones of predominantly forest animals such as beaver (*Castor fiber*) and sable (*Martes zibellina*) (Istoricheskaya ekologiya…, 2013: 255–256).

Notably, in most of the studied samples, there is an abundance of vegetative parts of sphagnum mosses (*Sphagnum* sp.) and a small amount of remains of green mosses (Bryales). These mosses are an integral component of the tundra ground cover. As mentioned above, during the construction of the fort, the internal spaces of the walls of the buildings were filled with peat and turf briquettes. The use of sphagnum mosses ensured better thermal insulation and maintained the microclimate by absorbing excess moisture. The population of the fort probably used sphagnum mosses in everyday life, as a hygroscopic material, and in the manufacture of small ropes (a fragment of such a rope was found in sample No. 5 from the central space of building 8).

Almost all the obtained pollen spectra contained various spores of fungi of the family Sordariaceae (see Fig. 3). Fungal species of this taxonomic group are predominantly obligate coprophilous fungi, which use organic substances from the excrement of animals—mainly herbivores, but also dogs and humans (Prokhorov, Armenskaya, 2001). The coprolites of dogs and humans were discovered in the frozen cultural layer of the Bukhta Nakhodka fort.

Conclusions

The archaeobotanical study of the upper part of the cultural layer of the Bukhta Nakhodka fort has identified pollen and spores, vegetative parts, fruits and seeds of wild plants of the modern flora of the Yamal Peninsula. No significant differences or features in the taxonomic composition of micro- and macro-remains of different utilitarian/functional parts of the fort were revealed.

The abundance of pollen and remains of vegetative parts of plants in the cultural layer inside the structures confirmed the assumption previously made during archaeological excavations about the use of peat and turf briquettes in the construction of the fort. The revealed taxonomic composition of micro- and macrofossils characterizes grass, moss, and subshrub tundras. Peat and turf briquettes were likely obtained by the removal of turf layer precisely in such widespread tundra communities.

The activities of the pre-Nenets aboriginal population led to the anthropogenic transformation of the tundra vegetation on the territory of the fort and its immediate vicinity. As a result of violation of the soil cover integrity during the construction and operation of the site, plants of non-turfed substrates settled widely in the vicinity and on the surfaces of the structures themselves. Later, when the turf layer was restored, tundra ruderals spread in the communities adjacent to the fort. Subsequently, after the end of the site's functioning, a secondary turfed ground cover of wild graminoids, sedges, and herbs was formed on the territory of the fort, and was already different from the natural tundra communities.

The diversity of fossils of wild food plants suggests the use of local plant resources by the inhabitants of the site. The small number of seeds of these plants may be due to the fact that the fort was populated mainly in cold seasons. No remains of cultivated plants were found during the study. This confirms the existing opinion that the pre-Nenets population was not yet familiar with plants of this group and/or did not use their fruits and seeds.

Thus, in the 13th to early 14th centuries AD, in the subarctic tundra of the Yamal Peninsula, there was a functioning fort of Sikhirtya people—the indigenous pre-Nenets population. Residents, as a result of their economic activities during the functioning of the site, transformed the surrounding plant communities. The assessment of the degree of anthropogenic impact of the indigenous population on the tundra plant communities of the subarctic region of Western Siberia in the first half of the 2nd millennium AD will be possible only with further detailed archaeobotanical studies of the cultural layers of the already known or new archaeological sites, contemporaneous to the Bukhta Nakhodka fort.

Acknowledgments

This study was carried out under state assignments of Surgut State University (Project No. 2023-227-18) and the Institute of Plant and Animal Ecology of the Ural Branch of the Russian Academy of Sciences (Topic No. 122021000095-0).

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Received May 5, 2022.
Received in revised form August 9, 2022.