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MOSSES OF KOSTOMUKSHA CITY (REPUBLIC OF KARELIA, RUSSIA)

МХИ ГОРОДА КОСТОМУКШИ (РЕСПУБЛИКА КАРЕЛИЯ, РОССИЯ)

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Abstract

Kostomuksha was founded in 1983; it is the youngest city in the Republic of Karelia. The paper summarizes the results of a long-term inventory of mosses. An annotated list contains 150 species occurring in the city area, including four arbitrary zones: residential, forest, mire and water. Mosses in the disturbed habitats of the industrial zone are also discussed. The moss flora of Kostomuksha is compared with that of Kostomuksha Strict Nature Reserve, showing minor changes in moss species diversity due to anthropogenic transformations. Thus, moss populations in the north-taiga subzone of European Russia are well preserved in Kostomuksha.

Резюме

Костомукша – самый молодой город Республики Карелия (основан в 1983 г.). В статье обобщены результаты многолетней инвентаризации мхов. Аннотированный список насчитывает 150 видов, встречающихся на территории города, включая четыре условные зоны: жилая, лесная, болотная и водная. Рассматриваются и мхи нарушенных местообитаний в промышленной зоне. Флора мхов г. Костомукша сравнивается с таковой заповедника «Костомукшский», показывая весьма незначительные изменения видового разнообразия мхов из-за антропогенных преобразований. Таким образом, г. Костомукша хорошо сохраняет популяции мхов в северотаежной подзоне европейской России.

KEYWORDS: annotated list, bryoflora, city, nature reserve, species

INTRODUCTION

In 1946, near the Lake Kostomukshskoye and Kostomuksha village which was completely destroyed during the war in 1941–1945, an iron deposit was discovered. In 1967, it was decided to build an iron concentration plant (ICP), and in 1982–1984 the plant was put in operation. The Kostomuksha village was flooded and the Lake Kostomukshskoye turned into a tailings dump. The construction of a town on the shore of Lake Kontokki, 13 km SW of the plant, formerly occupied by Kontokki village, was launched. In 1983, the town was granted a city status. The operation of the ICP and the growth of Kostomuksha city made nature protection in the area an acute problem. Therefore, in 1983, the Kostomuksha State Nature Reserve (KSNR) was established 25 km SW of the city to protect a typical fragment of European Russia's north-taiga subzone (Belousova *et al*., 1988).

Information on mosses of Kostomuksha city was collected gradually. Three species (*Dicranum spurium, Meesia triquetra,* and *Ulota curvifolia*) were recorded in the monograph "Mosses of Fennoscandia" (Brotherus, 1923) for Kontokki village (now the western part of Kostomuksha city). In the study of vegetation cover in the surroundings of Lake Kontokki, 12 species were found (Yurkovskaya, 1974). In 1972–1974, studies conducted by the Kostomuksha Expedition of the Karelian Branch of the USSR Academy of Sciences led by I.M. Nesterenko to assess natural resources near the Kostomuksha iron deposit, revealed 27 species (Elina & Kuznetsov, 1977). In 1995 and 1998, the author found 98 species outside of Kostomuksha's residential area (Boychuk, 2001). The aim of the article was to re-assess the old data, to add a new data on Kostomuksha's mosses, to summarise and to compare them with those for KSNR.

MATERIAL AND METHODS

The City of Kostomuksha (64°35'N, 30°36'E) is located in the northwestern Republic of Karelia, near the Russian-Finnish border (Fig. 1), and is a part of the Kostomuksha City District. The city covers an area of 41.5 km^2 and has a population of 30131 (2024).

Geologically, the city lies in the eastern Fennoscandian (Baltic) Shield. It consists mainly of Archean felsic rocks, such as gneisses, granites, granodiorites and tonalites (Gorkovets *et al*., 1981). The crystalline basement is overlain by Quaternary rocks (gravel-sandy moraine) and is exposed locally.

Kostomuksha lies on the northern West Karelian Upland. A denudation-tectonic (ridge-hilly to ridge) type of relief at an altitude of 150 to 300 m a.s.l. prevails (Filatov, 2021).

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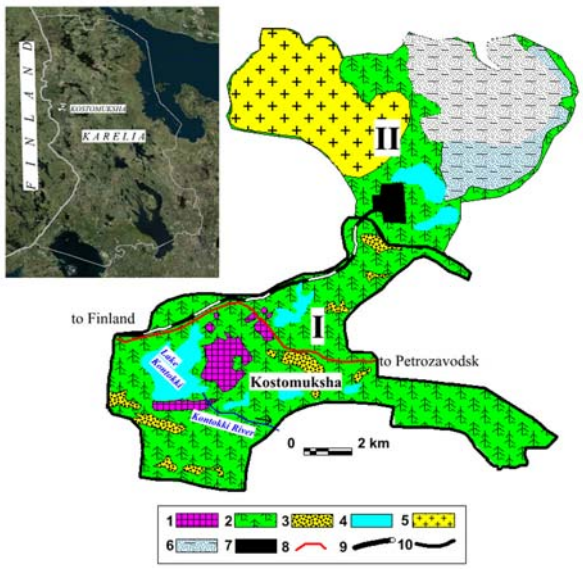

Fig. 1. Arbitrary zones of the study area.
I – Kostomuksha city: 1 – residential zone (**R**), 2 – forest zone (**F**), 3 – mire zone (**M**), 4 – water zone (**W**); **II –** industrial zone: 5 – open-pit mine, 6 – tailings dump, 7 – ICP.
8 – highways, 9 – railways, 10 – city precincts.

Kostomuksha has a temperate continental climate. Its mean annual temperature is +1.1°C (Salo, 1997). The coldest month is January (–12.6°C) and the warmest month is July (+15.8°C). Mean annual precipitation is 540 mm. Snow cover persists for 175 days. South-westerly winds predominate.

The soil cover is heterogeneous. Illuvial-ferrous humic soils, combined with mire-podzols, prevail (Fedorets *et al*., 2003). The trampling of the soil in the city results in soil degradation.

The main water body is Lake Kontokki. The central residential area is on its east shore. This oligotrophic lake has a high-quality water (Filatov & Kukharev, 2013). Flowing from the lake is the River Kontokki. The Lake Sapozhok and some minor streams are also within the city precincts.

The city area was covered earlier by pine-dominated forests (Shcherbakov *et al*., 1977). According to the project "a city in the forest" (Ilyukha *et al*., 1997), 1000 hectares of forest remained unaffected by the construction. Spruce stands are present. Birch and aspen stands occur locally. Depressions between ridges are occupied by small mires dominated by ring aapa and mesotrophic grass-sphagnum mires (Elina & Kuznetsov, 1977).

According to the geobotanical zoning (Aleksandrova & Yurkovskaya, 1989; Elina *et al*., 2000), Kostomuksha's territory is a north-taiga subzone and part of the West Karelian Geobotanical District of the Kola-Karelian Subprovince of the North European Province of the Eurasian Taiga Zone. According to Karelia's floristic zoning (Ramenskaya, 1960), this territory is a part of the Kuitozero-Leksozero floristic province.

The city is affected by ICP, a major source of environmental pollution in Karelia (Gromtsev *et al*., 2023). Sulphur dioxide and industrial dust containing heavy metals are major pollutants. The impact zone with a radius of up to 12 km is actively polluted by gas and dust. Elevated Fe, Pb, Cr, Ni concentrations in *Hylocomium splendens* growing in the impact zone were reported (Fedorets *et al*., 2008). The application of bioindication methods, e.g. a paleoindication approach, etc. (Erokhina *et al*., 2011), has shown that ICP emission does not considerably affect Kostomuksha's natural environment. The construction of the city (a residential zone) 13 km away from the plant with regard for the wind rose and the preservation of the maxium number of forest fragments has made Kostomuksha the greenest and cleanest city of Karelia.

The present study was based on the identification of 800 moss samples collected by the author in Kostomuksha in 2010–2012, 2020, 2022 and 2024, and on the revision of "old" (mainly personal) moss samples kept in the KarRC RAS Herbarium (PTZ). The relevant literature (Brotherus, 1923; Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001; Sofronova *et al*., 2023) was also taken into account. Kostomuksha was arbitrarily divided into four zones (Fig. 1): **R** – a residential zone (yards, roads, grass plots and wasteland), **F** – a forest zone (urban forests, forest parks, parks and public gardens), **M** – a mire zone (mires of various types), **W** – a water zone (Kontokki and Sapozhok lake shores, the Kontokki River bank, as well as rivers and streams). The author also discusses the ICP territory: **I** – an indistrial zone (near the open-pit mine, near the tailings dump, near the administration building and overburden dumps). Mosses growing on natural, anthropogenic and artificial substrates were collected.

ANNOTATED LIST

The species names are followed by literature references, frequency, distribution in five arbitrary zones (Fig. 1), habitat type, and substrate. The names of moss species are given according to Hodgetts *et al*. (2020).

Moss species not recorded previously in Kostomuksha City are marked with asterisk.

Amblystegium serpens (Hedw.) Schimp. – Boychuk, 2001. Not rare. **R:** roadsides, yards. On asphalt, concrete slabs, stairs, monument pedestals.

Andreaea rupestris Hedw. – Boychuk, 2001. Not rare. **R:** roadsides, meadows; **F:** pine and spruce forests; **W:** Kontokki Lake shore. On boulders and rock outcrops.

Aongstroemia longipes (Sommerf.) Bruch & Schimp. – Sofronova *et al*., 2023. Rare. **I:** near the tailings dump, on a site filled with pulp.

Atrichum tenellum (Röhl.) Bruch & Schimp. – Boychuk, 2001. Sporadic. **R:** roadsides, wet ditches. On soil.

Aulacomnium palustre (Hedw.) Schwägr. – Elina & Kuznetsov, 1977; Boychuk, 2001. Frequent. **R:** wet meadows; **F:** paludified forests; **M:** bogs, poor and rich fens, aapa; **W:** river banks and lake shores; **I:** near the tailings dump, overburden dumps. On soil.

Bartramia pomiformis* Hedw. – Rare. **F: spruce forest. On bedrock exposures.

Brachythecium albicans (Hedw.) Schimp. – Boychuk, 2001. Not rare. **R:** lawns, wastelands, dry meadows. On soil, boulders, concrete slabs, and monument pedestals.

B. mildeanum* (Schimp.) Schimp. – Rare. **W: brook bank. On soil.

B. rivulare* Schimp. – Sporadic. **M: fens; **W:** springs. On soil.

B. salebrosum (Hoffm. ex F. Weber & D. Mohr) Schimp. – Boychuk, 2001. Frequent. **R:** lawns, yards, dry meadows; **F:** mixed, birch and aspen forests; **W:** lake shores and river banks; **I:** near the administration building. On asphalt, concrete slabs, manhole covers, on soil, boulders and bedrock exposures, rotting wood, at the base of tree trunks.

Bryum argenteum Hedw. – Boychuk, 2001. Not rare. **R:** yards, walls, lawns, dry meadows. On soil, asphalt, concrete slabs.

Callicladium haldaneanum* (Grev.) H.A. Crum – Rare. **W: Kontokki Lake shore. On soil and boulders.

Calliergon cordifolium (Hedw.) Kindb. – Boychuk, 2001. Not rare. **F:** paludified forests; **W:** lake shores and river banks. On soil.

C. richardsonii (Mitt.) Kindb. – Boychuk, 2001. Sporadic. **F:** paludified spruce forests; **W:** springs, streams. On soil.

Calliergonella cuspidata (Hedw.) Loeske – Boychuk, 2001. Rare. **W:** stream bank, spring. On soil.

C. lindbergii (Mitt.) Hedenäs – Boychuk, 2001. Not rare. **W:** lake shores and river banks. On soil, boulders, rotting wood, at the base of tree trunks and protruding roots.

Campyliadelphus elodes* (Lindb.) Kanda – Rare. **W: the River Kontokki, on boulder in water.

Campylium protensum (Brid.) Kindb. – Boychuk, 2001. Sporadic. **W:** Kontokki Lake shore. On soil, rotting wood.

C. stellatum (Hedw.) Lange & C.E.O. Jensen – Boychuk, 2001. Not rare. **M:** fens and aapa mires; **W:** lake shores and river banks, streams. On soil, rotting wood.

Ceratodon purpureus (Hedw.) Brid. – Boychuk, 2001. Frequent. **R:** lawns, yards, walls, dry meadows, roadsides; **F:** pine forests; **W:** Kontokki Lake shore and the River Kontokki bank; **I:** near the open-pit mine, the tailings dump, overburden dumps. On asphalt, concrete slabs and monument bases, on walls and roofs of houses, on soil, boulders and bedrock exposures, rotting wood, at the base of tree trunks, protruding roots and uprooted trees.

Climacium dendroides* (Hedw.) F. Weber & D. Mohr – Sporadic. **W: lake shores. On soil, boulders.

Cynodontium strumiferum (Hedw.) Lindb. – Boychuk, 2001. Sporadic. **R:** roadsides, dry meadows; **F:** pine forests. On boulders and bedrock exposures.

Dichelyma falcatum (Hedw.) Myrin – Boychuk, 2001. Not rare. **W:** lake shores and river banks. On wet boulders.

Dicranella cerviculata (Hedw.) Schimp. – Boychuk, 2001. Sporadic. **F:** spruce forest; **W:** Kontokki Lake shore; **I:** near the tailings dump, overburden dumps. Under a windfallen spruce tree, on wet soil.

D. subulata (Hedw.) Schimp. – Boychuk, 2001. Frequent. **R:** roadsides, yards, ditches, dry meadows; **F:** spruce forest; **W:** Kontokki Lake shore and the River Kontokki bank. On soil, under a windfallen spruce.

Dicranum bonjeanii De Not. – Boychuk, 2001. Sporadic. **M:** fens. On soil.

D. flexicaule Brid. – Boychuk, 2001. Not rare. **F:** pine and spruce forests. On soil, boulders and bedrock exposures.

D. fuscescens Sm. – Boychuk, 2001. Frequent. **F:** pine and spruce forests. On rotting wood, boulders, at the base of tree trunks.

D. majus Sm. – Boychuk, 2001. Not rare. **F:** spruce and mixed forests. On soil.

D. montanum Hedw. – Boychuk, 2001. Not rare. **F:** spruce forests. On boulders and exposures of bedrock, at the base of tree trunks and protruding roots.

D. polysetum Sw. – Boychuk, 2001. Frequent. **F:** coniferous and mixed forests. On soil.

D. scoparium Hedw. – Boychuk, 2001. Frequent. **R:** lawns, meadows, roadsides; **F:** forests of various types; **W:** Kontokki Lake shore. On soil, rotting wood, boulders and bedrock exposures, at the base of tree trunks and on protruding tree roots.

D. spurium Hedw. – Brotherus, 1923.

D. undulatum Schrad. ex Brid. – Boychuk, 2001. Not rare. **M:** bogs. On soil.

Didymodon fallax* (Hedw.) R.H. Zander – Rare. **R: old stadium, on a concrete structure.

Ditrichum heteromallum (Hedw.) E. Britton – Boychuk, 2001. Sporadic. **R:** roadsides. On soil.

Drepanocladus aduncus (Hedw.) Warnst. – Elina & Kuznetsov, 1977. Sporadic. **M:** fens and aapa mires. On soil.

D. polygamus (Schimp.) Hedenäs – Boychuk, 2001. Sporadic. **W:** Kontokki Lake shore and the River Kontokki bank. On soil and boulders.

Fissidens adianthoides* Hedw. – Sporadic. **W: the River Kontokki bank. On boulders, rooting wood.

F. osmundioides Hedw. – Boychuk, 2001. Not rare. **W:** the River Kontokki bank, brooks. On boulders, rotting wood.

Flexitrichum flexicaule* (Schwägr.) Ignatov & Fedosov – Rare. **R: small hydraulic structure, on a concrete slab.

Fontinalis antipyretica Hedw. – Boychuk, 2001. Rare. **W:** the River Kontokki. On wet boulders (rapids).

F. dalecarlica Schimp. – Boychuk, 2001. Sporadic. **W:** the River Kontokki. On wet boulders (rapids).

Funaria hygrometrica* Hedw. – Sporadic. **I: near the open-pit mine, overburden dumps. On soil.

Grimmia longirostris* Hook. – Sporadic. **W: Kontokki Lake shore. On boulders.

Hedwigia ciliata* (Hedw.) P. Beauv. – Sporadic. **F: coniferous forests. On bedrock exposures.

H. mollis* Ignatova, Ignatov & Fedosov – Sporadic. **F: coniferous forests. On bedrock exposures.

Helodium blandowii (F. Weber & D. Mohr) Warnst. – Boychuk, 2001. Rare. **M:** fens. On soil.

Hylocomiadelphus triquetrus (Hedw.) Ochyra & Stebel – Boychuk, 2001. Not rare. **F:** spruce and mixed forests. On the soil, boulders, at the base of tree trunks.

Hylocomiastrum pyrenaicum (Spruce) M. Fleisch. – Boychuk, 2001. Rare. **F:** paludified spruce forest. On boulder.

Hylocomium splendens (Hedw.) Schimp. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Frequent. **F:** forests of various types. On soil, boulders and bedrock exposures, at the base of tree trunks.

Hymenoloma crispulum (Hedw.) Ochyra – Boychuk, 2001. Not rare. **F:** spruce and mixed forests; **W:** Kontokki Lake shore and the River Kontokki bank. On boulders and bedrock exposures.

Leptobryum pyriforme (Hedw.) Wilson – Boychuk, 2001. Sporadic. **W:** the River Kontokki bank; **I:** near the open-pit mine, tailings dump. On soil.

Leptodictyum riparium (Hedw.) Warnst. – Boychuk, 2001. Not rare. **W:** Kontokki and Sapozhok lake shores, the River Kontokki bank, streams. On soil, boulders, rotting wood.

Lescuraea radicosa (Mitt.) Monk. – Boychuk, 2001. Sporadic. **R:** dry meadow, în boulder.

Lewinskya elegans* (Schwägr. ex Hook. & Grev.) F. Lara, Garilleti & Goffinet – Sporadic. **R: lawns; **F:** grassy aspen. On the bark of poplar, aspen.

Loeskypnum badium (Hartm.) H.K.G. Paul – Boychuk, 2001. Sporadic. **M:** fens and aapa mires. On soil.

Meesia triquetra (L. ex Jolycl.) Ångstr. – Brotherus, 1923.

Nyholmiella obtusifolia* (Brid.) Holmen & E.Warncke – Sporadic. **R: lawns, squares; **F:** grassy aspen. On the bark of poplar and aspen.

Oligotrichum hercynicum (Hedw.) Lam. & DC. – Boychuk, 2001. Rare. **R:** roadside. On soil.

Oncophorus wahlenbergii Brid. – Boychuk, 2001. Sporadic. **W:** Kontokki Lake shore, streams. On soil, rotting wood, boulder.

Paludella squarrosa (Hedw.) Brid. – Elina & Kuznetsov, 1977; Boychuk, 2001. Sporadic. **M:** fens. On soil.

Paraleucobryum longifolium* (Hedw.) Loeske – Not rare. **F: coniferous forests; **W:** Kontokki Lake shore. On boulders and rock outcrops.

Philonotis fontana (Hedw.) Brid. – Boychuk, 2001. Not rare. **W:** Kontokki lake shores; **I:** near the tailings dump. On soil.

Plagiomnium cuspidatum* (Hedw.) T.J. Kop. – Sporadic. **R: lawns, roadsides. On boulders, concrete slabs, metal hatches.

P. ellipticum (Brid.) T.J. Kop. – Boychuk, 2001. Sporadic. **R:** wet meadows; **M:** fens. On soil.

Plagiothecium denticulatum* (Hedw.) Schimp. – Sporadic. **F: coniferous and small-leaved forests. On the bases of tree trunks and protruding roots.

P. rossicum* Ignatov & Ignatova – Frequent. **F: coniferous and small-leaved forests. On rotting wood, boulders and exposures of bedrock, at the base of tree trunks and protruding roots.

Platyhypnum alpestre (Hedw.) Ochyra – Boychuk, 2001. Rare. **W:** the bank of small river flowing into Kontokki Lake. On boulders in the water (rapids).

Pleurozium schreberi (Willd. ex Brid.) Mitt. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Frequent. **R:** roadsides, parks; **F:** forests of various types; **M:** bogs; **W:** lake shores and river banks; **I:** near the tailings dump, overburden dumps. On soil, rotting wood, boulders and rock outcrops, at the base of tree trunks.

Pogonatum dentatum (Menzies ex Brid.) Brid. – Boychuk, 2001. Sporadic. **R:** roadsides; **F:** blueberry spruce forest; **I:** overburden dumps. On soil, bedrodk exposures, under a windfallen spruce tree.

P. urnigerum (Hedw.) P. Beauv. – Boychuk, 2001. Frequent. **R:** roadsides, wastelands. On soil, boulders and rock outcrops.

Pohlia bulbifera (Warnst.) Warnst. – Boychuk, 2001. Not rare. **R:** damp ditches and roadsides; **W:** Kontokki Lake shore, streams. On soil.

P. cruda* (Hedw.) Lindb. – Sporadic. **F: spruce forests. On tree butts, exposures of bedrock.

P. nutans (Hedw.) Lindb. – Boychuk, 2001. Frequent. **R:** roadsides, lawns, yards; **F:** forests of various types; **M:** bogs; **W:** lake shores and river banks; **I:** near the open-pit mine, the tailings dump. On soil, rotting wood, boulders and rock outcrops, uprooted trees, bases of trunks and protruding tree roots.

Polytrichastrum alpinum* (Hedw.) G.L. Sm. – Sporadic. **F: pine and spruce forests. On rock outcrops.

Polytrichum commune Hedw. – Yurkovskaya, 1974. Frequent. **R:** damp ditches, wet meadows; **F:** spruce forests; **W:** Kontokki Lake shore, the River Kontokki bank, streams. On soil.

P. juniperinum Hedw. – Boychuk, 2001. Frequent. **R:** roadsides, lawns, wastelands, clearings; **F:** coniferous and small-leaved forests; **I:** overburden dumps. On soil, boulders and rock outcrops, on a windfallen trees.

P. longisetum* Sw. ex Brid. – Not rare. **F: paludified spruce forests; **M:** fens; **W:** lake shores and river banks. On soil.

P. piliferum* Hedw. – Not rare. **R: lawns, wastelands; **F:** pine forests. On soil, boulders and rock outcrops.

P. strictum Menzies ex Brid. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977. Not rare. **M:** bogs. On soil.

Pseudobryum cinclidioides (Huebener) T.J. Kop. – Boychuk, 2001. Sporadic. **M:** fens; **W:** stream banks. On soil.

Ptilium crista-castrensis (Hedw.) De Not. – Boychuk, 2001. Not rare. **F:** coniferous and mixed forests. On soil, boulders.

Ptychostomum creberrimum (Taylor) J.R. Spence & H.P. Ramsay – Boychuk, 2001. Not rare. **R:** lawns, wastelands, roadsides; **I:** near the open-pit mine. On soil.

P. inclinatum (Sw. ex Brid.) J.R. Spence – Boychuk, 2001. Sporadic. **R:** roadsides. On soil.

P. pallens (Sw. ex anon.) J.R. Spence – Boychuk, 2001. Sporadic. **R:** roadsides. On soil.

P. pseudotriquetrum (Hedw.) J.R. Spence & H.P. Ramsay ex Holyoak & N. Pedersen – Boychuk, 2001. Not rare. **M:** fens; **W:** lake shores and river banks, streams and strings. On soil, boulders.

P. weigelii (Biehler) J.R. Spence – Boychuk, 2001. Sporadic. **W:** Kontokki Lake shore, the River Kontokki bank, springs. On soil.

Pylaisia polyantha* (Hedw.) Schimp. – Sporadic. **R: laws; **F:** aspen forests. On the bark of poplar and aspen.

Racomitrium canescens (Hedw.) Brid. – Boychuk, 2001. Not rare. **R:** wastelands, lawns, roadsides; **I:** near the open-pit mine, overburden dumps. On soil, boulders and outcrops.

R. microcarpon (Hedw.) Brid. – Boychuk, 2001. Frequent. **R:** roadsides, lawns, dry meadows; **F:** pine and spruce forests; **W:** Kontokki Lake shore; **I:** near the tailings dump, overburden dumps. On soil, boulders and rock outcrops.

Rhizomnium pseudopunctatum (Bruch & Schimp.) T.J. Kop. – Boychuk, 2001. Not rare. **R:** wet ditches; **F:** paludified forests; **M:** fens; **W:** lake shores and river banks. On soil.

R. punctatum (Hedw.) T.J. Kop. – Boychuk, 2001. Sporadic. **W:** lake shores, streams. On soil, rotten wood.

Rhytidiadelphus squarrosus (Hedw.) Warnst. – Boychuk, 2001. Sporadic. **R:** roadsides, dry meadows. On soil.

R. subpinnatus (Lindb.) T.J. Kop. – Boychuk, 2001. Sporadic. **F:** spruce forest near stream. On soil.

Sanionia uncinata (Hedw.) Loeske – Boychuk, 2001. Frequent. **R:** roadsides, lawns, yards, dry meadows; **F:** mixed and small-leaved forests; **W:** lake shores and river banks, streams; **I:** near the administration building, near the tailings dump. On soil, asphalt, concrete slabs, rotting wood, boulders and rock outcrops, at the base of tree trunks and protruding roots.

Sarmentypnum exannulatum (Schimp.) Hedenäs – Boychuk, 2001. Not rare. **M:** poor and rich fens; **W:** Sapozhok Lake shore, streams, springs. On soil.

S. procerum* (Renauld & Arnell) Hedenäs – Sporadic. **M: fens; **W:** the River Kontokki (in water).

S. sarmentosum (Wahlenb.) Tuom. & T.J. Kop. – Boychuk, 2001. Not rare. **M:** fens. On soil.

S. tundrae* (Arnell) Hedenäs – Rare. **W: Sapozhok Lake (in water).

Schistidium agasszii Sull. & Lesq. – Boychuk, 2001. Sporadic. **W:** the River Kontokki. On wet boulders (rapids).

S. apocarpum (Hedw.) Bruch & Schimp. – Boychuk, 2001. Frequent. **R:** yards, lawns, roadsides, meadows; **W:** Kontokki Lake shore and the River Kontokki bank. On concrete slabs, asphalt, metal manholes, boulders and rock outcrops.

Schistostega pennata (Hedw.) F. Weber & D. Mohr – Boychuk, 2001. Rare. **F:** blueberry spruce forest. On a windfallen spruce trees.

Sciuro-hypnum curtum* (Lindb.) Ignatov – Not rare. **F: mixed and small-leaved forests. On the soil, boulders, at the base of tree trunks.

S. plumosum* (Hedw.) Ignatov & Huttunen – Sporadic. **W: Kontokki Lake shore. On boulders.

S. populeum* (Hedw.) Ignatov & Huttunen – Rare. **R: old stadium, on a concrete slab.

S. reflexum (Starke) Ignatov & Huttunen – Boychuk, 2001. Frequent. **R:** lawns, yards, dry meadows; **F:** mixed and birch forests. On concrete slabs and monument pedestals, rotting wood, boulders, at the base of tree trunks and protruding tree roots.

S. starkei (Brid.) Ignatov & Huttunen – Boychuk, 2001. Sporadic. **F:** spruce forests. On rotting wood, at the base of tree trunks.

Scorpidium revolvens (Sw. ex anon.) Rubers – Boychuk, 2001. Not rare. **M:** poor and rich fens; **W:** Kontokki and Sapozhok lakes and the River Kontokki bank. On soil, wet boulders and rotting wood.

S. scorpioides (Hedw.) Limpr. – Elina & Kuznetsov, 1977; Boychuk, 2001. Sporadic. **M:** fens; **W:** Sapozhok Lake (in water).

Sphagnum angustifolium (C.E.O. Jensen ex Russow) C.E.O. Jensen – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Frequent. **M:** bogs, poor and rich fens. On soil.

S. aongstroemii C. Hartm. – Boychuk, 2001. Sporadic. **M:** poor fens. On soil.

S. balticum (Russow) C.E.O. Jensen – Elina & Kuznetsov, 1977; Boychuk, 2001. Sporadic. **M:** bogs. On soil.

S. capillifolium (Ehrh.) Hedw. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** bogs. On soil.

S. centrale C.E.O. Jensen – Boychuk, 2001. Not rare. **M:** fens; **W:** Kontokki and Sapozhok lakes. On soil.

S. compactum Lam. & DC. – Boychuk, 2001. Sporadic. **M:** bogs. On soil.

S. contortum Schultz – Elina & Kuznetsov, 1977. Not rare. **M:** rich fens; **W:** Kontokki and Sapozhok lakes. On soil.

S. cuspidatum Ehrh. ex Hoffm. – Boychuk, 2001. Rare. **M:** bogs. On soil.

S. divinum* Flatberg & Hassel – Not rare. **M: bogs, poor fens and aapa mires. On soil.

S. fallax (H. Klinggr.) H. Klinggr. – Elina & Kuznetsov, 1977; Boychuk, 2001. Sporadic. **R:** damp roadside ditches; **M:** poor fens. On soil.

S. fimbriatum Wilson – Boychuk, 2001. Sporadic. **W:** shores of small rivers. On soil.

S. flexuosum Dozy & Molk. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Rare. **M:** poor fens; **W:** Sapozhok Lake shore. On soil.

S. fuscum (Schimp.) H. Klinggr. – Yurkovskaya, 1974; Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** bogs. On soil.

S. girgensohnii Russow – Yurkovskaya, 1974; Elina & Kuznetsov, 1977. Sporadic. **F:** spruce and mixed forests. On soil.

S. inundatum Russow – Boychuk, 2001. Rare. **W:** Kontokki Lake shore. On soil.

S. jensenii H. Lindb. – Elina & Kuznetsov, 1977. Sporadic. **M:** poor fens. On soil.

S. lindbergii Schimp. – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** bogs. On soil.

S. majus (Russow) C.E.O. Jensen – Elina & Kuznetsov, 1977. Not rare. **M:** bogs. On soil.

S. obtusum* Warnst. – Rare. **M: fens. On soil.

S. papillosum Lindb. – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** poor fens and aapa mires. On soil.

S. platyphyllum (Lindb. ex Braithw.) Warnst. – Boychuk, 2001. Not rare. **M:** fens; **W:** the River Kontokki bank, streams. On soil.

S. pulchrum (Lindb. ex Braithw.) Warnst. – Boychuk, 2001. Sporadic. **M:** poor fens. On soil.

S. quinquefarium (Braithw.) Warnst. – Boychuk, 2001. Sporadic. **F:** spruce forests. On soil.

S. riparium Ångstr. – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **R:** damp ditches; **M:** poor fens; **W:** lake shores, streams. On soil.

S. rubellum Wilson – Boychuk, 2001. Rare. **M:** bogs. On soil.

S. russowii Warnst. – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **F:** paludified forests; **M:** poor fens, aapa mires. On soil.

S. squarrosum Crome – Yurkovskaya, 1974; Elina & Kuznetsov, 1977. Not rare. **W:** lake shores and river banks, streams. On soil.

S. subfulvum Sjors – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** rich fens and aapa mires; **W:** lake shores. On soil.

S. subsecundum Nees – Elina & Kuznetsov, 1977; Boychuk, 2001. Not rare. **M:** fens, aapa mires; **W:** lake shores and river banks, streams. On soil.

S. teres (Schimp.) Ångstr. – Yurkovskaya, 1974. Sporadic. **M:** fens and aapa mires; **W:** lake shores. On soil.

S. warnstorfii Russow – Elina & Kuznetsov, 1977. Not rare. **M:** fens and aapa mires. On soil.

S. wulfianum Girg. – Boychuk, 2001. Sporadic. **F:** paludified spruce forests. On soil.

Splachnum ampullaceum Hedw. – Boychuk, 2001. Rare. **W:** Kontokki Lake shore. On rotten wood.

S. luteum Hedw. – Boychuk, 2001. Rare. **W:** the River Kontokki bank. On rotten wood.

Straminergon stramineum (Dicks. ex Brid.) Hedenäs – Boychuk, 2001. Not rare. **M:** poor and rich fens; **W:** streams, springs. On soil.

Streblotrichum convolutum* (Hedw.) P. Beauv. – Rare. **R: old stadium, on a concrete structure.

Tetrapis pellucida Hedw. – Boychuk, 2001. Not rare. **F:** coniferous and small-leaved forests. On rotten wood.

Tetraplodon mnioides (Hedw.) Bruch & Schimp. – Boychuk, 2001. Sporadic. **R:** shoulders of dirt roads; **W:** the River Kontokki bank. On soil, rooten wood.

Tomentypnum nitens (Hedw.) Loeske – Elina & Kuznetsov, 1977; Boychuk, 2001. Sporadic. **M:** fens. On soil.

Tortella tortuosa* (Hedw.) Limpr. – Sporadic. **F: blueberry spruce forest. On rock outcrops.

Ulota curvifolia (Wahlenb.) Lilj. – Brotherus, 1923.

Warnstorfia fluitans (Hedw.) Loeske – Boychuk, 2001. Not rare. **M:** bogs and poor fens; **W:** lake shores and river banks. On soil.

Species excluded

Critical check of the previous collections reveales erroneos records of five following species: *Scorpidium cossonii* (Elina & Kuznetsov, 1977), *Sphagnum magellanicum, Sarmentypnum trichophyllum, Warnstorfia pseudostraminea, Fontinalis squamosa,* and *Schistidium rivulare* (Boychuk, 2001).

DISCUSSION

Our studies show that moss flora of Kostomuksha city (41.5 km^2) includes 150 species, making up to 60% of the moss flora of Kuitozero-Leksozero floristic province (37 890 km^2, 250 species) and almost 30% of the moss flora of Karelia (492 760 km^2, 519 species: Volkova & Maksimov, 1993; Maksimov *et al*., 2003; with additions). Five species (*Didymodon fallax, Flexitrichum flexicaule, Sarmentypnum tundrae, Streblotrichum convolutum,* and *Tortella tortuosa*) are reported for the Kuitozero-Leksozero floristic province for the first time.

A comparison of the list of moss species of Kostomuksha (150 species) and KSNR (180 species: Boychuk, 2021), that is 10 times larger in area (492,8 km^2), shows a great similarity (132 common species), which seems to be due to their growing within the same north-taiga denudation-tectonic, hilly-ridge, mid-paludified landscape dominated by pine habitats (Gromtsev, 2000), and a special city design chosen for the maximal preservation of the natural environment. 18 species not recorded for KSNR (*Bryum argenteum, Calliergonella cuspidata, Didymodon fallax, Drepanocladus aduncus, Flexitrichum flexicaule, Hedwigia mollis, Hylocomiastrum pyrenaicum, Lescuraea radicosa, Oligotrichum hercynicum, Ptychostomum creberrimum, P. inclinatum, P. pallens, Sarmentypnum tundrae, Sciuro-hypnum populeum, Sphagnum aongstroemii, S. cuspidatum, Streblotrichum convolutum,* and *Tortella tortuosa*) were found in the city. Half of them grow in disturbed habitats. Specific species growing in KSNR (not found in the city) occur in old-growth forests mixed with aspen (e.g., *Campylidium sommerfeltii, Eurhynchiastrum pulchellum, Eurhynchium angustirete, Neckera pennata*), on mafic rocks (e.g., *Amphidium lapponicum, Grimmia torquata, Neckera oligocarpa*); on boulders along the shore of Lake Kamennoye (e.g., *Hygrohypnella ochracea, Pterigynandrum filiforme, Pseudoleskeella nervosa*), and on wet boulders (Tzar Rapid) in the River Kamennaya (e.g., *Blindia acuta, Hygroamblystegium fluviatile, Platyhypnum smithii*).

A comparison of the moss families from Kostomuksha (33 families) and KSNR (44) also shows a great similarity (32 common families). Only 1 family (Flexitrichaceae), not found in the KSNR, with 1 species, *Flexitrichum flexicaule*, was found in the city. It usually grows on carbonate soils, but in the city it was found on a concrete slab containing calcium. All of Karelia's leading families are represented in the bryoflora of the city, but with slightly less species than in KSNR: Sphagnaceae (32 species in Kostomuksha and 33 in KSNR), Dicranaceae (10, 14), Polytrichaceae (10, 10), Brachytheciaceae (10, 12), Amblystegiaceae (9, 11), Calliergonaceae (9, 11), Mniaceae (8, 14), Grimmiaceae (5, 8), Bryaceae (3, 5), and Pottiaceae (3, 2).

In the city residential area (**R**) 44 species are growing (for comparison, in KSNR 27 species grow in disturbed habitats, 26 of them are common with the city). These species were found mainly on sodded roadsides in **R**. Mosses in the residental area grow on artificial substrates. For example, *Amblystegium serpens*, *Brachythecium albicans,* and *Ceratodon purpureus* were found on asphalt; *Brachythecium salebrosum, Plagiomnium cuspidatum,* and *Schistidium apocarpum* grew on sewer manhole lids; *Brachythecium salebrosum, Sanionia uncinata,* and even the calciphile *Streblotrichum convolutum* were collected on concrete blocks. However, most species in the residential area occur in natural habitats. Some of them, e.g. *Bryum argenteum, Didymodon fallax, Oligotrichum hercynicum,* and *Streblotrichum convolutum* are resistant to human activities.

Fifty-three moss species were found in the city's forest zone (**F**) (in KSNR, 74 species are confined to the forest habitats, and 46 of them are common species with the forest zone of the city). This could be due to a special city design ("a city in forest" project), the presence of various forest types and a system of planting trees and bushes in addition to decorative trees and shrubs. Almost all of the species are known for KSNR. Seven species not found in KSNR grew in the city's spruce forest on various substrates, such as soil (*Rhytidiadelphus subpinnatus*), boulders and rock outcrops (*Hedwigia ciliata, Hylocomiastrum pyrenaicum, Hymenoloma crispulum,* and *Tortella tortuosa*) and wind-fallen spruce-trees (*Dicranella cerviculata, D. subulata*). In the city's forest zone, our studies have revealed 5 species (*Nyholmiella obtusifolia, Philonotis fontana, Pseudobryum cinclidioides, Sphagnum quiquefarium* and *S. wulfianum*) (9 in KSNR) indicative of biologically valuable forests in northwestern European Russia (Andersson *et al*., 2009).

The presence of 55 species in the city's mire zone (**M**) (74 mire species in KSNR, 46 of them common with the city) can be explained by the diversity of mire types and their natural (undrained) state. The mires of Kostomuksha have even more *Sphagnum* mosses (25 species) than in KSNR (23). The city exhibits lowland grass-mossy and exuberant aapa-mires (scarce in KSNR) that provide habitats for *Dicranum bonjeanii*, *Meesia triquetra, Ptychostomum pseudotriquetrum*, *Sarmenthypnum procerum*, *Scorpidium scorpioides, Sphagnum contortum,* and *S. platyphyllum.* The species of this group listed for KSNR were only found on lake shores and river banks.

The largest number of species (68) was registered in the city's water zone (**W**) (94 in KSNR, 59 of them common with the city), which is caused by a well-developed hydrographic network in Kostomuksha. Among them, There are some interesting species not found in KSNR, i.e. *Calliergonella cuspidata* and *Sarmentypnum tundrae*. Kontokki Lake shores in the residential area are affected by recreation (trampling, trimming, and garbage). They are colonized by mosses from disturbed habitats, such as *Brachythecium salebrosum, Ceratodon purpureus, Dicranella subulata,* and *Tetraplodon mnioides*; these species have not been found on the shore of Lake Kamennoye (the cleanest lake in Karelia).

Seventeen species resistant to industrial pollution were found in the industrial zone (**I**). Almost no mosses grow on the tailings dump shore, but they occur at some distance from the shore in the damp sink holes of willow-sedge communities (*Philonotis fontana*), on crushed stone (*Aulacomnium palustre, Pleurozium schreberi,* and *Dicranella cerviculata*), and on boulders (*Racomitrium microcarpon* and *R. canescens*). Mosses near the administration building (*Brachythecium salebrosum* and *Sanionia uncinata*) grow on grass plots, concrete structures and asphalt. *Pohlia nutans, Funaria hygrometrica, Leptobryum pyriforme,* and *Ptychostomum creberrimum* were found on soil and crushed stone at the viewing site of the open-pit mine. Piles of overburden dumps resemble artificial wasteland, but the pioneers *Ceratodon purpureus* and *Polytrichum juniperinum* find their way locally between lumps of crushed stone. In 2022, *Aongstroemia longipes* was found by the author on the shore of the tailings dump, on a pile of pulp in the industrial zone (Sofronova *et al.,* 2023). A visit to the site in 2024 revealed positive dynamics: the population increased in size and sporophtes were abundant. It is the only location of the species in Karelia. The species is protected in the neighbouring Murmansk (Konstantinova *et al*., 2014) and Leningrad Regions (Geltman, 2018).

One rare species (*Campyliadelphus elodes*), listed in the Red Data Book of Karelia (Kuznetsov, 2020) with category 3VU, was found in Kostomuksha. It grew on a wet boulder in the Kontokki River with a swift current. It is the 6th and northernmost locality of the species in Karelia (the 5th find was in KSNR). Seven species (*Campyliadelphus elodes, Fontinalis dalecarlica, Helodium blandowii, Meesia triquetra, Scorpidium scorpioides, Splachnum ampullaceum,* and *Tomentypnum nitens*) listed in the Red List of Europe (Hodgetts *et al*., 2019) were found within the city precincts.

Our studies revealed 150 species of mosses in the Kostomuksha city. A comparative analysis indicates that the bryoflora of Kostomuksha is a hardly transformed by anthropogenic impact variant of the bryophlora of Kostomuksha State Nature Reserve, i.e. the bryoflora of the north-taiga subzone in European Russia.

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