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Tapio Lindholm, Raimo Heikkilä and Marjo Heikkilä (eds.)

Ecosystems, fauna and flora of the Finnish-Russian Nature Reserve Friendship

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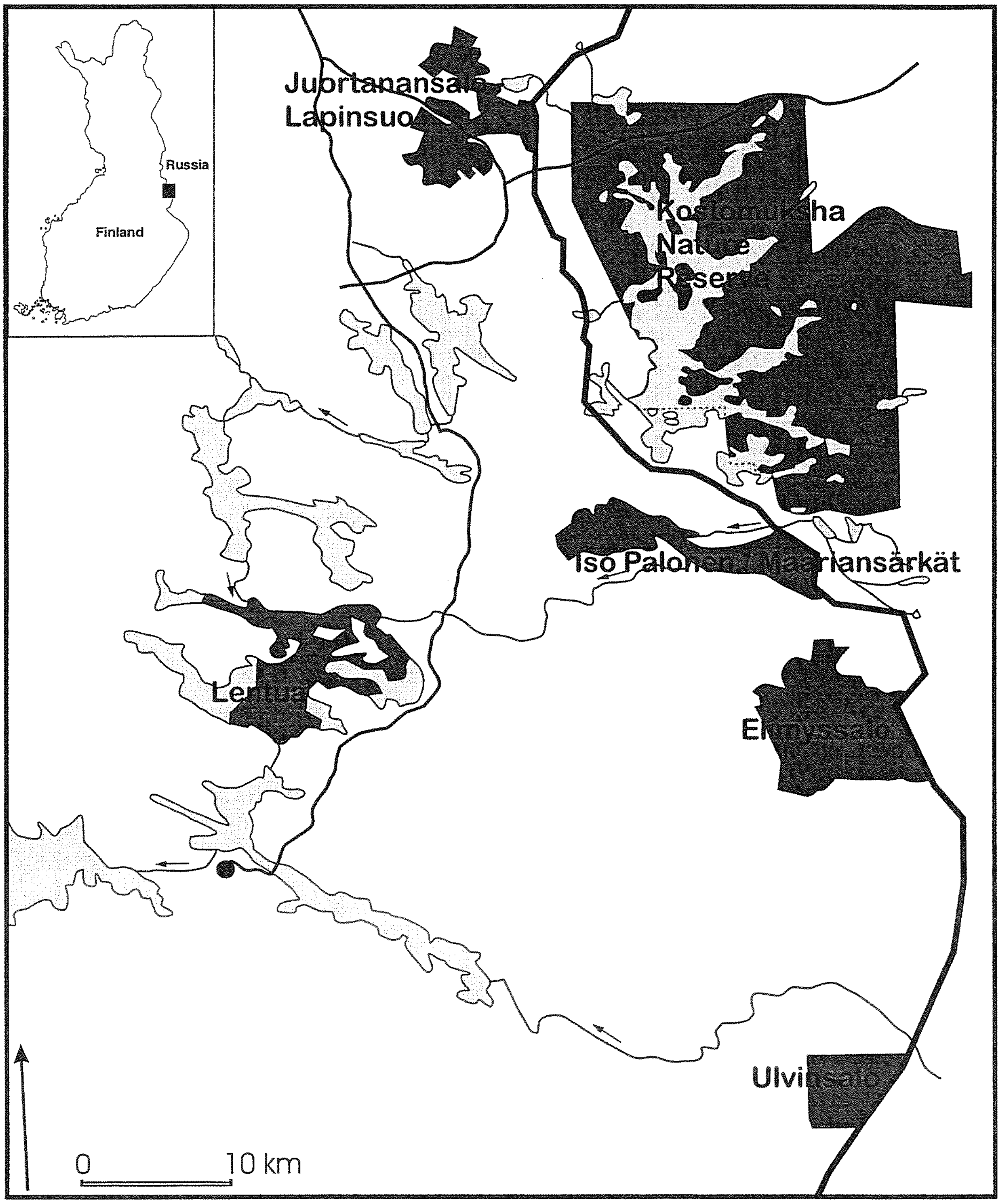
The Nature Reserve Friendship

The nature reserve Friendship consists of six different parts in Russia and Finland (Fig. 1). It was established in 1990 on the basis of an agreement signed by the presidents of Finland and the Soviet Union, Mauno Koivisto and Mihail Gorbachov in 1989.

On the Russian side there is Kostomuksha state nature reserve (zapovednik), which is strictly protected and reserved for ecological research. Tourists have been able to visit the reserve since 1995 on guided tours along eight routes. Earlier the reserve, established in 1984, was strictly closed for the public. Kostomuksha nature reserve covers c. 48 000 hectares including the large Lake Kiitehenjärvi (in Russian Ozero Kamennoye), pristine forests and small aapamires.

On the Finnish territory there are five nature reserves belonging to Friendship Park. Ulvinsalo strict nature reserve (2500 hectares) was established already in 1956 to protect a mosaic of pristine forests and small aapamires as well as small watercourses. It is reserved for ecological research and it is closed for the public. Juortanansalo mire reserve (2600 ha) was established in 1988 to protect relatively large aapamires and old forests between the mires. The following three nature reserves were established in connection with the establishment of Friendship Park in 1990. Elimyssalo nature reserve (7300 ha) is the largest nature reserve in the province of Kainuu. There are pristine forests, large diversity of small mires, and small lakes. Iso-Palonen - Maariansärkät nature reserve (4000 ha) consists of pine forests on eskers, and beautiful oligotrophic lakes with very clear water. Lentua nature reserve (5100 ha) contains a part of the largest unregulated lake in Kainuu, and some islands with pine forests.



Ecological research in the Nature Reserve Friendship

The Finnish-Russian research and nature conservation co-operation in the nature reserve Friendship started officially in 1990. It is based on two-year programmes ratified by the ministries of environment of Finland and Russia. However, research co-operation in the territory started much earlier. From mid-70s scientists from the University of Oulu in Finland and from the Biological Institute of the Karelian Research Centre have made joint research on the ecology of wild forest reindeer (*Rangifer tarandus fennicus*). Also in connection with the establishment of the town of Kostomuksha in the 70s, a lot of research on biodiversity was conducted by the different institutes of Karelian Research Centre. On the Finnish side extensive studies were made in the late 80s in connection with the planning of Friendship Park.

The coordinators of the research co-operation have been the Research Centre of Friendship Park on the Finnish side, and Kostomuksha Nature Reserve together with Karelian Research Centre on the Russian side. In addition, several universities and research institutes have participated the research co-operation. The most important partners in the research have been universities of Oulu, Helsinki, Turku and Joensuu, Finnish Environment Institute, Game and Fisheries Research Institute, the Kainuu Park Area of Forest and Park Service and Museum of Kainuu in Finland, Moscow state university and universities of Petrozavodsk and St. Peterburg in Russia.

The main topics of research have been surveys of ecosystems, fauna and flora in the early stages of the research co-operation. Also the environmental impacts of Kostomuksha iron mine and refinery have been studied intensively. In Kostomuksha Nature Reserve there is a station for all-european integrated monitoring. At this moment, the main directions in the research are the influence of land use, especially forestry, on biodiversity, and analyses of the functioning of ecosystems on biotope and landscape level. The research also aims to produce information needed to prepare a proposal to UNESCO to establish a World Heritage object in the so-called Green Belt along the Finnish-Russian boundary.

Finnish-Russian seminar on the research co-operation

To present the results of the first period of study, the first Finnish-Russian seminar of the research co-operation in the Nature Reserve Friendship was arranged in Kuhmo, 2-5 May, 1994. There were presented 19 lectures and 12 posters by 30 participants. In the seminar the presentations were partly based on recent results, but some presentations originated from the studies conducted in Kostomuksha in the 1970s. The chairmen of the sessions were Prof. Sergei Zjabtshenko, director of the Forest Research Institute of the Karelian Research Centre and dr. Tapio Lindholm from the Finnish Environment Institute. The languages of the seminar were Finnish and Russian with Aleksei Repin as interpreter.

On the basis of the seminar, altogether 37 manuscripts were received. The coordinators of collecting the material were Sergei Zjabtshenko, Evgeni Ieshko, Andrei Gromtsev and Oleg Kuznetsov in the Karelian Research Centre, Boris Kashevarov in the Kostomuksha Nature Reserve, and Raimo Heikkilä in the Research Centre of Friendship Park and Tapio Lindholm in the Finnish Environment Institute. All the manuscripts were reviewed by two referees, and after corrections the volume includes 30 articles. Part of the articles are strictly scientific, but some of them are more descriptive reports. As a whole they all contain a lot of interesting information about the biodiversity of the region, first time available in English.

In addition to the editors there are many persons who have made a lot of work to make this volume true. Ms. Marjut Hyvärinen is responsible for the technical editing of the publication. Ms. Pirjo Appelgrén has prepared the figures in the final form. Grigori Sokolov translated most of the articles by Russian authors into English. The coordinators who collected the manuscripts from the authors helped very much in the preparing of many articles. This publication is dedicated to the late Professor Sergei Zjabtshenko, who promoted many new subjects in the co-operation, initiated the arranging of the seminar, and very strongly influenced the preparing of this publication.

Geology of the Kostomuksha Nature Reserve

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Abstract

The territory of the Kostomuksha Nature Reserve, which lies in the Lake Kiitehenjärvi basin, provides a geological link between two well-known Late Archean greenstone belts: the Kuhmo-Suomussalmi belt in Finland and the Kostomuksha belt in Russian Karelia. The territory of the reserve is dominated by the oldest rocks on earth such as pre-3.15 Ga gneiss diorites, plagiogranites and tonalites which form a basement for Late Archean volcanic-sedimentary strata. Here, Late Archean supracrustal rocks are represented by tholeiite-series metabasalts and by an intensely reworked and boudinated dyke swarm understood as Late Archean basalts. All the above rocks are migmatized by 2.72-2.7 Ga plagiomicrocline and microcline granites and are cut by Proterozoic dolerite dyke bodies as well as pegmatite and quartz veins. It has been shown by analysing the geological structure of the Kuhmo-Suomussalmi belt, the Kostomuksha belt, the Vuokkiniemi block and other adjacent unites that the Kostomuksha Nature Reserve territory is a fragment of a unique type of tectonic structure observed in the rimmed domes formed at the Early Archean - Late Archean boundary. The central part of this fragment is composed of the oldest Lower Archean granulites, tonalites and various gneisses and are rimmed by Upper Archean supracrustal strata.

Key words: Geologigal structure, tectonic processes, late Archean supracrustal rocks

Introduction

Until 1993, only general data on the geological structure of the Kostomuksha Nature Reserve, were available. No geophysical (magnetic, gravimetric etc.) or medium- to large-scale geological maps were made. According to earlier workers (Anon. 1976; Sokolov 1987), the nature reserve territory was composed of integrated, completely indistinctive granitoid (gneissose granite, granite gneiss and migmatite) fields of uncertain age and genesis with problematic exposures of Lower Archean (Saamian) supracrustal and infracrustal rocks.

The geological study of Precambrian complexes conducted by the Institute of Geology, Karelian Research Centre, in the Kostomuksha Nature Reserve in 1993-1995 has shed light on the long and intricate evolution of this part of the Earth's crust from Lower Archean time until now.

Study area

The Kostomuksha Nature Reserve lies between two well-studied geological structures east of the Kuhmo-Suomussalmi greenstone belt extension (Hanski et al. 1983) and southwest of the Kostomuksha structure (Geology and metallogeny...1981). The study area consists of the oldest crustal rocks that form a basement for volcanic-sedimentary strata in Upper Archean greenstone belts. Presumably Early Archean gneiss diorites, plagiogranites, tonalite gneisess as well as basic volcanics (metamorphosed tholeiitic basalts) and highly altered and deformed rocks that make up Late Archean doleritic dykes are common here. All the before-mentioned rocks are migmatized by 2.72-2.7 Ga plagiomicrocline and microcline granites and cut by Proterozoic dolerite dyke bodies and pegmatite and quartz veins (Fig.1).

The absolute age determined for the Upper Archean strata of the Kostomuksha structure suggests that the basement rocks are pre - 3.15 Ga. The oldest rocks in the Kostomuksha Nature Reserve are gneiss diorites. They occur near the northwestern boundary of the reserve along the northeastern and, to a lesser extent, eastern shore of Lake Kiitehenjärvi. Gneiss diorites are dark-grey, relatiely coarse-grained rocks. Their gneissosity is due to the parallel orientation of platy biotite clusters. One can clearly see under the microscope that the rock was affected by tectonic processes that gave rise to its cataclastic structure. Elongated plagioclase plates are irregular and sometimes have cracks filled with fine quartz, plagioclase and biotite aggregate. Plagioclase contains secondary minerals dominated by zoisite.

Tonalites, traced in the central and northern part of the reserve, were intensely recrystallized in the course of tectonic movements. A large amount of epidote present in the rocks suggests considerable changes in plagioclase composition. The tonalites are migmatized by plagiomicrocline granites. Plagioclase gneissose granites are common in the southeastern part of the reserve. They cut gneiss diorites as indicated by gneiss diorite xenoliths with relict gneissosity found in them. The xenoliths are over 1,0 m in length and their diameter can be up to 0,5 m.

In plagiogranites, plagioclase has obscure rounded contours and is overfilled with secondary minerals (pelitized and seritized). The original granite structure has been altered by tectonic movements. Plagioclase grains are broken by cracks along which their fractions moved to form fine aggregate. Interstices between subtabular plagioclase grains are filled with small recrystallized quartz and plagioclase-biotite-epidote grains. The plagiogranites are migmatized by plagiomicrocline and microcline granites to various degrees.

The plagiogranites are cut by ca. five-meter thick metadolerite dykes. The metadolerites consist of hornblende, contain some plagioclase and a small amount of quartz and epidote. Metadolerite dykes are often boudinated. They are most abundant in the central part of the reserve, where they form a NE-trending dyke swarm.

The Late Archean rocks of the Kostomuksha greenstone belt occur as a wedging-out band and are represented by metamorphosed tholeiitic basalt pillow lava. The late Archean basaltic pillow lavas discussed are highly altered, recrystallized rocks in which new minerals, e.g. hornblende, plagioclase and quartz and new structure developed. Pillow contours are visible because their monomineral (hornblende) margins ("chill zones") are darker. In this case, the deformed lenticular pillows are oriented parallel to each other. They are up to 1,0 m long and 10-15 cm wide.

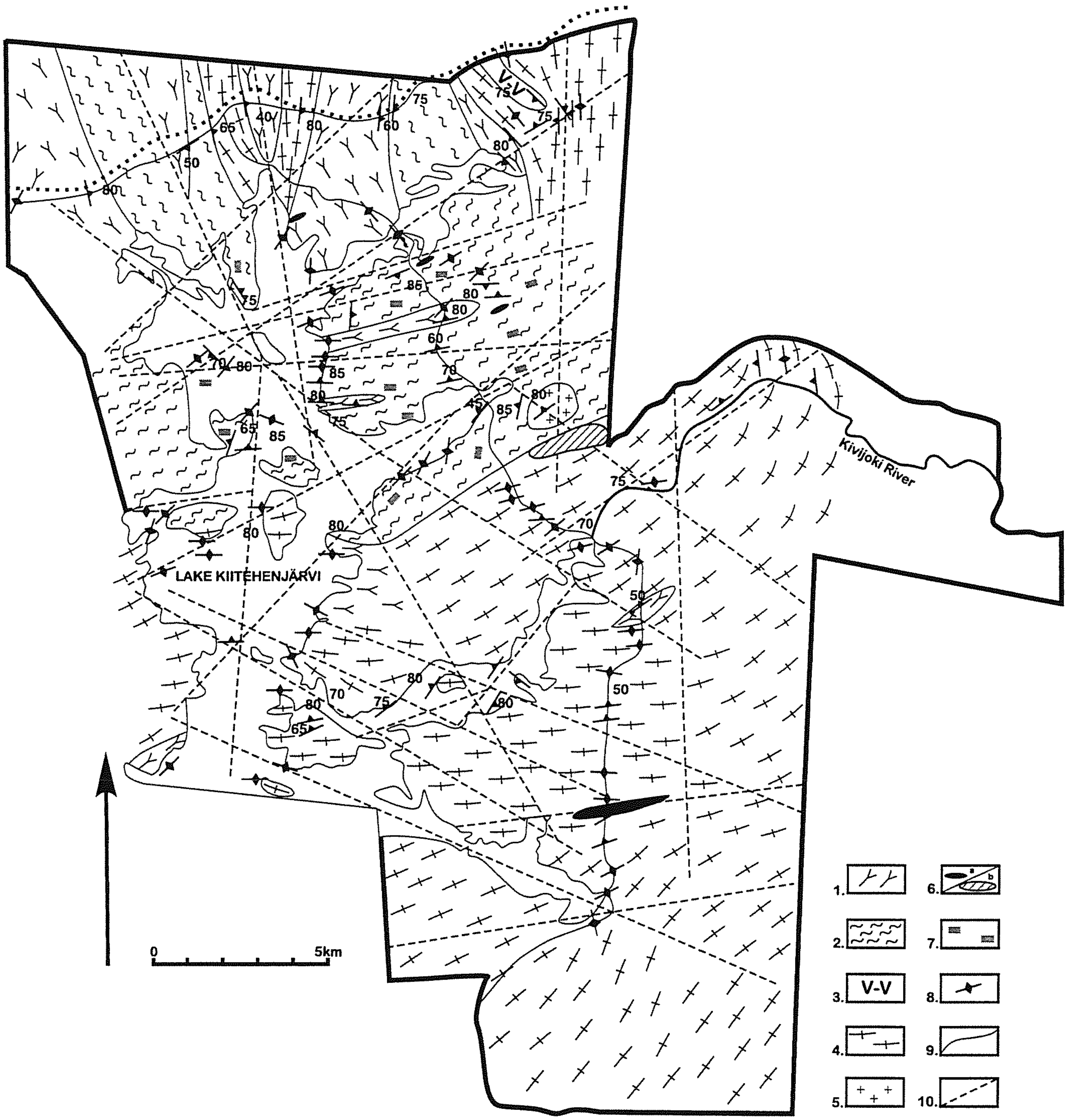

Fig. 1. Geological sketch map of the Kostomuksha Nature Reserve. (1 - gneiss diorites and gneiss granodiorites; 2 - migmatized tonalites; 3 - metamorphosed basaltic pillow lava; 4 - plagiogranites; 5 - plagiomicrocline granites; 6 - dolerites (a) and metadolerites (b); 7 - metadolerite dyke swarms; 8 - gneissosity; 9 - assumed rock boundaries; 10 - tectonic dislocations).

Younger, presumably Proterozoic strata are represented by dolerite dykes consisting of chaotically arranged, twinned basic plagioclase laths. The interstices between the laths are filled with monoclinic pyroxene, less commonly combined with ore mineral (titanomagnetite). Pegmatite and quartz veins, usually linearly elongated and unequally oriented, are the youngest crystalline rocks. The chemical composition of the crystalline rocks occurring in the reserve is shown in Tables 1 and 2.

Table 1. Chemical composition of crystalline rocks in the Kostomuksha Nature Reserve (wt %).

Oxides	1	2	3	4	5	6	7	8	9	10
SiO_2	72,7	68,66	60,3	60,1	47,6	68,56	59,6	63,38	43,88	50,58
TiO_2	0,16	0,32	0,54	0,58	0,58	0,27	0,6	0,38	0,96	0,85
Al_2O_3	15,02	12,85	16,36	18,42	14,04	14,96	16,84	16,2	22,88	18,25
Fe_2O_3	1,10	3,29	2,81	1,17	3,23	1,37	2,69	2,14	5,06	4,27
FeO	0,72	1,72	2,87	2,37	7,18	1,65	3,88	2,58	3,01	5,74
MnO	0,027	0,068	0,09	0,036	0,143	1,72	0,076	0,054	0,092	0,12
MgO	0,67	0,82	3,67	1,92	9,27	2,05	3,22	2,32	3,93	4,53
CaO	2,45	10,51	4,55	1,82	12,02	2,45	5,04	3,78	13,73	6,72
Na_2O	4,69	0,07	4,46	5,5	1,97	4,21	4,5	4,45	0,15	3,02
K_2O	1,72	0,2	2,96	6,86	0,62	3,58	2,08	3,2	2,5	3,33
H_2O	0,05	0,06	0,11	0,14	0,12	0,07	0,17	0,15	0,21	0,08
Losses on ignition	0,53	1,03	0,87	0,54	3,2	0,53	0,96	0,89	2,66	1,69
P_2O_5	0,07	0,18	0,33	0,26	0,07	0,15	0,31	0,22	0,49	0,45
LiO	0,002	0,0007	0,0048	0,0026	0,0015	0,0032	0,0046	0,0035	0,0033	0,0067
Rb_2O	0,0074	0,0011	0,0127	0,015	0,0017	0,0115	0,0089	0,0094	0,0165	0,0138
Cs_2O	0,0001	0,0001	0,0002	0,0001	0,0002	0,0002	0,0002	0,0002	0,0002	0,0004
ZnO	0,003	0,004	0,015	0,01	0,012	0,06	0,011	0,009	0,019	0,017
Total	99,91	99,78	99,92	99,71	100,04	99,89	99,96	99,74	99,55	99,63

Note: 1 = plagiogranite; 2 = metasomatic rocks; 3 = gneiss diorite; 4 = migmatite after tonalite; 5,10 = metadolerite from dyke; 6 = migmatite after gness diorite; 7,8 = migmatite after tonalite; 9 = tectonite.

Table 2. Amount of trace-elements in the crystalline rocks of the Kostomuksha Nature Reserve.

	Trace-elements, g/t						
N	Ni	Co	Cr	V	Mn	Ti	Cu
1	22	7	23	19	180	1000	12
2	26	10	45	62	500	2200	22
3	32	19	86	110	650	3600	12
4	25	10	25	38	240	3800	160
5	230	55	400	240	1200	3500	31
6	46	12	90	48	300	1800	12
7	32	16	53	95	520	3800	28
8	38	13	54	72	370	2800	15
9	70	24	90	110	780	6000	19
10	28	23	57	190	900	5400	42

Structural differences in Archean crystalline rocks suggested long and intricate structural evolution with multiple folding. A system of compositionally expressed planar elements such as migmatite banding, up to three gneissosities and mineral lineament after biotite and quartz was measured in bedrock exposures. The study of the planar elements has revealed migmatites and up to three gneissosity systems seen as the plane-parallel arrangement of biotite scales. The earliest gneissosity (S_1) observed in diorite gneisses strikes 25-35 NE and dips at steep to vertical angles. Subsequent gneissosity systems S_2 and S_3 revealed in tonalites and plagiogneissose granites, strike 60-65 NE and 300-325 NW, respectively. In some cases, submeridional gneissosity S_2, caused by tectonic movements in this direction, is apparent. Late planar elements such as gneissosity are emphasized in each outcrop by a system of quartz, quartz-feldspar and epidote veinlets.

One of the most striking features in the geological structure of the entire reserve is an abundance of cross-cutting rupture dislocations (paleodislocations) interpreted as evidence for vigorous tectonic processes. ca N-S-, ca. E-W, N-E and N-W trending dislocations are topographically distinct. They gave rise to groove-shaped depressions varying in width from several meters to a few hundred meters and bounded by subvertical scarps along their flanks. Tectonic dislocations are responsible for the elongation of lakes, river and creek channel bed patterns and the bizarre outlines of Lake Kiitehenjärvi bays.

Additional evidence for high tectonic activity was provided by petrographic investigations. Dynamo-metamorphic alterations are observed along fault zones in the rocks. In close proximity to tectonic dislocations, the amount of cataclastic material, finely dispersed at high pressure, increases sharpy. Plagioclase is replaced by muscovite and almost loses its contours and epidote content is observed to rise. Tectonites are formed here, and in the course of metasomatism some minerals are replaced by others with changes in their chemical composition caused, by rock-gas phase-solution interaction. Compositional changes are clearly shown by chemical analyses (Table 1.). The alkali content of the rocks declines, while their aluminium and calcium content increases rapidly.

Tectonic zones are fairly old. They remained active for a long period of time, as shown by the fact that basic rock dykes of different ages such as old and younger dolerites, microcline pegmatites and quartz veins are confined to them. Since rupture dislocations form a dense network, it is safe to assume that fault zones are easily permeable and that they serve as channels for migrating gases and juvenile water.

Geological mapping of the reserve, based on scattered boulder areas and some bedrock exposures found on the western shore of Lake Kiitehenjärvi, provide prerequisites for the discovery of Proterozoic complex in this area. The goal of further investigations is to delineate and study this structure.

Summary and conclusions

1. The territory of the Kostomuksha Nature Reserve consists dominantly of the oldest (Lower Archean) crustal rocks such as diorite gneisses, tonalites, plagiogranites and migmatites which form a basement for volcanic-sedimentary strata in Upper Archean greenstone belts.
2. Structural observations have revealed multiple, unequally intense deformations accompanied by tectonic processes responsible for the complex and bizarre configuration of Lake Kiitehenjärvi and its bays.
3. Boudinated metadolerite dyke swarms seem to form the intensely altered roots of feeder channels for Late Archean tholeiitic basalts that developed in the Kostomuksha and Kuhmo-Suomussalmi greenstone belts.
4. Analyses of available geological materials such as a) The geological structure of the Kostomuksha greenstone belt (Gorkovets et al. 1981; Volodichev & Golovanova 1991) and the Kuhmo-Suomussalmi greenstone belt (Hanski et al. 1983); b) Rock Assemblages in the Lower Archean Vuokkiniemi block (Lazarev & Kozhevnikov 1973; Sviridenko 1974); c) Late Archean volcanism (metabasalts and dolerite dyke swarms) small-scale gravimetric and magnetic maps have led us to conclude that the Kostomuksha Nature Reserve is a fragment of a unique type of tectonic rimmed domal structures (Fig. 2). This tectonic structure came to exist at the Early Archean-Late Archean boundary. Its characteristics differ from those of typical Late Archean rimmed granite domal structures (Condie 1983). The unique feature of the structure is that its central part is composed of the oldest Lower Archean infracrustal and supracrustal complexes such as granulites, tonalites and amphibole, pyroxene and mica-alumina gneisses rimmed by a concentric (circular) and radial system of long-lived tectonic zones along which magmatics of different ages and compositions intruded. The goal of further investigations is to study the reserve territory and adjacent areas in more detail and to determine the age of various rock complexes. Such data are needed to tie the Early Precambrian complexes of the study area more accurately to the stratigraphic scale.

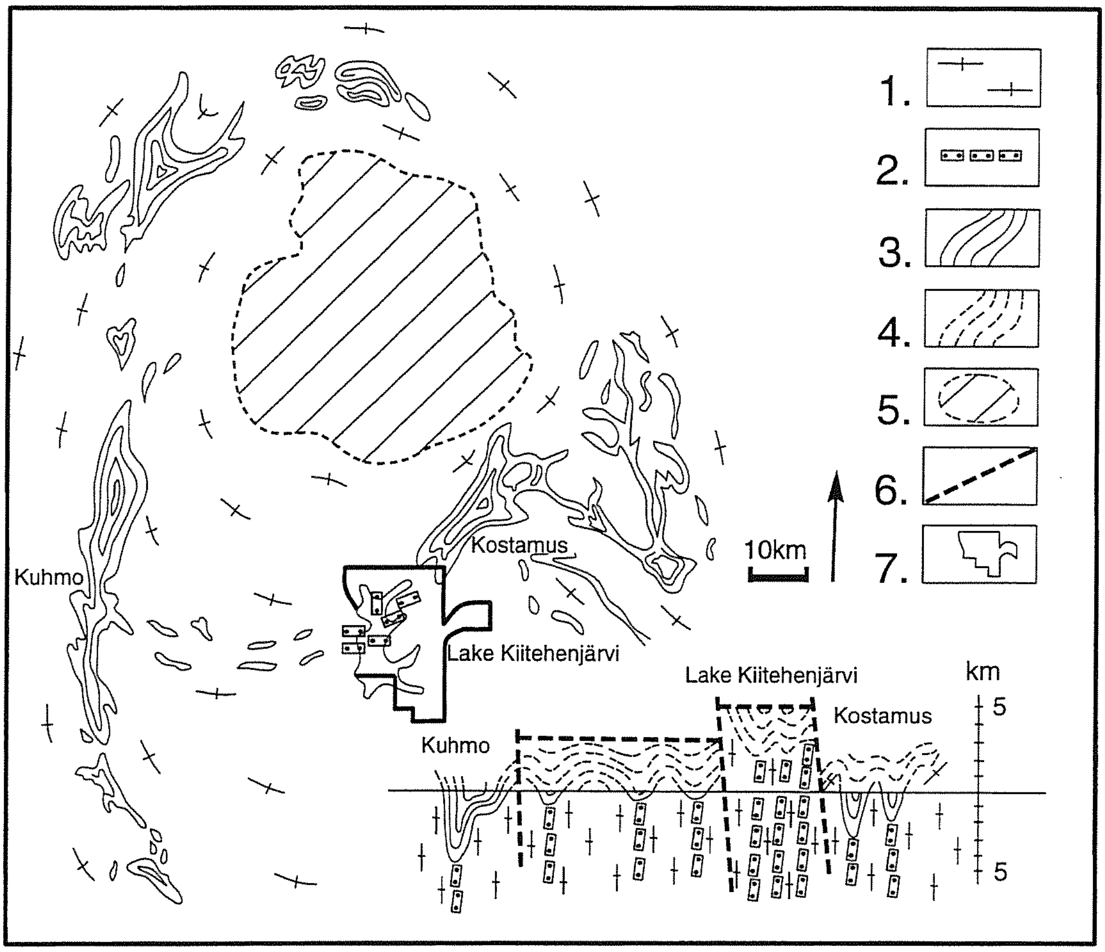

Fig. 2. Structural scheme of the Kuhmo-Suomussalmi-Lake Kiitehenjärvi-Kostomuksha area. (1 - gneiss diorites, gneissoses granites, tonalites and migmatites formed after them; 2 - metadolerite dyke swarms; 3 - volcanic-sedimentary strata in Late Archean greenstone belts; 4 - reconstructed Late Archean volcanic-sedimentary strata; 5 - Vuokkiniemi block rocks; 6 - tectonic dislocations; 7 - Kostomuksha Nature Reserve boundary).

Acknowledgments

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Soils and soil cover of the Kostomuksha Nature Reserve

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Abstract

The article gives a characterization of soil formation conditions and a list of the most common soils in the Kostomuksha Nature Reserve. Investigations showed that the reserve has a large variety of different soils. A group of weakly developed soils (Leptosols) formed as a result of the vicinity of rock foundation and shallows. Quaternary deposits cover has been singled out. Boulder or stony places (Boulders) are widespread. In various relief elements and in various moisture conditions ferric podzols, humus podzols and gley podzols are common. Peat bog soils (Histosols) are formed under the conditions of excessive moisture. The soil cover composition of the area is noted for its heterogeneity and mosaic development. Chemical properties (bulk composition, exchange base and acidic-alkaline properties) of the soils are also discussed.

Key words: Soil formation, chemical properties, soil profiles, podzols, Kostomuksha Nature Reserve

Introduction

The first inventory of soils and soil cover in the Kostomuksha Nature Reserve and adjacent areas was done in 1972-1975 (Zavarzin 1977, Zavarzin & Morozova 1977, Erukov et al. 1977). Some zonal, landscape and biogeocoenotic characteristics affecting soil formation in this area were elucidated. Soil cover structure as well as the morphological, physical and chemical characteristics of soils were studied to promote monitoring of forest ecosystems in the region.

Material and methods

Soil cover was studied by digging profiles in various forest site types. Soils were described morphologically, and samples were taken from each genetic horizon. The bulk composition of soils was determined by the X-ray spectral method, and their acidic-alkaline properties were assessed using some international techniques (Environment data centre 1993). The Truog method was used to estimate the amount of mobile phosphorus and potassium compounds, and the Tyurin technique was employed to determine organic carbon content (Sokolov 1975).

Results and discussion

Morphology of soils

The soil cover megastructure of the study area is due to cold and humid north taiga climate, rugged topography, the grain-size distribution of loose sediments such as sand and loamy sand, and the abundance of crystalline rock exposures and the predominance of coniferous forests. All this favours podzol formation on the uppland sites and peat formation in depressions.

The proximity of the crystalline basement to the surface provides a basis for distinguishing a group of poorly developed soils (leptosol) which comprises lithosols and the soils resting on ca. 1.5 m thick Quarternary deposits. This group occupies 10-15% of the soil cover and it is characteristic for denudation-tectonic landscape, whereas boulders and rock debris are common in the rest of the study area. The bedrock and boulders are cut by fractures. This process which began in pre-Quarternary time and is still in progress. Nowadays, it is observed in the form of scaling. Influx gives rise to the pediments seen as sheets on the lateral faces of boulders and in cracks. The bright-red, brown and other colours of such pediments are due to the presence of Fe and Mn hydroxides. Linear crusts of weathering occur in the fracturing zones near Kamalahti Bay, Lake Kiitehenjärvi and in the mainstream of the River Kivijoki. When describing lithosols, attention was drawn to some biodiagnostic characteristics such as polsters, which occur as a mass of epilithic lichens and algae (which are formed of small lichen- or algaecovered pebbles). Most epilithic lichens grow in "dry" habitats, whereas algae develop in supra- and subaquatic enviroments. The distribution of lithosols and boulder soils is uneven. The largest terrains are located on the north-eastern and south-eastern shores of Lake Kiitehenjärvi as well as in the middle and upper River Kivijoki at a distance of 5-10 km from both banks. The above types are encountered among other soils. The leptosol profile structure may be as follows: O-D; O-E-D; and O-E-V-D, where D is crystalline rocks. The completeness of profile is related to the thickness of the Quaternary sediments resting on the bedrock. The thicker the sediments, the more complete the soil profile.

In the study area, the Holocene deposits are overlain by ferric and humus-ferric podzols (Soil map of the world 1990); illuvial-ferric-humus or grey podzols (grey podzols) as well as raised and transitional peat bog soils called folic and fibric histosols. Ferric podzols occur on well-drained fluvioglacial and till deposits. They are normally confined to coarse sands with varying amounts of boulders. The morphological structure of these soils is: O-E-Bs-BC-C.

Podzols with a mottled illuvial horizon form a fairly interesting group of soils. Their soil profile is structurally complicated, and their genetic horizons vary greatly in thickness over short distances. Mottled soils are most commonly formed in boulder-rich environments, the petrographic composition of boulders varying from basic and ultrabasic to mafic and ultramafic rocks.

The profiles of carbic and gley podzols are structurally different. A fairly thick peaty litter deposit, the white horizon Eh and the continuous dark-brown horizon Bh are characteristic. The formation of the above soils is due to impeded drainage and temporary waterlogging. Some soils of this type are confined to dingle-ravine habitats, and others are encountered along swamp margins and in flat depressions between swamps. The morphological structure of carbic podzols is O-E-Bhs-BC-C; O-E-Bh-BC-C and that of gley podzols is H-Eh-Bh-BCg-Cg.

Histosols are formed in waterlogged environments. They are subdivided into soils drained by lateral discharge and those with a stagnant water regime. The former are represented by fibric histosols having the following morphological structure: H1-H2-Bg-Y. Folic histosols that have the structure H1-H2-H3 are formed in stagnant water or poorly influent environment. Podzols and histosols are observed to alternate in all landscapes.

All the soil varieties mentioned above are typical of Karelia, and their abundance in the study area is valuable. When discussing the influence of parent rocks on soil cover structure, the role of boulder free parent rocks should be evaluated They occur in the central part of the nature reserve as a mixture of sand, silt and varved loam as well as alluvial deposits of sand and loamy sand composition that alternate in the soil profile. The boulder free composition of parent rocks and the intercalation of sand, silt and clay provide a basis for recognition of a group of soils known as planosols. In the lower River Kivijoki some rare soil types, such as fluvisols, were encountered. The soil cover structure of the nature reserve is thus fairly varied.

The chemical characteristics of soil

The chemical characteristics of some soils are given in Tables 1 and 2. The bulk chemical composition of the podzols (Morozova et al. 1991) indicates that silicic acid and uncombined oxide distribution is clearly differentiated horizontally. The podzol horizon is depleted in Fe_2O_3 and Al_3O_3 and enriched in Si (Table 1), whereas Mg-and Mn-bearing minerals are almost completely eliminated. Elevial-illuvial differentiation along the profile is observed for Mg, but is not reported for Ca, K and Na. Biogenic accumulation in the forest litter is obvious for all elements, except Si.

Table.1 Bulk chemical composition of the podzols.

Horizon (cm)	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	SO_3
					Ferric Podzols						
O 1-2	64,88	3,23	13,95	1,61	7,18	1,8	1,88	2,59	0,43	0,68	0,89
E 4-7	78,1	1,44	11,88	0,05	2,34	0,67	1,52	2,11	0,41	0,03	0,04
Bs 7-17	68,98	6,06	16,81	0,39	2,84	1,64	1,44	2,79	0,55	0,07	0,07
B2 25-35	70,02	3,62	16,13	0,13	2,6	1,64	1,67	3,07	0,39	0,06	0,02
BC 40-50	71,68	3,08	14,88	0,11	2,56	1,53	1,64	3,11	0,35	0,06	0,16
C 50-60	72,04	2,98	14,7	0,11	2,59	1,47	1,55	2,98	0,34	0,06	0,02
					Humus Podzol						
O 0-3	63,83	4,32	13,65	0,13	3,77	3,25	-	-	0,28	0,11	0,46
E 3-19	79,06	0,91	12,63	0,01	1,14	0,49	-	-	0,09	0,06	0,02
B 19-24	68,44	4,11	18,1	0,04	3,21	2,28	-	-	0,06	0,11	0,04
B2 24-55	78,66	2,26	12,32	0,16	1,58	0,72	-	-	0,36	0,06	0,05
C 80-100	79,8	2,77	11,21	0,17	1,52	0,60	-	-	0,34	0,04	0,07

The ferric podzols (Table 2) have a profile typical of podzol soils with distinct differentiation into horizons, a well-developed ca. 5 cm-thick coarse humus litter and a ca. 10 cm-thick podzol horizon. The soils, primarily the forest litter and the podzol horizon, are highly acid. In the illuvial horizon pH decreases. Exchange and non-exchange acidity is high. The distribution of exchange bases in the profile is characteristic of podzols. Organic carbon is most abundant in the litter and far less abundant in mineral horizons, its quantity decreasing downwards. The organic

Table. 2. The chemical characteristics of ferric podzols and fibric histosols.

Horizon Depth, cm	pH EW	pH EK	ACiET	AL E	NaE	K E	Ca E	MgE	Bs %	ACi_ETB	CEC_E	CEC_P	P_2O_5	K_2O	C,%
					me/kg						me/kg		mg/100		
					Ferric Podzol										
O 0-5(7)	3,7	2,9	49,8	4,4	6,8	18,7	41,6	16,8	62,8	860,0	133,7	943,9	68,0	200,0	83,2*
E 5(7)-15	4,4	3,4	17,2	10,1	0,1	0,3	2,8	1,2	20,4	36,0	21,6	40,4	2,0	1,5	0,1
Bs 15-26	5,8	5,4	0,5	0,3	0,4	0,4	4,5	0,8	92,3	130,4	6,6	136,5	7,5	2,7	1,1
B2 26-46	5,9	5,1	0,7	0,3	0,2	0,3	3,1	1,3	87,5	24,8	5,6	29,7	17,5	1,5	0,7
BC 46-87	6,0	4,7	0,6	0,3	0,2	0,1	1,6	0,5	79,0	15,2	3,0	17,6	14,0	1,5	0,2
C>87	5,9	4,7	0,6	0,4	0,1	0,1	2,0	1,2	85,9	8,0	4,1	12,5	45,0	1,1	0,1
					Fibric histosol										
O	4,0	3,0	64,0	3,0	5,9	48,2	305,6	118,4	88,2	1020,0	542,1	1498,1	5,9	0,7	0,8
H1	4,0	3,5	170,6	88,8	4,5	3,6	273,2	203,2	74,0	1060,0	655,5	1544,9	19,0	61,0	87,9*
H2	4,5	3,6	84,8	52,1	2,9	1,3	92,8	27,2	59,4	932,0	209,0	1056,2	19,0	55,0	86,5*
Cg	4,9	3,0	0,4	1,0	2,1	1,2	8,5	2,1	97,2	53,6	14,3	67,5	6,0	12,0	-

Abbreviations in the table 2 are according to the EDC Field and Laboratory Manual (1989). pH/EW = pH extractable with water, pH/EK = pH extractable with KCl, ACI/ET = exchangeable titratable acidity, ACI/ETB = Total exchangeable acidity, Al/E = exchangeable aluminium, Na/E = exchangeable sodium, K/E = exchangeable potassium, Ca/E = Exchangeable calcium, Mg/E = exchangeable magnesium, BS = base saturation, CEC/E = catione exchange capasity / effective, CEC/P = catione exchange capacity / potential, C = carbon, * = loss on ignition.

matter bound to uncombined oxides in the horizon Bs tends to accumulate in the alluvial horizon. The mineral horizons are not differentiated in terms of exchange K content, but the amount of K is observed to increase in the litter. The illuvial-humus podzols, especially the peaty litters, generally have a more acid reaction over the entire profile. Besides, they differ from ferric podzols in the horizon Bh (up to 3-4%) and in the high humus content of the whole profile.
Raised bog peat soils are formed by excessive atmospheric moisturising beneath oligotrophic vegetation. The soil profile is poorly differentiated into genetic horizon. The light yellow *Sphagnum* layer is underlain by the yellow-brown poorly decomposed *Sphagnum* peat layer H1. Peat decomposition degree increases downwards to 30%. These soils are highly acid. Al is absorbed in large quantities, and non-exchange acidity is very high. The peat horizons are rich in mobile K and P compounds.

Conclusion

Our study has shown that the soil types, typical of Karelia and widespread in the north taiga subzone, are abundant in the Kostomuksha Nature Reserve. Some soils such as ferric (illuvial-iron and illuvial-humus-iron) podzols can be used as reference when describing northern podzols. Besides, the nature reserve has a rare soil type known as fluvisol which is genetically interesting. Because the soil cover of the study area is structurally complex and mosaic, it should be analysed in more detail with due regard for the distribution at a lower taxonomic level.

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Principal characteristics of climate of the Kostomuksha Nature Reserve

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Abstract

The climate of the Kostomuksha Nature Reserve, which forms part of the Nature Reserve Friendship, is discussed using some statistically prosessed data obtained at the Repola, Jyskyjärvi and Kalevala weather stations in 1946-1993 and the results of some earlier studies of the climate in Karelia. Annual air temperatures and precipitation as well as their monthly distribution over a 48-year period are assessed. Other climatic indices of the study area are also discussed.

Key words: climate, air temperature, precipitation, norm, extreme values

Introduction

Climate is an important physio-geographic factor largely responsible for the functioning of natural ecosystems. The definition of climate as a long-term weather regime is based on statistically processed long-time air temperature, precipitation, atmospheric pressure, humidity and wind records. Relevant long-term mean values (climatic standard) are as important as annual, seasonal and daily variations as well as abnormal and extreme values. It is difficult to describe in detail the climate of the Kostomuksha Nature Reserve because there are no permanent weather stations in this area. Therefore, long-term record kept at some nearest stations was used to characterize the climate in the vicinity of the Kostomuksha iron deposit over a relatively short period of time (1949-1974) (Startsev 1985) and to generalize the results of other climatic studies (Anon 1972; Atlas of the Karelian ASSR 1989).

Methods and relationships

The long-term record kept at the Repola, Jyskyjärvi and Kalevala weather stations located near the Kostomuksha Nature Reserve around Lake Kiitehenjärvi (Fig.1.) was used to evaluate major climatic parameters in this area over a 48-year period.

Average annual air temperature values (T_i) were calculated for the period 1946-1993 using the formula:

$$T_i = 0{,}55T_{Y,i}+0{,}24T_{R,i}+0{,}21T_{K,i}, \qquad (1)$$

where $T_{Y,i}$, $T_{R,i}$ and $T_{K,i}$ are the average annual air temperatures (°C) recorded at theJyskyjärvi, Repola and Kalevala weather stations, respectively, and i is the year number beginning with 1946. The weight coefficients in (1) are proportional to the altitudinal distance between the geometric centre of the nature reserve and the corresponding weather station.

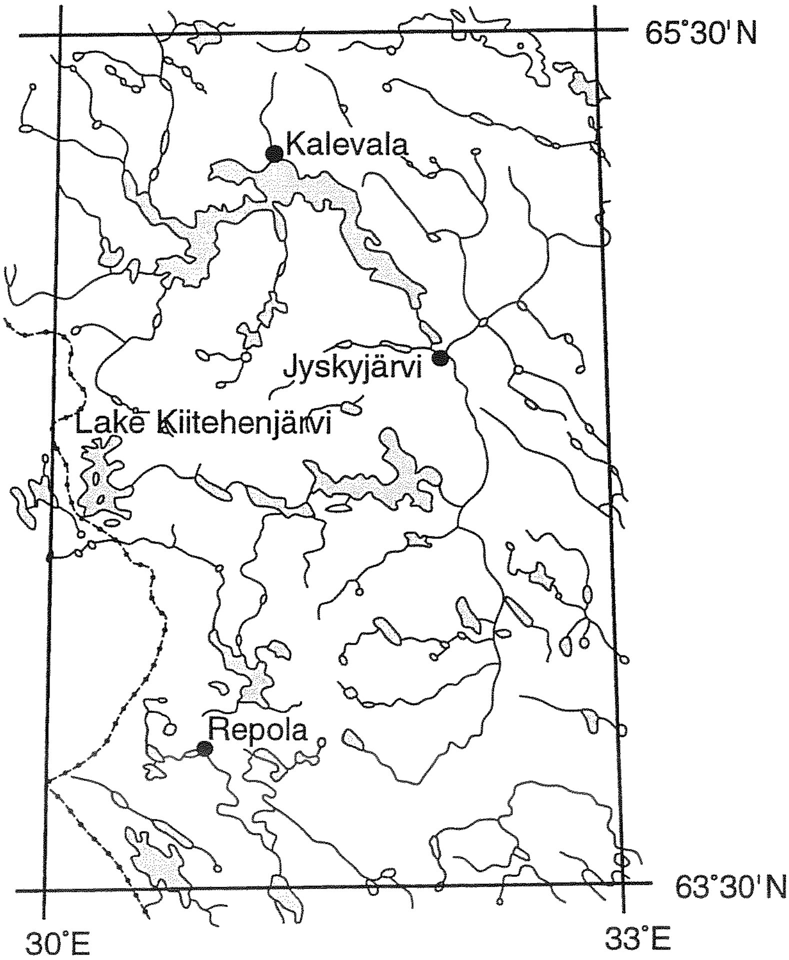

Fig. 1. Location of the weather stations.

The 48-year observation record was also used to analyse monthly air temperature variations, to calculate extreme values and to determine zero air temperature transition dates in spring and fall.

The annual amount of precipitation (X_i, mm) in the nature reserve was estimated as a mean arithmetic value for the above three stations

$$X_i = \frac{1}{3}(X_{Y,i} + X_{R,i} + X_{K,i}) \qquad (2)$$

where Y,i; R,i ; and K,i are the stations, like in (1).

The monthly distribution of precipitation and its propotion in warm and cold seasons were also calculated using the observation record kept at the stations. The wind regime in the study area is strongly affected by local (orographic) factors. Therefore, only some general evidence for predominant wind directions in different seasons is presented here. Data on the lenght of climatic periods and some characteristic dates were borrowed from earlier publications.

Principal characteristics of climate in the Kostomuksha Nature Reserve

The climate of the study area is dependent on its geographic position, the predominance of westerly air transport and orographic factors. Long, severe winter, short, cool summer and a short frostless period are characteristic. Air temperatures are no more than -5 °C about 130 days a year. They rise above +10 °C for only three months. The transition of daily air temperatures to positive values is observed approximately on 20 April and to negative temperatures on 20 September.

Figure 2. shows average annual air temperatures and total annual precipitation calculated from (1) and (2). In 1946-1993, the average annual air temperature in the study area was +1,1 °C. The coldest year was 1966 (-1,7 °C) and the warmest year was 1989 (+3,4 °C). When analysing long-term variation in annual air temperatures by 5-year moving average, cyclicity was revealed, each cycle approximately being close to an 11-year solar cycle.

In the study area, fallout is observed 180-190 days in year. The amount of precipitation in November-March (cold period) accounts for 20-40 per cent of annual amount. The average annual amount of precipitation over the 48-year period is 540 mm , maximum (750 mm) and minimum (300 mm) values being recorded in 1983 and 1947, respectively.

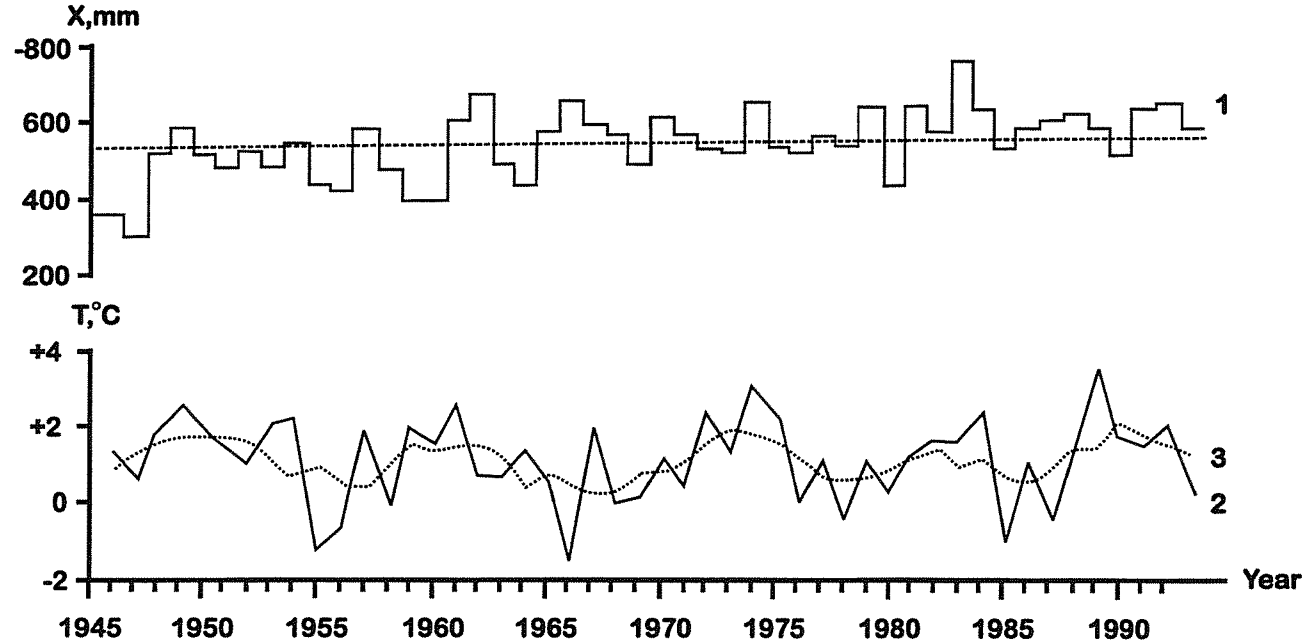

Fig. 2. Annual precipitation (1) and air temperatures (2) in the Kostomuksha Nature Reserve in 1946-1993 and 5-year moving average values (3).

Figure 3. shows average monthly air temperatures and precipitation. July is the warmest month (+15,8 °C) and January is the coldest one (-12,6 °C). The absolute maximum and minimum temperatures in the nature reserve are + 33 °C and -49 °C. The smallest amount of precipitation is observed in February and March, but in July-September it rains so heavily that the water level rises in the rivers of the study area. Snow accumulates from 20 October until April. Snow cover persists for about 175 days.

The predominance of westerly and south-westerly winds is due to some characteristics of atmospheric circulation over the study area. South-westerly winds prevail in summer and easterly to north-easterly ones dominate in winter. The direction and speed of wind near the ground are strongly affected by orographic factors and by a large number of lakes in the study area.

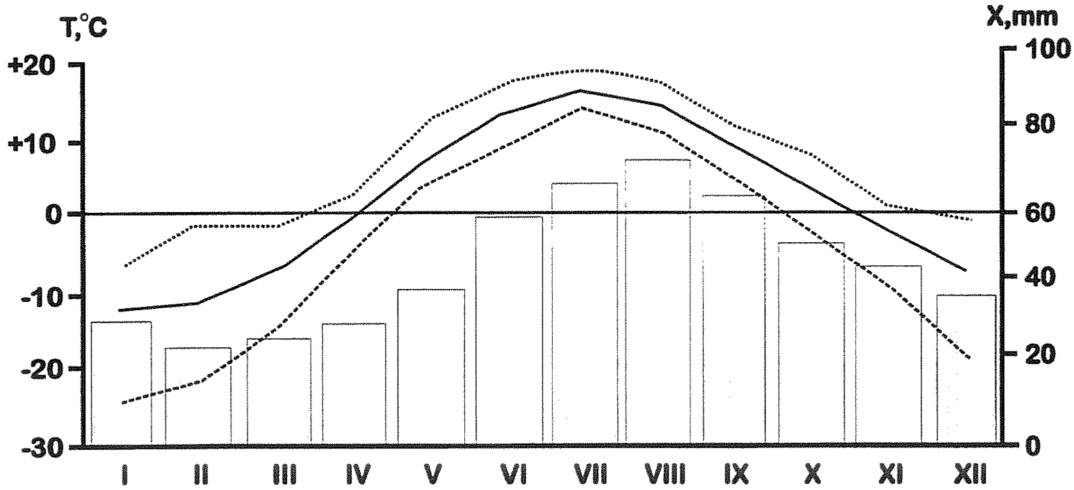

Fig. 3. Monthly air temperature distribution (solid line)*, average maximum and minimum monthly temperatures over a 48-year period* (broken lines) *and average monthly amount of precipitation.*

Conclusion

The climate in the Kostomuksha Nature Reserve reflects the characteristics of weather conditions observed for a long time in North Karelia where lakes are so numerous. Long-term air temperature, precipitation and wind record was analysed to provide a better understanding of the climate in the nature reserve. When studying variations in annual air temperatures over a 48-year period, cyclicity was revealed, each cycle being close to an 11-year solar cycle. The available data are insufficient to indicate a general warming trend, characteristic of the nothern hemisphere in the late 20th centry, but they can be used to determine whether weather conditions, observed in individual years, season or months, fit long-term mean values. The results obtained can also be used in keeping enviromental record, in doing phenological studies etc. It would be of interest to facilitate climatic monitoring in the nature reserve by conducting regular weather observations based on standard programmes.

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The landscapes of the Kostomuksha Nature Reserve

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Abstract

The comprehensive study was carried out in the Kostomuksha Nature Reserve. Specialized and coordinated investigations of peatlands, soil cover, forest vegetation and bird fauna were conducted. The study was based on the original map and classification of forest landscapes. The present paper briefly discusses the characteristics of taiga ecosystems of landscape and sublandscape (terrains, biogeocoenoses) levels: 1) genetic landforms and Quaternary deposits; 2) structure of paludified areas; 3) predominant soil types; 4) structure and features of forests; 5) specificity of floristic and faunistic complexes. References are made to the authors publications with detailed description of landscape structure and its natural and anthropogenic dynamics in Eastern Fennoscandia. The paper contains six figures with maps and fragments of landscape profiles.

Key words: landscapes, classification, map, structure

Introduction

Landscape characteristics of any territory provide a basis for various ecological investigations. This is a comprehensive description of the structure and dynamics of an ecosystem with regard for topography, parent rocks, waterlogging and other landscape forming factors that casts light on the wildlife of the study area. So far no other landscape studies have been undertaken in the Kostomuksha Nature Reserve.

Materials and methods

Landscape ecological studies began in the late 1970s. Since then, taiga landscapes have been quantitatively characterized, classified and mapped (Volkov et al. 1990, 1995). Landscapes were differentiated in terms of genetic landforms, Quaternary deposits, paludification pattern (proportion of various types of open mires and paludified forests) and dominant primaeval forests. Structurally similar landscape contours were collectively defined as "a type of landscape" (Table 1, Fig. 1).

Table 1. Classification of landscapes in Karelia

Predominant habitats	degree of paludification		
	intense, >50%	medium, 20-50%	weak <20%
I. Lacustrine, lacustrine glacial and marine(m) plains:			
Spruce	1	2	-
Pine	3	4	5
II. Glacial (g) and fluvioglacial (f) hilly-ridge plains:			
Spruce	-	6	-
Pine	7	8	9
III. Glacial accumulation plains with rugged topography:			
Spruce	-	10	-
Pine	-	11	-
IV. Denudation-tectonic hilly-ridge plains with a complex of glacial deposits(gd) and low mountain topography (lmt):			
Spruce	-	12	-
Pine	13	14	-
V. Denudation-tectonic ridge (selga):			
Spruce	-	15	16
Pine	-	17	18
VI. Rock:			
Pine	-	19	20

Investigations in the Kostomuksha Nature Reserve began in 1992. In each terrain, a landscape profile was made across the most typical part to study mires, soil cover, forest vegetation including suprasoil cover and fauna. Each of the above constituents was studied using an individual technique developed for our joint research programme (Volkov et al. 1990, Gromtsev 1993, Kolomytsev 1993).

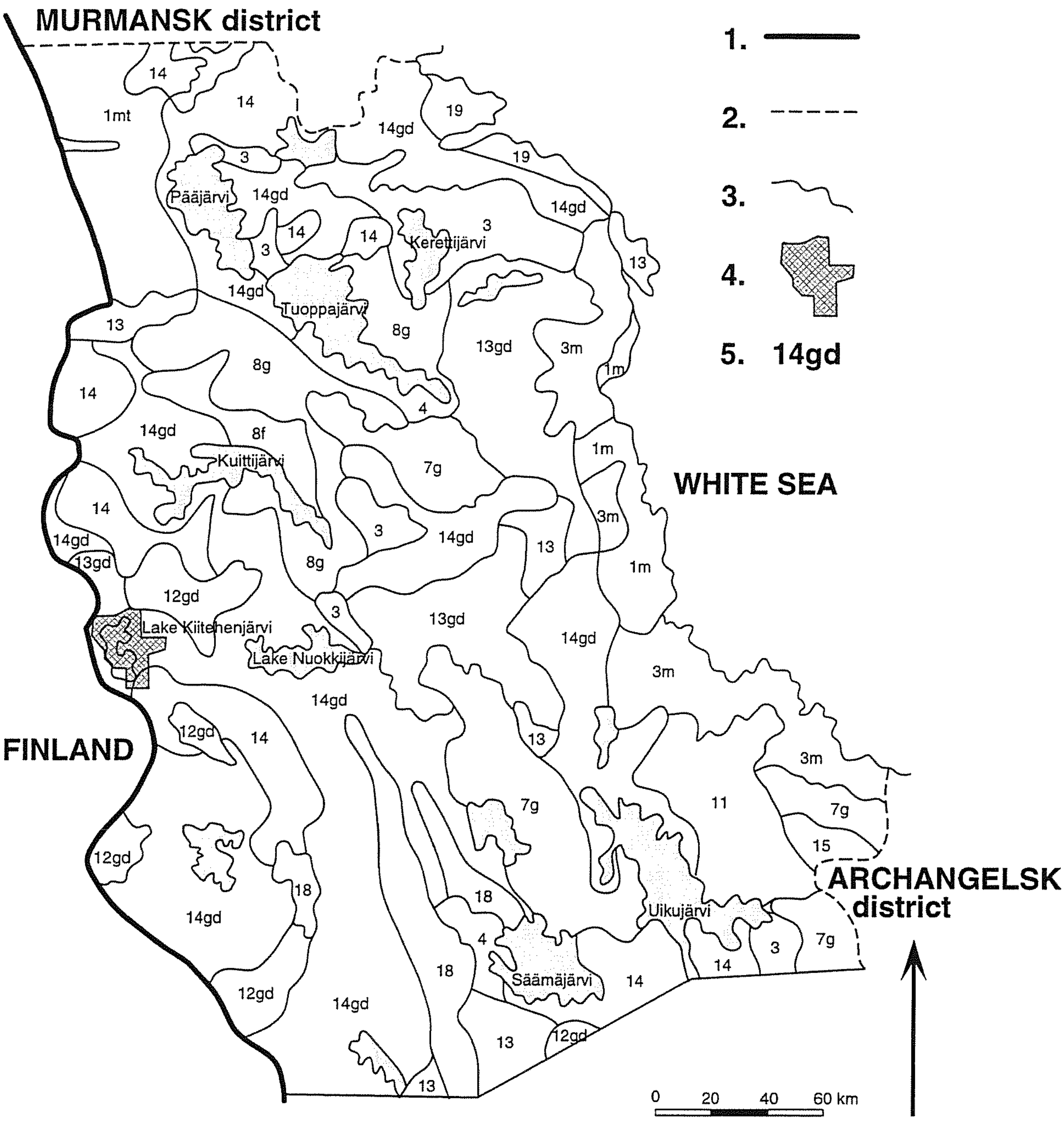


Fig. 1. Map of landscapes. North taiga subzone of Karelia. 1) State border, 2) Administrative boundary, 3) Landscape boundary, 4) Kostomuksha Nature Reserve, 5) Landscape type number (see Table 1).

Results and discussion

The Kostomuksha Nature Reserve lies in the central part of the north taiga subzone in Eastern Fennoscandia (Fig. 2). The region has two most typical north taiga landscapes covering over 95 % of its territory. The northernmost part of the nature reserve has a pine-dominated, denudation-tectonic hilly-ridge highly paludified landscape with glacial deposits (13 gd). A primeval pine-dominated, mid-paludified, denudation-tectonic, hilly-ridge landscape with glacial deposits (14 gd, Table 1) is predominant and occupies 43 % of the nature reserve. Structurally it can be subdivided into three major morphological constituents (terrains) (Fig. 2).
1) pine-dominated, large hilly-ridge, mid-paludified uplands of denudation-tectonic genesis
2) pine-dominated, small hilly-ridge, heavy paludified crystalline basement depressions
3) pine-dominated small hilly-ridge fluvioglacial weakly paludified terrains

1) Pine-dominated, large hilly-ridge mid-paludified uplands of denudation-tectonic genesis (indicated as 7 in Fig. 3) cover 43 % of the landscape area and 40 % of the nature reserve. The type is widespread in the study area. Geomorphologically, they occur as the elevated parts of the crystalline rock basement composed of pre-3.0 Ga granodiorites, plagiogranites and migmatites overlain by 0,5-3,0 m thick Quaternary loamy sand till. The relative elevation of the terrains over the surrounding territory varies from 30 to 60 m, and their absolute altitude is more than 220 m. Topographically, they occur as domes cut by tectonic faults and thrusts. It is the main factor responsible for a diversity of ecosystems.

The total percentage of mires in this terrain is about 35 % of which 34 % are open oligotrophic and meso-oligotrophic types. The central parts of the oligotrophic mires (rather facies or biogeocoenoses within extensive marshlands) consists largely of *Empetrum-* and *Scheuchzeria-Sphagnum* associations of carpets and hollows. The underlying peat deposit is 2-4 m thick. The oligotrophic *Sphagnum* peat layer, traceable to a depth of 0,5-1 m, is underlain down to the mineral bottom by mesotrophic woody-*Carex* peats.

The mesotrophic (16 %) and co-dominant oligotrophic (18 %) facies occur mainly as thin *Empetrum*-dwarf shrub-*Sphagnum* pine stands growing on mesotrophic woody-*Carex* and woody peats along the margins of wetlands. Most common in this terrain (56 % of total mire area) are paludified *Vaccinium myrtillus-* and *Equisetum fluviatile- Sphagnum* spruce forests. The rugged topography of the area contributes to their weak flowage regime. They are confined to narrow depressions formed along faults in the crystalline rocks. Forest peatlands , which account for 11 %, are represented by low density *Empetrum-Sphagnum* pine stands growing on ca. 2,0 m thick mesotrophic woody-*Carex* peat. The soil cover is uniform and is dominated on mineral land by duff loessivated loamy sand podzols. In small depressions between ridges and hills peat-podzols-gley and transitional peat soils are most common (Fig. 3).

Pine stands occupy 3/4 of the forested area. *Vaccinium myrtillus*-pine forests in which pine is usually replaced by spruce are clearly predominant. The spruce stands are confined to the lower parts of hill and ridge slopes with wetter soils (fresh *V. myrtillus* and wet *V. myrtillus*-spruce stands) and to the different parts of the hydrographic network (grass-*Equisetum fluviatile-Sphagnum* and creek (stream bank) spruce forests). The fauna and flora of the study area are most typical of the north taiga subzone of East Fennoscandia.

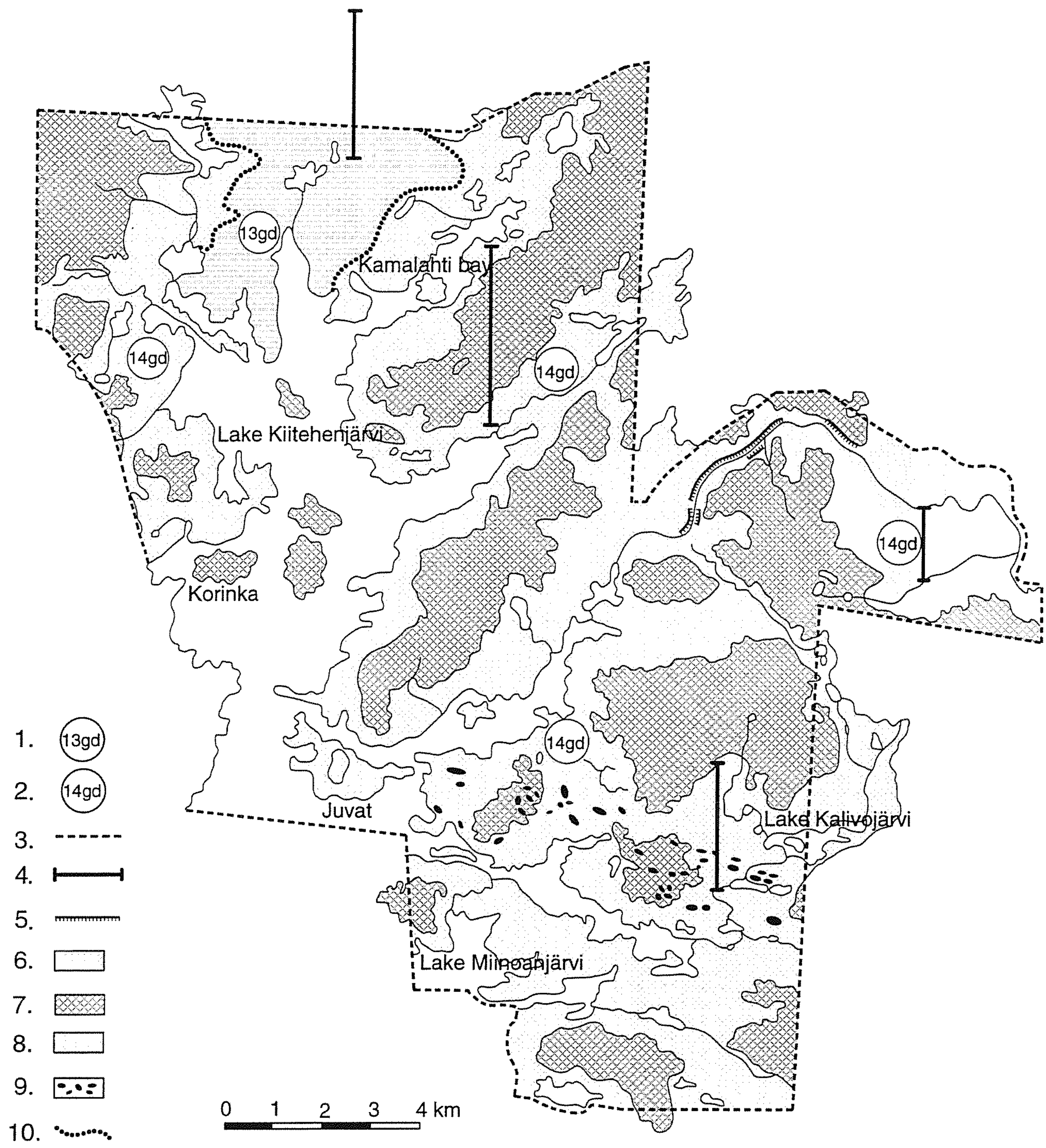
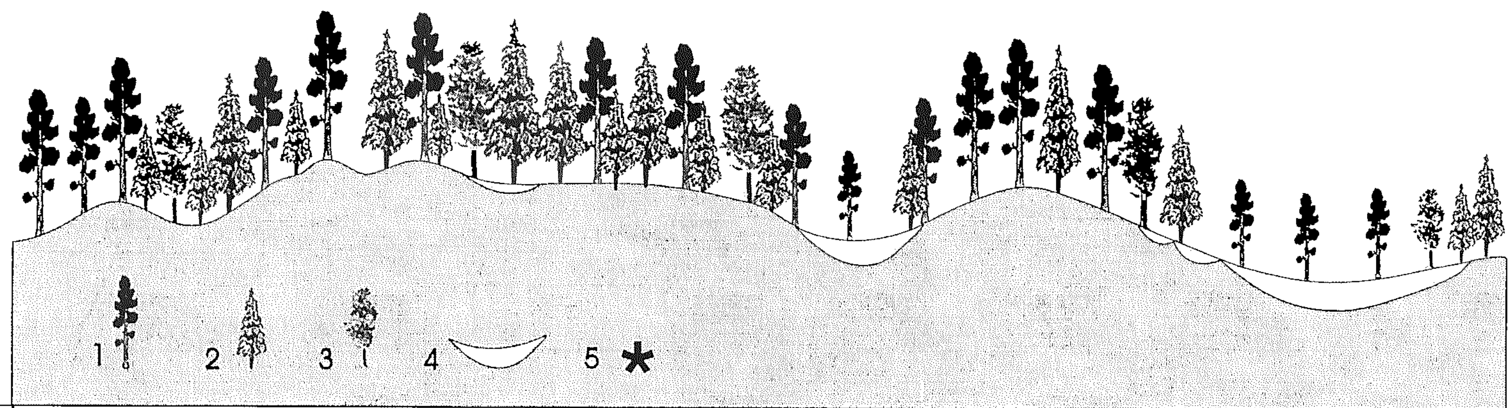


Fig. 2. Map of terrains of the Kostomuksha Nature Reserve. 1) Pine-dominated, highly paludified, denudation-tectonic, hilly-ridged, landscape with glacial deposits (13 gd), 2) Pine-dominated, partly-paludified, denudation-tectonic, hilly-ridge landscape with glacial deposits (14 gd), 3) Kostomuksha Nature Reserve boundaries, 4) landscape profiles, 5) Tectonic faults, 6) Pine-dominated, highly paludified, small ridge-hilly crystalline basement depressions, 7) Pine-dominated, partly-paludified, large hilly-ridge uplands of denudation-tectonic genesis, 8) Pine-dominated, small ridge-hilly, partly-paludified, fluvioglacial terrains, 9) Drumlins, 10) Boundary between landscapes 13 gd and 14 gd.



Distance	2000 2100 2200	2300	2400	2500	2600	2700	2800	2900
Native rock and Quaternary debosity	Sandyloam till on granite gneisses							
Soils	Moderhumus loessial podzol	Peat-podzol gley	Moderhumus loessial podsol	Peat transitional	Moderhumus loessial podsol	Peat-humous gley	Peat gley	Peat-humous gley
Forest type	Pinetum myrtillosum	Piceetum myrtillosum Sphagnosum	Pinetum myrtillosum	Palus fruticulosa sphagnosum	Pinetum myrtillosum	Piceetum myrtillosum sphagnosum in valle rivuli	Pinetum fruticulosa sphagnosum	Piceetum mirtillosum humidus
Class of estimated	IV	V	IV		IV	IV	V[a]	IV
Age of tree stand	120	230*	120		120	140*	180	95

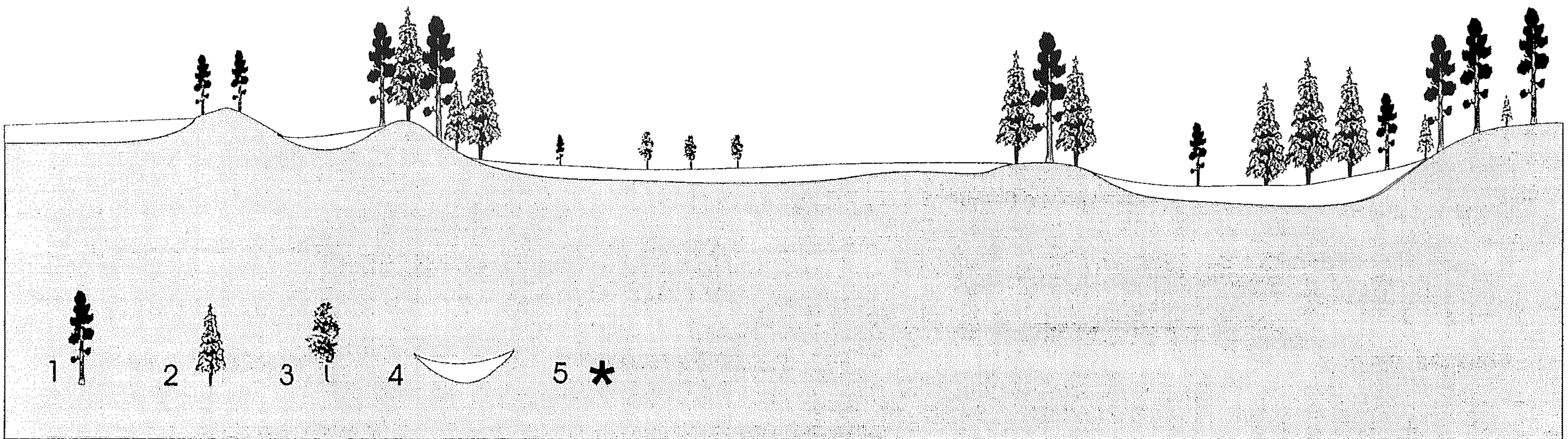
Fig. 3. Fragment of landscape profile in pine-dominated, large hilly-ridge uplands terrain of denudation-tectonic genesis. Numbers 1) pine, 2) spruce, 3) birch, 4) mineral horizon underlying peat deposits, 5) avrage age in noncoeval stands.

2) Pine-dominated small hilly-ridge highly paludified crystalline basement depressions (indicated as 6, Fig. 4) cover 52 % of landscape area, 48 % of the nature reserve and are quite common. Terrains of this type are topographically flat. They are confined to the territory lying at an absolute altitude of 190-220 m, the relative altitude of adjacent topographic units varying from 5 to 10 m. The terrains were formed by emplacement of the crystalline rock basement and filling with loose Quaternary sediments such as till, silt and sapropel of lacustrine origin. These, in turn, are overlain by a ca. 4,5 m thick pile of peat.

The surface of the mineral (nonpaludified) uplands consists of till. The territory, thus formed in a passive deposition environment, was subsequently flattered in the course of peat accumulation. This process goes on and is the most substantial relief forming factor. Here, mires cover 63-75 % of the terrain.This is due to poor drainage caused by flat topography and the paludification of the shallow-water parts of lakes. Oligo-mesotrophic, mesotrophic (29 %) oligotrophic (18 %) types are most common. They are dominated by dwarf shrub-*Empetrum-(Carex)-Sphagnum* and dwarf shrub-*Sphagnum* facies with a hummock-and-swale microrelief and thin pine stands. The underlying 4,5 m thick woody-*Carex* mesotrophic peat is stratigraphically similar to the peat deposited in the mires of the previous terrain. Forest peatlands, which cover 23 % of this territory, are represented by meso-oligotrophic *Empetrum-* and *Carex-Sphagnum* pine stands confined to the margins of open mires. The peat layer is either thin or is completly absent here. This suggests that the mires, which developed within the background terrains of this landscape type, have the same genesis and evolutionary trends. In depression terrains paludified forests account for 30 % of ecosystems with a large ridge-hilly relief. Another difference is the predominance of paludified *Empetrum-* dwarf shrub-*Sphagnum* and dwarf shrub pine stands over *Vaccinium myrtillus-* and *Equisetum fluviatile-Sphagnum* spruce stands caused by the scarcity of narrow faults in the crystalline basement, where most spruce forests grow.

The soil cover formed on mineral lands is dominated by coarse-humus, loessivated, iron-humus, loamy sand podzols. Transitional peat soils are clearly preponderant in large mires, whereas peat-mull-gley types usually occur in small depressions. Generally speaking, this terrain type is dominated by soils of unequally paludified habitats (Fig. 4).

The forest cover is remarkable for the prevalence of *Vaccinium myrtillus* and dwarf shrub -*Sphagnum* pine stands. Spruce trees usually grow along or near watercourses. Spruce undergrowth, estimated at few thousand individuals per hectare, is observed beneath the pine canopy. The fauna and flora are typical of the north taiga subzone of East Fennoscandia.



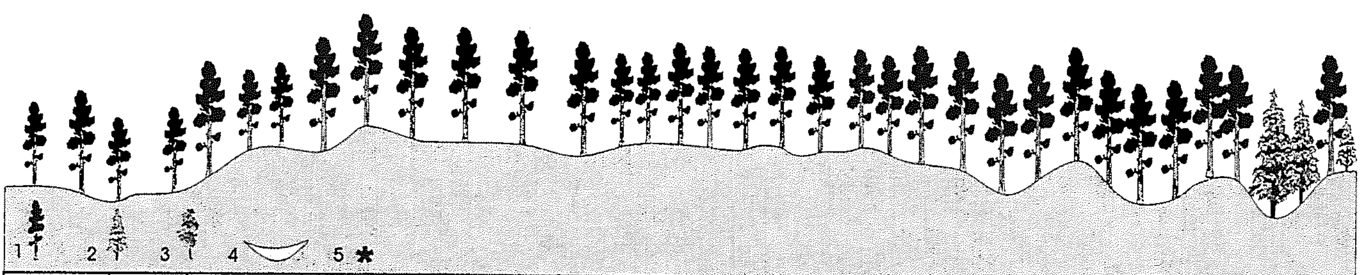
Undiffirentiated, chiefly granitoid rock and migmatites												
High peat bog	Primitive	Peat transitional	Ferro humus podsol	Peat-podsol	Peat transitional	Peat transitional	Peat transitional	Ferro humus podsol	Peat- podsol gley	Peat transitional		Stiff humus loessival podsol
Palus caricoso sphagnosum	Pineta cladinosa saxatille	Palus caricoso sphagnosum	Piceeta pineta myrtillosum	Piceetum myrtillosum humidus	Palus caricoso sphagnosum	Palus herboso sphagnosum (fluens)	Palus caricoso sphagnosum	Piceetum myrtillosum	Palus caricoso sphagnosum	Piceetum in valle rivuli	Pinetum fruticulosa sphagnosum	Pinetum myrtillosum
	V^a		IV	V				IV		IV	V^a	IV
	160*		150	210*				170		120*	210*	130

Fig. 4. Fragment of landscape profile in pine-dominated, highly paludified small-ridge-hilly depression terrains (for symbols see Fig. 3).

3) Pine-dominated, small ridge-hilly, fluvioglacial, weakly paludified terrains cover 5 % of landscape area and 5 %of the nature reserve. They occur only in its easternmost part. Geomorphologically, these terrains differ greatly from the previously dicussed areas because they occur as fluvioglacial deltas formed by a thick pile (thick graded sand strata) of graded sands broken at surface by subsequent suffosial, thermal kettlehole formation and erosion. This type of terrains is also confined to deep crystalline basement depressions the environment in which they are always formed. The terrains lie at an absolute altitude of 150-175 m, and the adjacent topographic units occur at a relative altitude of 5-15 m.

Here, mires cover no more than 20 % of the area. Structurally, the waterlogged ecosystems are clearly dominated by small *Scheuchzeria* and *Carex-Sphagnum* mires with fens in centre formed in suffosial and thermal kettleholes. The margins of such mires are commonly rimmed with pine associated with *Empetrum* - dwarf shrub - *Sphagnum* (or green moss - *Cladonia*) communities. The peat in the mires is more than 2 m thick. It is underlain by sand, clay and sapropel-like sediments.

The soil cover is highly uniform. On the mineral lands it is almost solely represented by illuvial iron sandy podzols. Their peaty varieties and transitional peat soils are occasionally encountered in depressions (Fig.5). The forest cover is very unusual here. *Vaccinium vitis-idaea* and lichen pine stands predominate. Spruce trees are encountered only along watercourses. The clearly pyrogenic genesis of the forests is responsible for the composition and phytocenotic characteristics of forest communities. The fauna and flora are also peculiar as they had to adapt themselves to fires that often broke out in the last few millenia.



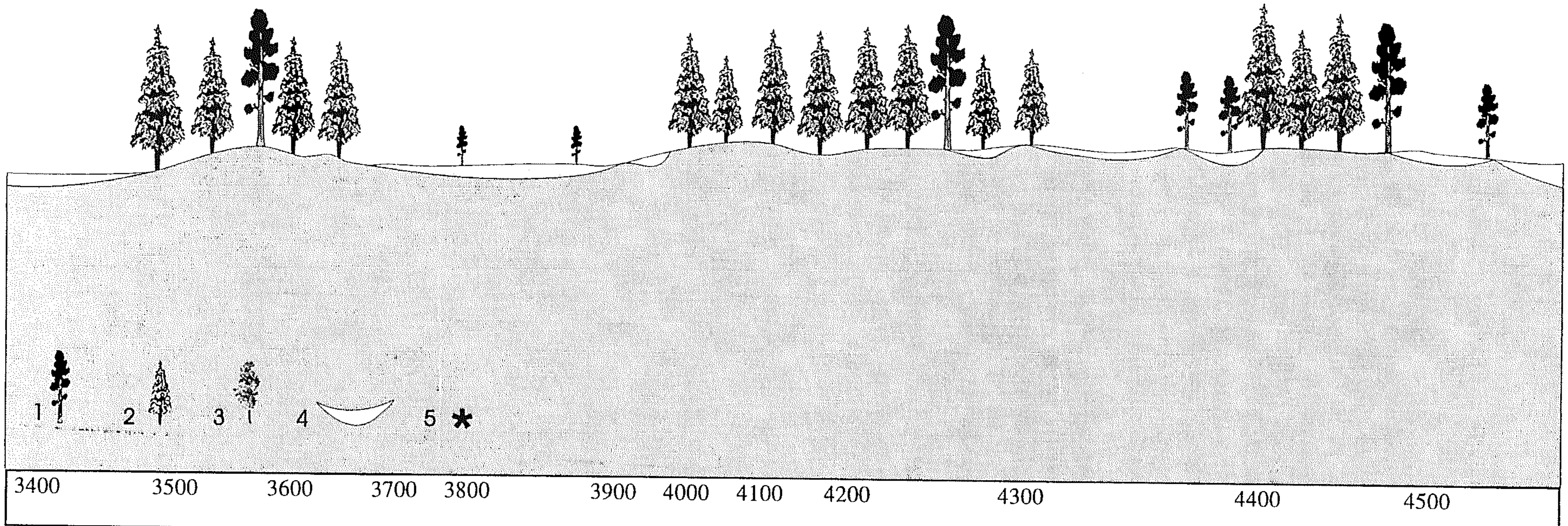
<table>
<tr><td>400</td><td>500</td><td>600</td><td>700</td><td>800</td><td>900</td><td>1000</td><td>1100</td><td>1200</td><td>1300</td><td>1400</td><td colspan="2">1500</td></tr>
<tr><td colspan="13">Sands of water-glacial genesis</td></tr>
<tr><td colspan="11">Sandy podsols</td><td></td><td></td></tr>
<tr><td colspan="2">Lichen pine forest</td><td colspan="9">Cowberry Pine forest (with fragments of lichen pine forest)</td><td>By-stream spruce forest</td><td>Cowberry pine forest</td></tr>
<tr><td colspan="2">110-220 (150)</td><td colspan="9">110-220 (150)</td><td>180</td><td>200</td></tr>
<tr><td colspan="2">V</td><td colspan="9">IV</td><td>III</td><td>IV</td></tr>
</table>

Fig. 5. Fragment of landscape profile in pine-dominated, weakly paludified small ridge-hilly, fluvioglacial terrain (for symbols see Fig. 3).

Pine dominated, highly paludified, denudation-tectonic, hilly-ridge-landscape with glacial deposits (13 gd, indicated as 10., Fig.6) occupies 7 % of the nature reserve and occurs in its northernmost part. Topographically, the landscape is a gently sloping dome with vertical roughness varying from 1 to 5 m, which is characteristic of plain landscapes. It lies in the watershed at an absolute altitude of 230-250 m. The relief reflects the irregular surface of the Precambrian rocks which seldom crop out and which usually do not build up big morphlogical units of the relief.

60 % of the landscape is paludified. Mires dominate in the structural organisation of ecosystems. Open mires account for about 60 % of total waterlogged area. They are defined in terms of their plant cover as mainly meso-oligotrophic and oligotrophic *Empetrum - Sphagnum* facies with a non-rugged to weakly rugged nanorelief or an oligotrophic ridge-hollow complex. The mire surfaces are markedly inclined, reflecting the ruggedness of the underlying strata. The peat layers are usually no more than 3 m thick. The mesotrophic facies are fragmentary (11 %) and have a poor plant cover. Forest swamps, dominated by dwarf shrub-*Empetrum-Sphagnum* pine stands rimming the swamps, account for only 15 %. Pine and spruce stands are most scarce, each making up 5 % of total waterlogged area, but they are confined to the different types of habitats and the morphological units of the relief. Wet coarse-humus gley loamy sand podzols are most common on mineral lands. In extensive mire systems transitional peat soils are dominant.

The forest cover is dominated by pine stands. The prevalence of *Vaccinium myrtillus* pine forests on mineral earths is obvious. Spruce stands are not abundant, but they are relatively evenly distributed, *Vaccinium myrtillus* type being predominant. Most stands occur as small nonpaludified sites surrounded by extensive open mires. The fauna and flora are typical of East Fennoscandia. The mammal and bird population density is lower than the average values calculated for the region.



Granitoid rock and migmatites

Peat transitional	Wet stiff humus podsol	Peat transitional	Peat podsol gley	Wet stiff humus gleyed podsol	Stiff humus gleyed podsol	Peat transitional	Wet stiff humus gleyed podsol			Peat bog
Palus caricoso fruticulosa sphagnosum	Piceetum myrtillosum	Palus caricoso sphagnosum	Pinetum fruticulosa sphagnosum	Piceetum myrtillosum	Piceetum myrtillosum	Palus caricoso sphagnosum	Pinetum myrtillosum humidus	Pinetum myrtillosum sphagnosum	Piceetum myrtillosum	Palus caricoso sphagnosum
	IV		V[a]	IV	V		V	V	III	
	130		320*	130	190		90*	230*	90*	

Fig. 6. Fragment of landscape profile in pine-dominated, highly paludified, denudation-tectonic, hilly-ridge landscape with glacial deposits (for symbols see Fig. 3).

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Forests in the Kostomuksha Nature Reserve : natural characteristics and dynamic pattern

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Abstract

The terrestrial ecosystems of the Kostomuksha Nature Reserve are mainly represented by forest coenoses. The typological spectrum, quantitative ratio, areal distribution and internal structure of forest coenoses are discussed in connection with the landscape characteristics of the study area. Forest ecosystems are typical to the north taiga subzone in Eastern Fennoscandia and are characterised by predominance of conifers, a variety of common plant species and normal productivity. Undergrowth or second spruce storey is observed below the canopy in over 60% of green-moss pine forests. The present-day large scale replacement of pine by spruce is thought to be a natural process in which virgin forest coenoses affected by sporadic fires were regenerated. Because of protective measures in nature reserve, large scale fires are unlikely. Therefore, pyrogenic pine stands are expected to be gradually replaced by spruce forest. In the future, spontaneous forest structure can only be retained by maintaining the fire regime formed in the late half of Holocene time.

Key words: forest ecosystem, forest landscape, fire regime, biogeocoenoses

Introduction

Forests are a major biotic component of terrestrial ecosystems in the Kostomuksha Nature Reserve. Spontaneous or anthropogenic forest dynamics is responsible for changes in the entire terrestrial biota as well as faunistic and floristic complexes. It seems, therefore, that the study of the various aspects of forest ecosystems in the Kostomuksha Nature Reserve is of primary importance.

Material and methods

The study of the forest cover was undertaken as a part of the landscape - ecological investigations in Karelia. Relevant methods are described in the article 'The landscapes characteristics of the Kostomuksha Nature Reserve in this publication. The methods used for studying the structure and dynamics of forest coenoses are described in Gromtsev (1993) and Volkov et al. (1995). These include the analyses of the archives, the description of forest biogeocoenoses on landscape profiles and in field observations, the stratigraphic analyses of peat deposits (locating and dating fire layers), dating fire scars on trees etc. On four landscape profiles, totalling about 20 km in length, some 150 forest biogeocoenoses were described, 125 holes were drilled in peat deposits (average thickness 1,0 m) and stratigraphically analysed and 45 fire scars were dated.

Results and discussion

General characterization of forests

Forests cover an area of about 30 000 hectares and account for over 60% of the Kostomuksha Nature Reserve (Table 1). Inland waters (23%) and mires (11,5%) are other common landcategories.

Table 1. Major landcategories in the Kostomuksha Nature Reserve (based on forest management record).

Land category	Area, ha	%
1. Forested area	29357	61,9
2. Unforested area	1345	2,8
including:		
a) thin forest	1180	2,5
b) burned-out forest and dead stands	57	0,1
c) cutting area	26	-
d) glades and barren land	82	0,2
3. Other	16755	35,3
including:		
a) hayland	89	0,2
b) waters	10891	22,9
c) roads and cuttings	78	0,2
d) mires	5497	11,6
e) sand	2	-
f) other lands	198	0,4
Total area	47457	100,0

Pine forests account for almost 84% of the forested area, spruce (16%) and deciduous species (less than 100 ha, 0,5%) being less abundant (Table 2). Forest habitats are dominated by a blueberry (*Vaccinium myrtillus*) type (60,7%). Most pine and spruce forests grow under blueberry and long stem moss type conditions.

80 to 160-year-old stands are predominant (over 70%, Table 3). Forest coenoses older than 200 years account for less than 10%.

Table 2. Forest types* in forested areas (based on forest management record).

Predominant species, ha / %

Forest type	Pine	Spruce	Birch	Aspen	Total, ha	%
1. Rupicolous	103 / +**	-	-	-	103	+
2. White moss	875 / 4	-	-	-	875	3,0
3. Calluna	1144 / 5	-	-	-	1144	4,0
4. Vaccinium vitis-idaea	3090 / 13	28 / 1	10 / 11	-	3128	10,8
5. Vaccinium myrtillus	15869 / 65	1867 / 40	45 / 47	2 / 100	17783	60,7
6. Oxalis	3 / +	2 / -	7 / 7	-	12	-
7. Long-stem moss	1042 / 4	1925 / 41	29 / 30	-	2996	10,2
8. Ravine	+	775 / 16	2 / 2	-	777	2,6
9. Ledum	1812 / 7	-	-	-	1812	6,2
10. Carex-Sphagnum	96 / +	47 / 1	3 / 3	-	146	0,5
11. Sphagnum	526 / 2	57 / 1	-	-	581	2,0
Total, %	24558 / 84,0	4701 / 16,0	96 / +	2 / +	29357 / 100	100,0

* The concepts "forest type" and "type of biogeocoenoses" (see below) are identical.

** Less than 0,5%.

Table 3. Distribution of forested areas in terms of predominant species and age groups (based on forest management record).

Age groups		Predominant	Species ha/%		Total
(years)	Pine	Spruce	Birch	Aspen	ha %
1-40	390	2	24	-	416
	1,5	+*	25,0		1,4
41-80	2118	108	51	1	2278
	8,7	2,3	53,2	50,0	7,8
81-120	9351	1447	20	1	10819
	38,0	30,9	20,8	50,0	36,8
121-160	8090	2316	1	-	10407
	33,0	49,3	1,0		35,5
161-200	2735	771	-	-	3506
	11,2	16,4			11,9
201-240	807	53	-	-	860
	3,3	1,1			3,0
241-280	1042	4	-	-	1046
	4,3				3,6
>281	25	-	-	-	25
	+				+
'Total ha, %	24558	4701	96	2	29357
	100	100	100	100	100*

Less than 0,5%.

The spruce stands show medium productivity for the north taiga subzone of East Fennoscandia and a medium density. The wood reserves in spruce stands older than 120 years are estimated at 125-140 m^3/ha.

Landscape representation of forests

The landscapes represented are most typical of the north taiga subzone of East Fennoscandia. The typological spectrum, quantitative ratio, areal distribution, phytocenotic characteristics and spontaneous dynamics of the forest coenoses are usual.

Out of 18 types of biogeocoenoses known from the north taiga subzone of Karelia 16 original types have been revealed in the nature reserve. Despite variable paludification and a variety of landforms, the biogeocoenotic structure of the forest cover over most of the study area is relatively uniform. The forests growing on mineral soils are clearly dominated by blueberry pine and spruce stands that account for no less than 40% (Table 4).

Lingonberry (*Vaccinium vitis-idaea*) pine forests usually account for no more than 10%. Dwarf shrub-*Sphagnum* pine stands predominate on peat-land (10-15%). Spruce forests, represented mainly by blueberry spruce stands, cover 25-35% of the woodland in this landscape.

Heavily paludified plains are commonly surrounded by denudation-tectonically derived hills and ridges with bedrock exposures. The topoecological sequence of forest coenoses observed in the landscape is thus typical of the north taiga subzone in East Fennoscandia. Here almost all types of north taiga biogeocoenoses succeed each other from hill and ridge tops with the partially exposed surface of the crystalline basement towards the central parts of large mires. The

Table 4. Biogeocoenotic structure of forests (based on landscape profile data).

Type of biogeocenosis	Area occupied in woodland, %			
	Denudation-tectonic hilly-ridge highly paludified pine dominated landscape	Denudation-tectonic hilly-rich mid-paludified pine dominated landscape		
		Terrains*		
		Large denudation-tectonic uplands	Depressions of crystalline basement	Fluvioglacial hills
Pine forests				
rupicolous	-	-	3	-
lichen	-	-	-	30
lingonberry				
rupicolous	7	-	-	-
fresh	5	7	10	53
blueberry				
rupicolous	7	-	-	-
fresh	30	42	40	10
humid	3	3	3	1
blueberry-*Sphagnum*	3	2	-	-
grass-*Equisetum*-*Sphagnum*	-	-	-	-
swampy-dwarf shrub	1	-	-	-
dwarf shrub-*Sphagnum*	8	13	15	2
sedge-*Sphagnum*	2	10	5	-
Total pine forests	66	77	76	96
Spruce forests				
blueberry				
fresh	25	7	11	-
humid	4	7	3	2
blueberry-*Sphagnum*	3	7	-	-
near-creek ravine	2	-	10	2
grass-*Equisetum* - *Sphagnum*	-	2	-	-
Total spruce forest	34	23	24	4
Forested area	$\frac{100}{56}$	$\frac{100}{87}$	$\frac{100}{66}$	$\frac{100}{100}$
Open mires	44	11	31	0
Lakes	-	2	3	0

*terrain - the biggest morphological part of landscape bedrock pine forests are confined to scarce crystalline basement exposures. On the hillsides they give way to blueberry pine stands growing on loamy sand podzols. In the more humid lower parts of hill and ridge slopes blueberry spruce forests are often in contact with creek or ravine spruce on peat soils. Dry valley forest coenoses pass into dwarf shrub - *Sphagnum* pine stands which, in turn, grade into sedge - *Sphagnum* pine forests growing on peat soils and then give way to extensive open plain mires dominated by a transitional type. It should be noted, however, that in nature some of the members of this sequence are missing.

The above mentioned forest coenoses are typical of the north taiga subzone in Eastern Fennoscandia. They are characterized by the predominance of conifers, a variety of common plant species and normal productivity (average quality class 4.5). Undergrowth or a second spruce storey is observed below the canopy of over 60% green-moss pine forests. There is no pine afforestation here. Some spruce trees growing in 100-140-year-old pine stands have already intruded the upper storey.

The part of forests growing on mineral soils have been affected by selective cuttings. The biggest pine trees have not been influenced by rot and have no fire scars. In the late 19th century, clear cuttings were done in some forests parts of the study area. Therefore, majority of stands are considered to be virgin.

The easternmost part of the nature reserve is an exception. Here fluvioglacial sediments form a compact terrain favouring the predominance of lichen and lingonberry pine forests growing on dry sandy podzols. Lichen pine stands generally grow in the highest dry oligotrophic sites, whereas lingonberry pine forests grow in more humid hillslope habitats. Other types are scarce (Table 4). The forest phytocoenoses are mainly characterized by an almost continuous lichen cover, the absence of spruce in the undergrowth and in the upper storey as well as the incompleteness of stands caused by frequent fires.

Spontaneous and anthropogenic dynamic trends in the forest cover

Pollen and spore analyses (Elina 1981) have shown that 1200 - 1500 years ago the northern (main) part of the present nature reserve was occupied by spruce forests mixed with lichen-moss and green-moss pine and birch stands. In the southern part of the territory south of the River Kivijoki, lichen and lichen-moss pine forests were mixed with spruce stands and pine forests were mixed with spruce-pine stands. Spruce was thus clearly predominant here.

The prevalence of spruce forests in the area is indirectly supported by the stratigraphic analysis of peat deposits. *Equisetum* spp. is abundant in peat deposits that accumulated in depressions between hills and ridges, but fire layers are scarce (Table 5).

Nowadays, spruce remains a predominant species in these habitats. Most fire layers are revealed in a mineral horizon along the periphery of dry valley pine forests, relevant peat deposits being no more than 0,5 m thick. This suggests that present-day spruce habitats *characterized by poor flowage* seldom suffered from fires in the past 1500-2000 years. Consequently, spruce could persist there. This is indirectly supported by an abundance of *Equisetum* in peat deposits that are typically indicative of spruce habitats. From here, spruce spread under the dry-valley pine forest canopy gradually outnumbering pine. This process was disturbed only by ground fires that destroyed spruce undergrowth. Pine forests could also reappear in areas devastated by large-scale fires. The stratigraphic analysis of peat deposits has shown, however, that 500-2000 years ago such disasters broke out in the study area once in every 500 years. Even though dry-valley pine forests could have been predominant, this period of time was long enough for spruce to replace pine at least in a blueberry-type forest habitat which prevails in the nature reserve. Thus, spruce seems to have been a predominant species over most of the study area.

Changes that have taken place in the last few centuries are largely caused by cuttings. During that period the number of fires increased markedly. Fire scar dating has shown that in the past 300 years one fire broke out in about 50 year periods in the driest forest habitats (about 70, 100, 160, 190, 260 and 300 years ago). Some fires were revealed in peat deposits that are not older than 500 years (Table 5). Most traces of disasters are found in upper peat horizons. The majority of fires were restricted to the driest bedrock and lingonberry habitats, but in the driest years they spread out affecting adjacent areas, contributing to pine regeneration and destroying spruce undergrowth beneath the pine forest canopy.

Table 5. Forest fire periodicity (based on stratigraphic analyses of peat deposits).

Fire periodicity indices (for more detail, see text)	Area occupied in woodland, %			
	Denudation-tectonic hilly-ridge highly paludified pine dominated landscape	Denudation-tectonic hilly-rich mid paludified pine dominated landscape		
		Terrains		
		Large denudation-tectonic uplands	Depressions of crystalline basement	Fluvioglacial hills
Occurrence (%)* of fire layers in peat deposit at a depth of(m)				
<0.2	8	6	0	31
0.21-0.50	6	17	22	45
0.51-1.00	8	5	11	78
1.01-1.50	7	7	7	-
1.51-2.00	0	0	0	-
Total occurrence (%) of fire layers in drillholes	20	29	25	92
Average number of fire layers per drillhole at a depth of(m)				
<0.2	0.09	0.06	0.25	0.40
0.21-0.50	0.08	0.17	0.10	1.3
0.51-1.00	0.15	0.05	0.07	1.8
1.01-1.50	0.07	0,07	0	-
1.51-2.00	0	-**	0	-
Average number of fire layers per drillhole	0.26	0.29	0.30	3.0
Maximal number of fire layers per one drill-hole, years ago				
<300	0	1	0	0
300-750	0	0	2	1
750-1500	3	0	-	5
Total number of fires based on record drillhole data	3	1	2	6

*Number of drillholes with at least one fire layer (%) relative to the total number of drillholes

**No data

It can be assumed that spruce is the naturally dominant species for nature reserve. The spread of pine forests in the last few centuries was due to the anthropogenic transformation of the natural fire regime formed in the last quarter of Holocene. The present-day large-scale replacement of pine by spruce is thought to be a natural process in which virgin forest coenoses affected by sporadic fires were regenerated. Because preventive measures are being taken in the nature reserve, large-scale fires are unlikely. Therefore, pyrogenic pine coenoses are expected to be gradually replaced by spruce forest. These woody plant successions are accompanied by the accumulation of coarse humus forest litter and undecomposed plant remnants. In addition biodiversity decreases.

The pine forests growing in the easternmost part of the nature reserve are an exception. It has been shown by fire scar dating that 100-150 years ago these lichen and lingonberry pine forests were affected by ground fires approximately once in 30 years. The stratigraphic analysis of peat deposits (Table 5) indicate that 300-1500 years ago six large-scale fires, that affected even some paludified areas, broke out here. Obviously there were more fires that did not influence waterlogged areas. As a result, spruce forests were completely destroyed and pine forests were thinned. Pine regenerated successfully beneath the windows formed in the canopy or in burned-out areas on partially mineralized substrate. Consequently, the above pine forests are at different stages of a distinct natural pyrogenic succession.

Conclusions

The forests presently growing in the nature reserve are most typical of a north taiga subzone in East Fennoscandia. In the last few centuries, however, the structure of virgin forest communities has substantially changed here and in other parts of the region because the economic development of the territory led to more frequent forest fires. Because protective measures are now being taken in the nature reserve, the primary composition of the forest cover is being gradually regenerated. In the future, spontaneous forest structure can only be retained by maintaining the fire regime formed in the late half of Holocene.

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Mires and paludified forests of the Kostomuksha Nature Reserve

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Abstract

The paludification and typological structure of the mires in the Kostomuksha Nature Reserve are not homogeneous. They depend on the landscape characteristics of the area. Mires cover 20 –75% of the virgin landscape. They are subdivided into open mires, forest mires and paludified forests. Raised bogs and poor fens are predominant mire complexes in the reserve. Paludified forests account for about 30% of peatlands, *Vaccinium myrtillus-Sphagnum* and *Equisetum fluviatile-Sphagnum* spruce stands being most common. In this area paludification began in the end of the Boreal period. Some mires are of lacustrine origin. Their peat deposits are 1-2 to 6 meters thick.

Key words: open and forested mires, paludified forests, paludification degree, origin of mire ecosystems

Introduction

Mire ecosystems are important components in the structural organization of taiga areas. At the same time paludification degree as well as the rate and trends of mire formation are close to some landscape characteristics, primarily the topography and soil-forming rock properties of the study area. Two types of landscape differing in the degree of paludification are distinguished in the Kostomuksha reserve (Gromtsev et al. 1997, this issue).

The main goals of the present investigation were to assess the degree of paludification, to determine mire types and to elucidate their origin and stratigraphy in different parts of the reserve.

Materials and methods

Mires were studied in in the most typical parts of landscape (Volkov et al. 1990; Kolomytsev 1993). Forest and mire vegetation was described and soils and quaternary deposits were studied along the profiles. To study mire stratigraphy, peat samples were taken with a Russian peat sampler every 20-25 cm down to the bottom. Macrofossil analysis was made and the degree of decomposition of peat samples was determined with microscopic method (Korotkina 1939). Peat types are distinguished according to the classification of Tyuremnov (1976), peat deposit types according to Kuznetsov (1988).

When analysing the plant cover of the reserve, mires are subdivided into three categories: paludified forests, forested mires and open mires. In Russia, paludified forests are generally understood as wet areas with a thin (less than 30 cm) peat layer and field layer with a dominance of hydrophilic plants (Tyuremnov 1976). Forest mires have a peat layer, which is over 30 cm thick, and a woody layer with crowns covering at least 30%. Their wood stand volume is over 40 m^3/ha. Other mire sites are defined as open mires, although some of them have scarce stands. Paludified forests and forested mires are not distinquished in Finnish mire and forest typology (Ruuhijärvi 1983; Heikurainen 1986; Eurola et al. 1994), but they often have considerable differences in the origin and trends of successions.

The structure of mire ecosystems is discussed at three levels: mire site, mire complex and system of mire complexes (Galkina 1959). Mire sites and their types (mire types) are distinguished by Karelian and Finnish researchers in similar manner (Eurola et al. 1994).Mire complexes are classified according to the types of mire sites dominating on them. An aapa type includes only mire complexes with typical string-flark microrelief in their central parts (Kuznetsov 1986).

Results and discussion

Mires of heavily paludified landscape (paludification 50%)

Heavily paludified, pine-dominanted, denudation-tectonic hilly to hilly-ridge landscape with glacial deposites 13 g (g=glacial) (Volkov et al. 1990) is located in the watershed north of Lake Kiitehenjärvi. Topographically it is characterized with gentle slopes and extremely small relative vertical ruggedness (1-5 m) typical of plain landscape. Because the area is flat, its degree of paludification is very high (60%). It is similar in this respect to plains, despite some differences in origin and morphometric parameters. Structurally, the landscape is dominated by mires that form an intricate system of mire complexes. As a result of paludification, forest grows here on insular uplands separated from each other and surrounded by mires (See Figure 1 in Gromtsev et al., this issue). This is a rare phenomenon because heavily paludified areas are commonly cut by rivers and lakes so that mire systems located within a fluvial or fluviolaucstrine network cannot be regarded as a single spatial structure.

This mire system is dominated by raised bogs and poor fens, but it is very difficult to distinguish individual mire complexes. There are not many types of mire sites. Ombrotrophic *Fuscum* humnock bogs and hollow bogs are predominant in the central flat parts of the system, whereas pine -dwarf shrub-*Sphagnum* and pine -*Eriophorum* -*Sphagnum* mire types are confined to more dry margins (Table 1).

Open mesotrophic and meso-oligotrophic *Carex-Sphagnum* and *Eriophorum-Carex-Sphagnum (Sphagnum papillosum, S. angustifolium)* mire types occur as narrow strips of runoff water tracks.

Table 1. Percentage of mire categories in landscape 13 g.

Category	Forest formation		Total
	Pine forests	Spruce forests	
Paludified forests	5	5	10
Forest mires	15	6	21
Total forest mires	20	11	31
	Water-mineral nutrition types of mires		
	Ombrotrophic	Mesotrophic	
Open mires	58	11	69

Most of the mire complexes of this landscape, conjucted into mire systems during their development, are of limnic origin. That is indicated by small remnant lakes and sapropel layers under their peat deposits (Fig. 1). Peat deposits in the central parts of these mire systems are about six meters thick. Such mires began forming in the late Boreal-early Atlantic period (Elina 1981). However, in this landscape average peat thickness is 2-3 meters. Ombrotrophic Scheuchzeria-*Sphagnum* and mesotrophic *Carex-Sphagnum* peat deposits are predominant (Kuznetsov 1988). In marginal *Eriophorum-Sphagnum* mire types the peat thickness is 2-2.5 meters. The bottom strata of the deposit consists of woody -*Carex* mesotrophic peat overlain by *Eriophorum* peat, and the uppermost 0.5-0.7 m peat layer is composed of ombrotrophic *Sphagnum* peat.

Forest mires are presented by dwarf shrub-*Eriophorum-Sphagnum* pine stands that account for 15% of mires in the landscape (Table 1). Such pine mires were generally formed along mire margins as ca. 100 meters wide strips. Stands of mire forests are sparse, low (6-10 m) and low productive. The field layer consists of dwarf shrubs, *Eriophorum* and *Rubus chamaemorus.* The bottom layer is composed of *Sphagnum* angustifolium, S. memoreum and forest mosses. In the pine mires the peat deposit is homogenious from bottom to top and consists of dense, strongly decomposed woody peat. This indicates considerable variations in groundwater level.

Spruce mires are generally represented by a *Vaccinium myrtillus-Sphagnum* type and occupy 6% of mires (Table 1). They are confined either to the narrow depressions or mire margins. The peat deposit is no more than 0.7 m thick. The peat is woody and highly decomposed. In this landscape, paludified forests account for only 10% of mires. It is an important diagnostive feature which can be used to distinguish between glattened denudation - tectonic landscapes and planes of limnoglacial origin, where paludified forests account for about half of the mire

Paludified forests and forest mires are similar in the productivity and of stands, but differ in the ground cover and peat thickness. Human activities have not affected mires in this type of landscape.

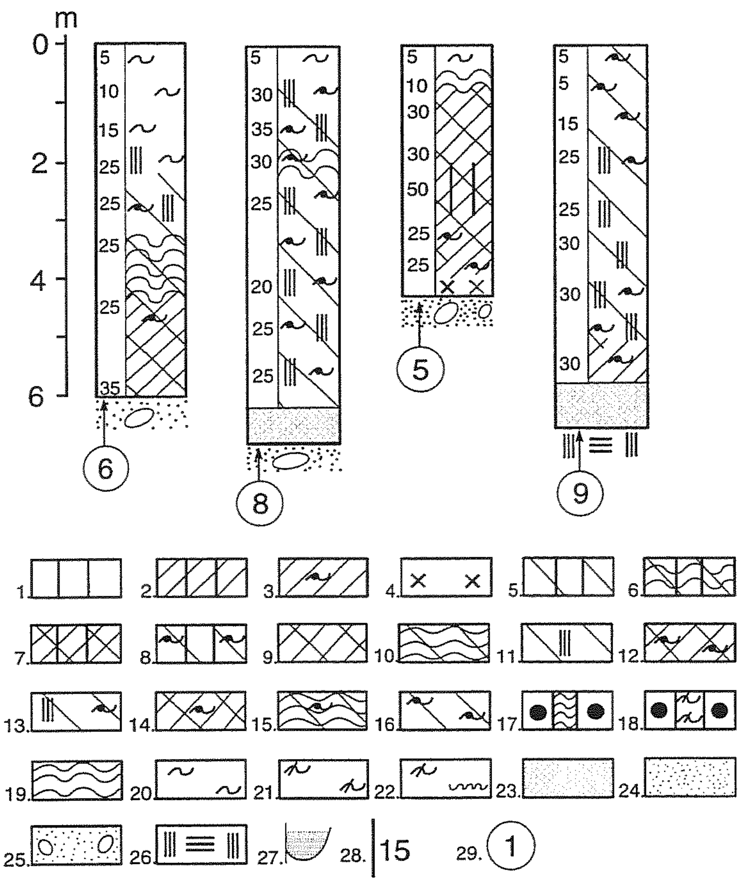

Fig. 1. Stratigraphic columns for mires in landscape 13 n. Peat types: 1-4 = fen types: 1 = woody, 2 = woody-sedge, 3 = sedge-Sphagnum, 4 = horesetail; 5 - 16 = transitional types: 5 = woody, 6 = woody-cottongrass, 7 = woody-sedge, 8 = woody-Sphagnum, 9 = sedge, 10 = cottongrass, 11 = Scheuchzeria, 12 = sedge-horsetail, 13 = Scheuczeria-Sphagnum, 14 = sedge- Sphagnum, 16 = Sphagnum; 17 - 22 = raised types: 17 = pine-cottongrass, 20 = Sphagnum-hollow, 21 = Fuscum, 22 = complex Sphagnum; 23 = sapropel, 24 = sand, 25 = till, 26 = clay and silt, 27 = water, 28 = decomposotion degree, %, 29 = drillhole number

Mires of mid-paludified landscape (paludification 15-50%)

The Kostomuksha Nature Reserve is located in a pine-dominated, mid-paludified denudation-tectonic hilly to hilly-ridge landscape (14g, g = glacial). Glacial deposits were formed here. This type of landscape is predominant in the north taiga subzone of Karelia. It has three types of terrains within the Nature Reserve (Gromtsev et al. 1997, this issue.). In this landscape paludification varies from 32 to 75 % depending on ruggedness. It is possible to analyse the structure of mire ecosystems for each terrain.

Hilly terrain mires

The landscape discussed is formed of 40-60 m high, pine dominated hilly-ridge mid-paludified uplands of denudation-tectonic origin (Fig. 2, I). The paludification degree of this terrain is about 35 %. Open mires account for 34 % of the total paludified area (Table 2). They are normally 1-2 km long, 100-200 m wide and developed between ridges. Some of them are of limnic origin. Ombrotrophic dwarf-shrub -*Eriophorum* -*Sphagnum* and minerotrophic grass-*Sphagnum* mire complexes dominate on open mires there. Dwarf-shrub-*Sphagnum* and *Eriophorum-Sphagnum* mire types are dominant in the central parts of ombrotrophic bogs, whereas pine-dwarf-shrub-*Sphagnum* communities are confined to their marginal parts. *Carex-Sphagnum* mire types dominate on minerotrophic mires. Their margins are forested (Elina & Kuznetsov 1977). The thickness of peat deposits is 2-4 m. They are generally woody-*Carex*, woody-*Sphagnum* mesotrophic-ombrotrophic or ombrotrophic types (Kuznetsov 1988). The thickness of ombrotrophic peats varies from 0.5 to 2 m, bottom layers are formed by the woody or woody-*Carex* mesotrophic peat in nearly the all sections investigated. Pine dominates in macrofossil composition of woody peats. It points out the terrestrial origin of these mires.

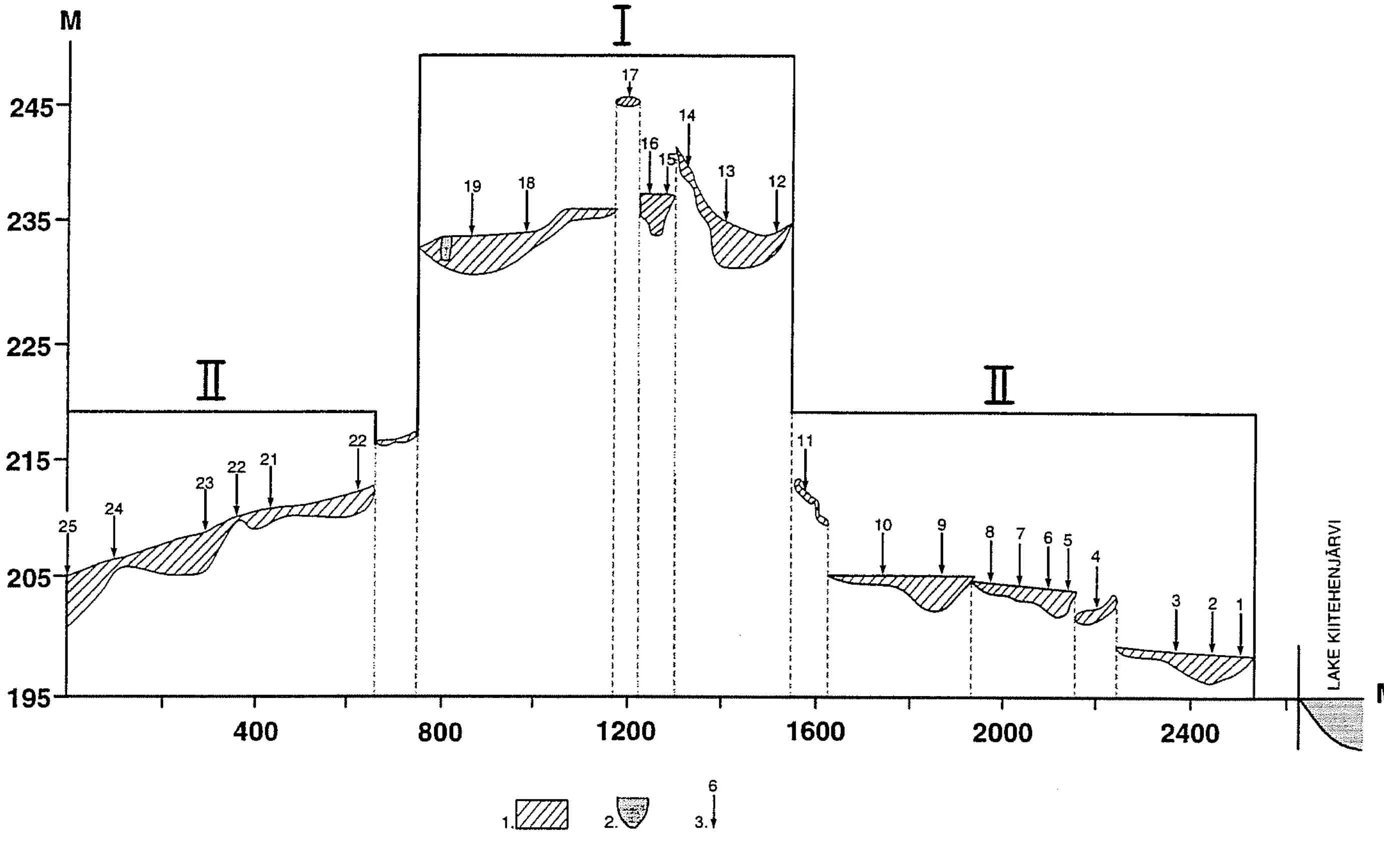

Fig. 2. Position of mires in landscape profile, landscape 14 n (Auromorphic forests growing between mires are not indicated). I - pine-dominated, mid-paludified big ridge-hilly upland terrain of denudation-tectonic genesis. II - pine-dominated, heavily paludigied, small ridge-hilly crystalline basement depression terrain. 1 - peat, 2 - water, 3 - numbers of stratigraphic sections (columns).

Table 2. Percentage of mire categories in mid-paludified large ridge-hilly upland terrain of denudation-tectonic origin (landscape 14 g).

Land category	Forest formations		TOTAL
	Pine forest	Spruce forests	
Paludified forests		55	55
Forest mires	11	-	11
Total forest mires			66
	Water-mineral nutrition types of mires		
	Ombrotrophic	Mesotrophic	
Open mires	18	16	34
Total swamp land			45

The high acidity (pH 3.0-5.0) and low ash content (2.8-8.0) of the peat observed throughout the entire peat deposit indicate poor mineralization of ground waters provided with the mire water-mineral nutrition during all the period of its development. The stratigraphy of the peat deposits in the mires studied shows the fairly synchronous plant cover successions depending on climatic and hydrological conditions within the entire landscape (Fig.3).

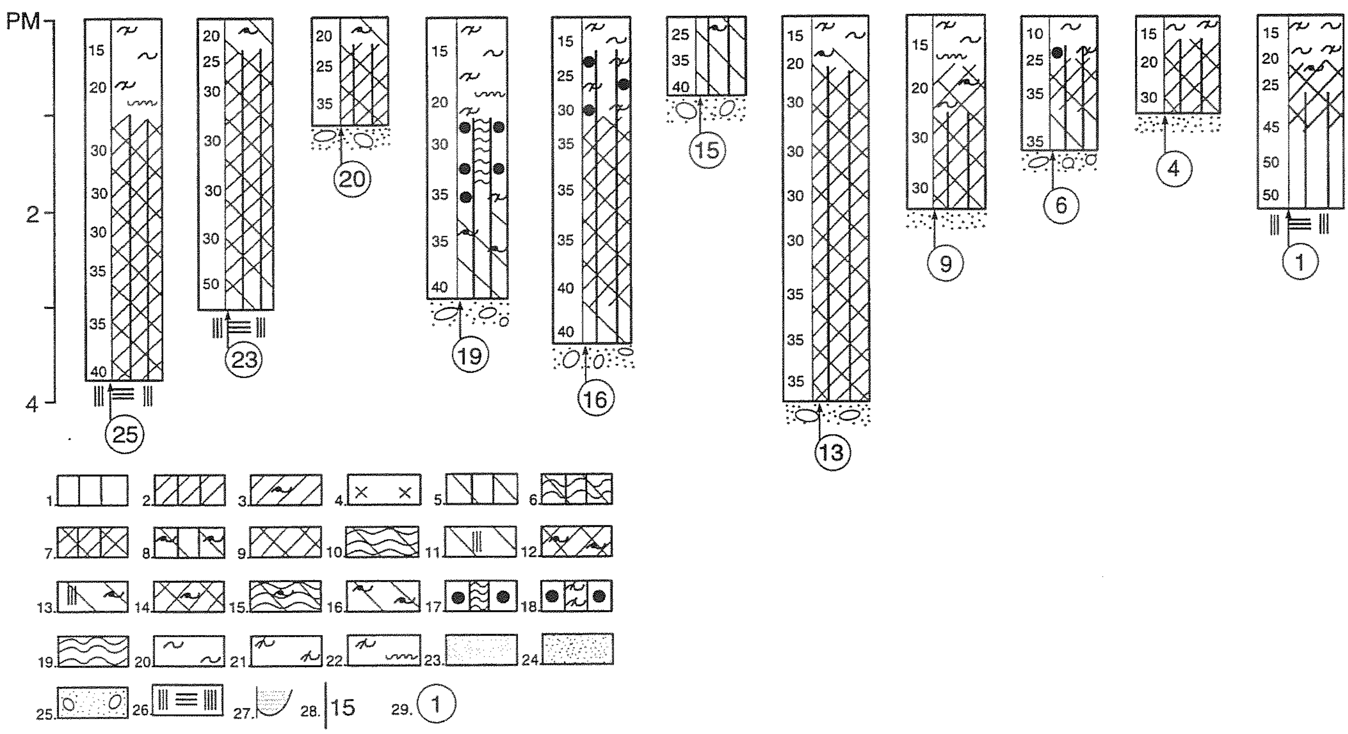

Fig. 3. Stratigraphic columns for mires on landscape profile (Fig. 2). For symbols, see Fig. 1.

There are two spruce mire types distinguished in this terrain: *Vaccinium myrtillus-Sphagnum* and *Equisetum fluviatile-Sphagnum*. They usually form a dynamic ecological range from paludified forests with a 20-30 cm thick peat layer to forested mires with a 1-2 m peat deposits, which are generally composed of woody and woody-*Carex* mesotrophic peats. Athin layer of woody-*Sphagnum* and *Sphagnum* peats indicates a recent appearence (about 1000 years) of *Sphagnum* mosses on these mires (Fig.3, drillholes 6, 15 ,20).

Mires of terrain of depressions between hills

Pine-dominated small ridge-hilly, intensely paludified crystalline basement depression terrains are characterized by flat relief and lie at an absolute altitude of 195-200 m, relative altitudes between mineral and paludified lands varying from 10 to 20 m. In this type of terrain the degree of paludification (63-75%) is due to poor drainage caused by the flat relief and the fact that most of the mires originate from shallow-water bays of Lake Kiitehenjärvi and other small relict lakes (Fig. 2 II, Table 3). The mire formation processes in kettles were also favoured by crystalline basement scarps that prevent drainage. Field investigations have shown that nowadays the paludification of shallow bays in small lakes, e.g. Lake Kalivo, is rather intensive.

Table 3. Percentage of mire categories in small ridge-hilly depression terrain (Landscape 14 g).

Category	Woody species		TOTAL
	Pine forests	Spruce forests	
Paludified forests	16	11	27
Forest swamps	24	1	25
Total forest swamps	40	12	52
	Mire types on nutrient status		
	Ombrotrophic	Minerotrophic	
Open mires	17	31	48

Aapa, mesotrophic herb-*Sphagnum* and ombrotrophic dwarf-shrub-*Sphagnum* mire complexes are now common in this terrain. Typical aapa mires with well developed string-flark microtopography in their central parts lie west of the River Munanki. However, no stratigraphic studies have been done there. Mesotrophic herb-*Sphagnum* mires with scarce or no pine and birch are widespread in the former bays of Lake Kiitehenjärvi, along river banks and in kettles provided with a constant water runoff. A stratigraphic section through a mire on the shore of Lake Kiitehenjärvi is depicted in Figure 4. It can be seen that the peat layer is underlain by sapropel at different hypsometric levels, indicating variations in the lake water level in Holocene time.

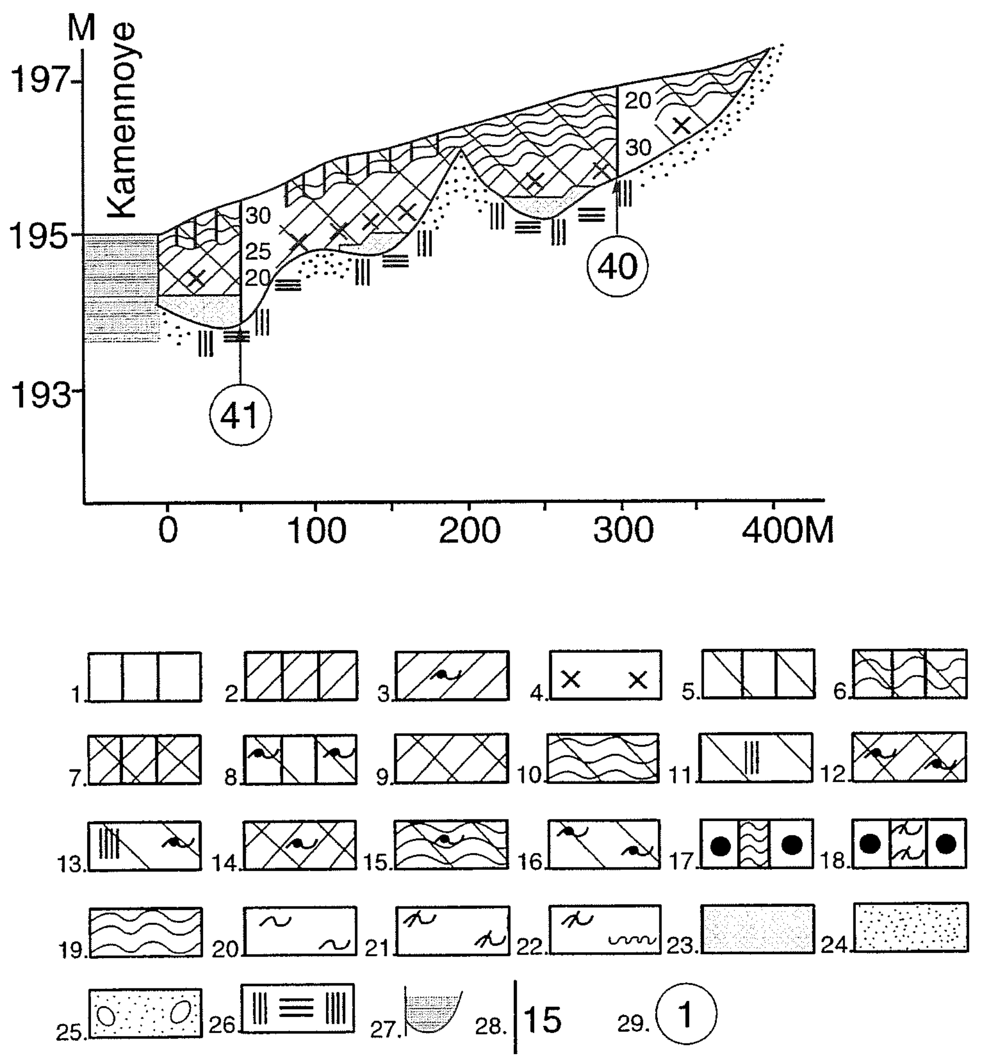

Fig. 4. Stratigraphic column for the mire lobated on the north shore of Kamalahti Bay, Lake Kiitehenjärvi. For symbols, see Fig. 1.

The stratigraphy of the mires studied in this terrain by landscape profiling (Fig. 3) shows that woody-*Carex* mesotrophic and meso-ombrotrophic deposits, in which the uppermost 25-75 cm layer is composed of ombrotrophic or mesotrophic *Sphagnum* peats, are predominant. It is noteworthy that the bottom layer resting on silt and sand is represented by mesotrophic or eutrophic woody-*Carex* and woody peats. It is an evidence of terrestrial origin of these mires. The deepest parts of mires, where the limnic stage of mire formation could probably be found, were not included in our investigations.

Forested mires are represented by dwarf-shrub-*Sphagnum* mire type confined to marginal parts of open mires. They account for 1/4 of the total mire area in this terrain (Table 3).

Mires of small ridges terrain of glacio-fluvial origin

No stratigraphic studies were conducted in the pine-dominated, mid-paludified, small ridge-hilly terrain of glacio-fluvial origin located along the banks in the middle of River Kivijoki. Here, paludification does not exeed 20 as indicated by forest management materials and maps. Earlier studies in other parts of Karelia show that quantitative and qualitative characteristics of mires and paludified forests are very similar (Kolomytsev 1993). This suggests that the terrain is dominated by ombrotrophic mire complexes with *Scheuchzeria-Sphagnum* mire site type in their central parts and pine-dwarf-shrub -*Sphagnum* ones on their margins.

The mires are fairly small there (up to 10 ha) because they were formed in kettles (closed basins of thermal karst and suffosion origin among sandy hills differing in configuration). Forested mires and paludified forests also occur there.

The mire ecosystems study of the Nature Reserve should be continued to reveal their diversity, to elucidate their dynamics under various landscape conditions and to forecast their future development.

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Comparison of the vegetation and development of three mires in Elimyssalo Nature Reserve

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Abstract

Vegetation and dynamics of mire ecosystems has been studied in the western part of Elimyssalo nature reserve, Friendship Park. 98 permanent sample plots have been established in three mires in 1991. One of the mires, Löytösuo is an ombrotrophic eccentric bog, the others, Joutensuo and Salmisuo minerotrophic aapamires. In each sample plot, the vegetation has been studied in a relevé of 1 square metre. In two sampling sites peat cores from the mire surface to bottom have been taken and analysed for peat humification and macrosubfossils. The development of the site and surrounding forest was analysed using pollen analysis in one core.

The vegetation of the sample plots was divided into seven groups using TWINSPAN classification. These groups are used further as the basis of the monitoring of short-term dynamics in ecologically different vegetation types. The stratigraphical analysis shows that the hummock-hollow structures of Löytösuo have been rather stable over the latest millennium, and that the vegetation has been very poor all through the development of the mire. Salmisuo has a lacustrine origin, and wet poor minerotrophic communities have dominated throughout the development.

Key words: Vegetation, stratigraphy, mires, succession

Introduction

Mires are optimal habitats when studying the changes in nature. In addition to the understanding of the present mire ecology knowledge about the past of the mires is needed. Thus, the aim of this study was **1)** to analyse the structure and differences of minerotrophic and ombrotrophic mires, **2)** to analyse the the background of the differences in present vegetation in different sites and **3)** to analyse the history and development of mire in relation to the vegetation history of Eastern Kainuu and the watershed area between the Baltic Sea and White Sea.

Also monitoring of short-term changes in vegetation and ecological conditions to analyse the natural variation and possible human influence on the mire ecosystems has been started in the summer 1991.

It is obvious that there is great small-scale variation of the microhabitats of mires (e.g. Lindsay et al. 1985, Økland 1989a) due to small-scale variation in hydrological and nutrient conditions (e.g. Lumiala 1945). Therefore, sample plots were placed in the mire in nearby sites with visibly different hydrological conditions. The aim was also to study the explanation of the boundary between omrotrophy and minerotrophy in transitional mires with no clear morphological explanation to differences in vegetation (see Sjörs 1948, Ruuhijärvi 1960, Eurola 1962, Galten 1987, Økland 1989a). Also the importance of water supply and water table for the vegetation and occurrence of different *Sphagnum* species was studied (see Lumiala 1944, 1945, Sjörs 1990). The importance of seasonal changes in water table, snow cover and ground frost conditions have been studied in boreal and subarctic conditions (Eurola 1968, 1975, Sonesson 1969). In Kuhmo the climate is more continental than in the areas studied previously, and the snow cover is more thick, and the duration of it is longer. Such conditions have been poorly known. One more important point to explain the present vegetation of mires is the Holocene development of the mire and its surroundings (e.g. Elina 1981, Elina & Filimonova 1995, Vasari et al. 1995). Therefore it is necessary to connect the present vegetation with the history determined using pollen and macrosubfossil analyses.

As a part of the Finnish-Russian cooperation in ecological research in the nature reserve Friendship, vegetation, stratigraphy and dynamics of mire ecosystems has been studied in the western part of Elimyssalo nature reserve adjacent to the Finnish-Russian boundary. One of the main ideas in the cooperation is to compare and intercalibrate the concepts and methods of research in Finland and in Russia. The best way in this is that scientists of both traditions meet solving together the problems of the study.

The vegetation of mires has earlier been studied in Kainuu by Ruuhijärvi (1960) and Havas (1961). Kaakinen & Kukko-oja (1981) evaluated the biodiversity and conservation of rich fens in Kainuu. In the Finnish-Russian cooperation programme of the nature reserve Friendship the hydrodynamics of the mires in relation to the conservation (Keränen et al. 1995) and the vegetation of mire margins (Tolvanen 1994) have been studied. Stratigraphical studies are very few in the region in comparison to the Finnish northern Karelia (e.g. Tolonen 1967a) and Kostamus region (e.g. Elina & Kuznetsov 1977, Elina 1981, Kolomytsev & Kuznetsov 1997).

Materials and methods

Altogether 98 permanent sampling plots were laid in the mires in July, 1991 to cover the main structural and ecological features. In each plot, vegetation was studied in one 1 m^2 relevé using cover percentages in the scale of +, 0.5, 1, 2, 3, 5, 7, 10, 15...90, 93, 95, 97, 98, 99, 100 (Heikkilä 1987). Monitoring of the vegetation was conducted in the plots in 1996. Only the results from the year 1991 are reported in this paper.

The nomenclature of vascular plants follows Hämet-Ahti et al. (1986) and that of bryophytes Koponen et al. (1977).

In each sample plot also the level of mire water is measured in ground water wells once a week as well as snow depth in winter. The ground frost depth is monitored using the methylene blue method (Anon. 1984) simultaneously in 40 of the sample plots. The time series results of some representative plots are presented in this study.

Peat corings were made in the deepest part of Löytösuo in 1991 for pollen analyses. In 1992, additional corings with a Russian type peat sampler (Tolonen 1967b) were made at the same site to collect material for macrosubfossil analysis. Pollen analyses were conducted using standard methods in Helsinki by Ms. Tuija Hänninen (Berglund & Ralska-Jasiewiczowa 1986) and macrosubfossil analyses in Petrozavodsk by Ms. Natalia Stoikina (Dickson 1986, Grosse-Brauckmann 1986, Wasylikova 1986). On the basis of content of macrosubfossils in stratigraphic layers palaeocommunities were determined.

The vegetation data was classified using TWINSPAN classification (Gauch 1982) in the CANOCO program package (ter Braak 1987) without any transformations of the data, in order to form ecological groups. Ecological gradients were defined using DCA ordination (Hill 1979) in the CANOCO program package.

Study area

In general, the study area lies in the zone of Pohjanmaa aapa mires in the section of Kainuu (Ruuhijärvi 1960, Ruuhijärvi & Hosiaisluoma 1988, Fig. 1) on the watershed between the Baltic Sea and White Sea. The forests of the study area belong to the middle boreal zone according to the Fennoscandian tradition (Ahti et al. 1965) and Northern Taiga in the Russian tradition (Yurkovskaya 1993).

The studies were conducted in three nearby mires (Fig. 1). Two of them, Joutensuo (38 hectares) and Salmisuo (15 hectares) are small aapa mires, typical of this region while large aapamires with a string and flark pattern are rather rare in Kainuu (Ruuhijärvi & Hosiaisluoma 1988). Löytösuo (29 hectares) is a small eccentric bog. Those are also common in Kainuu as well as in Kostamus region, but large ones are lacking (Keränen et al. 1995, Tolvanen & Teeriaho 1996, cf. Ruuhijärvi & Hosiaisluoma 1988, Elina & Kuznetsov 1977, Kolomytsev & Kuznetsov 1997).

The bedrock in the region is a part of the granite-gneiss complex of eastern Finland. The bedrock is mainly formed of acidic granodiorites (Rankama 1964, Gorkovets & Rayevskaya 1997).The soil in the area surrounding the mires is well leached moraine, forming gently undulating drumlins on the basis of our observations. The content of Ca and nutrients in the soil is low according to analyses made in the Forest Research Institute, Karelian Research Centre (Dr. Natalia Fedorets, pers. comm.). Therefore the mires are poor in nutrients, and the vegetation typically shows minerotrophic oligotrophy or pure ombrotrophy. More rich fens are rare in this region. They occur mainly in tectonic depressions with ground water influence or along lakes and rivers (Elina & Kuznetsov 1977, Kaakinen & Kukko-oja 1981). In Elimyssalo we have found rich fens with springs and a very high diversity of flora in a tectonic depression in Härkösuo mire in the northern part of the reserve. There the maximum peat depth is 8 metres.

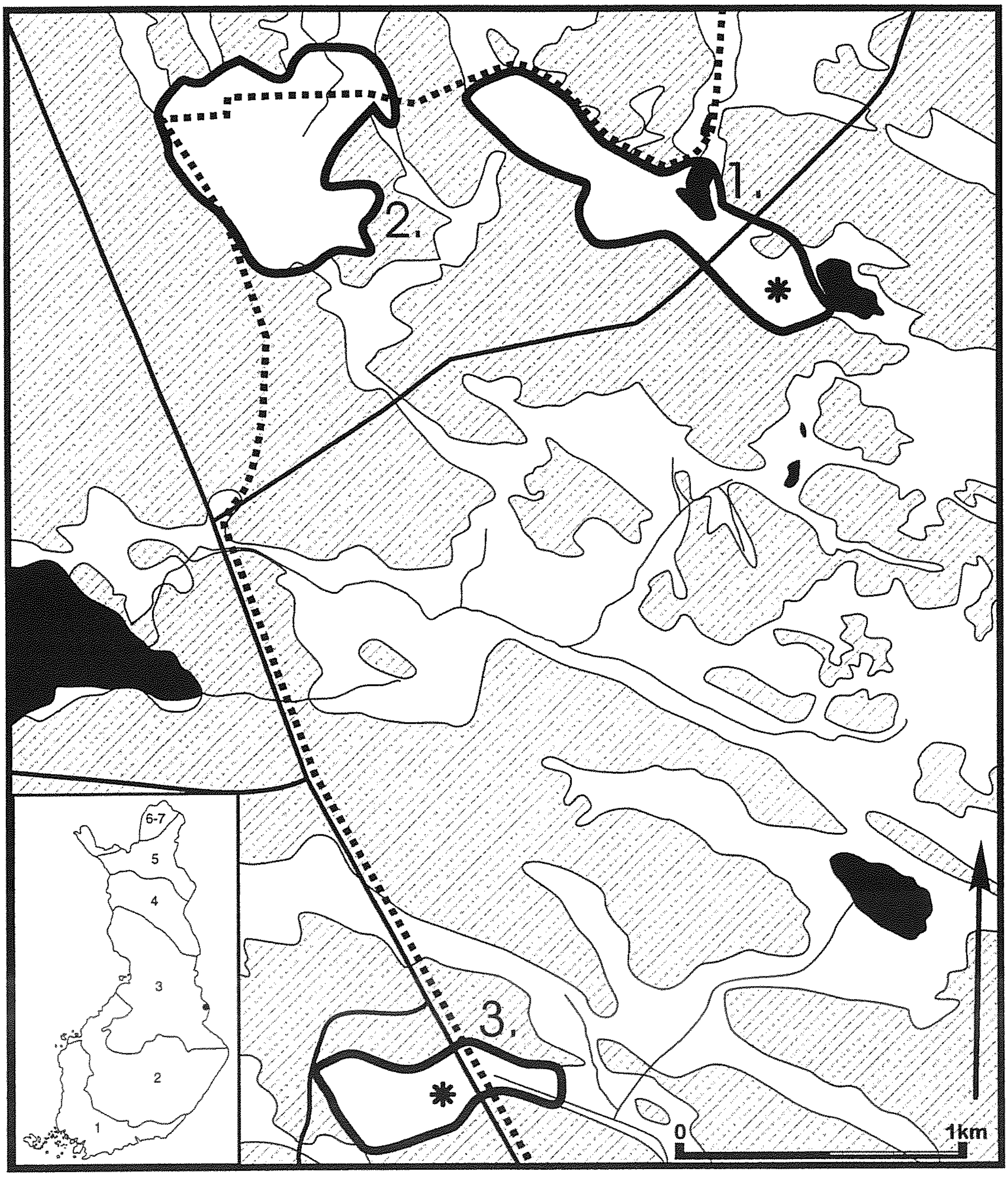


Fig. 1. Location of the study area in eastern Finland. Mire complex zones after Ruuhijärvi & Hosiaisluoma (1988), terminology modified after Aapala et al. 1996: 1 Concentric bogs, 2 Eccentric bogs and Sphagnum fuscum bogs, 3 Sedge aapas, 4 Flark aapas, 5 Northern aapa mires, 6 Palsa mires, 7 Orohemiarctic mires. The location and delimitation of the studied mires in the landscape mosaic of the western margin of Elimyssalo nature reserve. 1. Löytösuo, 2. Joutensuo and 3. Salmisuo. White = mire, Grey = mineral soil forest, Black = lake or pond, Solid thick line = road, Solid thin line = brook, Dotted line = boundary of nature reserve. Peat coring sites in Löytösuo and Salmisuo are indicated with asterisks.

The main mire site types in the central part of Löytösuo mire are *Sphagnum fuscum* pine bogs and hollow bogs forming a complex mosaic(for the mire sites, the classification of Eurola et al. 1994 has been used). There are dwarf shrub pine bogs in the margins. In the margin of the mire there is also a eustatic spring where studies also have been made. The maximum peat depth is 220 cm.

Almost 90% of Salmisuo mire is covered with a very wet oligotrophic *Sphagnum* flark fen with *Sphagnum compactum* and *S. pulchrum* as dominant species. In the margins there are dwarf shrub pine bogs. The maximum peat depth is 400 cm.

The vegetation of Joutensuo is somewhat more rich than in Salmisuo. In the mire centre there is oligo-mesotrophic *Sphagnum* flark fen with *Sphagnum pulchrum* on the carpet level and *S. platyphyllum* in the flarks. In the margins there are rather extensive dwarf shrub pine bogs and small sedge pine bogs as well as a small spruce mire. The maximum peat depth is 350 cm.

Results

Present vegetation

The vegetation cover of the microsites in the 98 sample plots was divided into seven groups (Fig. 1). The typical features for them, according to dominant moss species, are as follows: 1) *Sphagnum papillosum*, 2) *S. angustifolium - S. fuscum*, 3) *S. balticum - S. angustifolium*, 4) *S. balticum*, 5) *S. compactum*, 6) *S. majus - S. annulatum* var. *porosum* and 7) *S. pulchrum - S. annulatum* var. *porosum* (Table 1, Fig. 2).

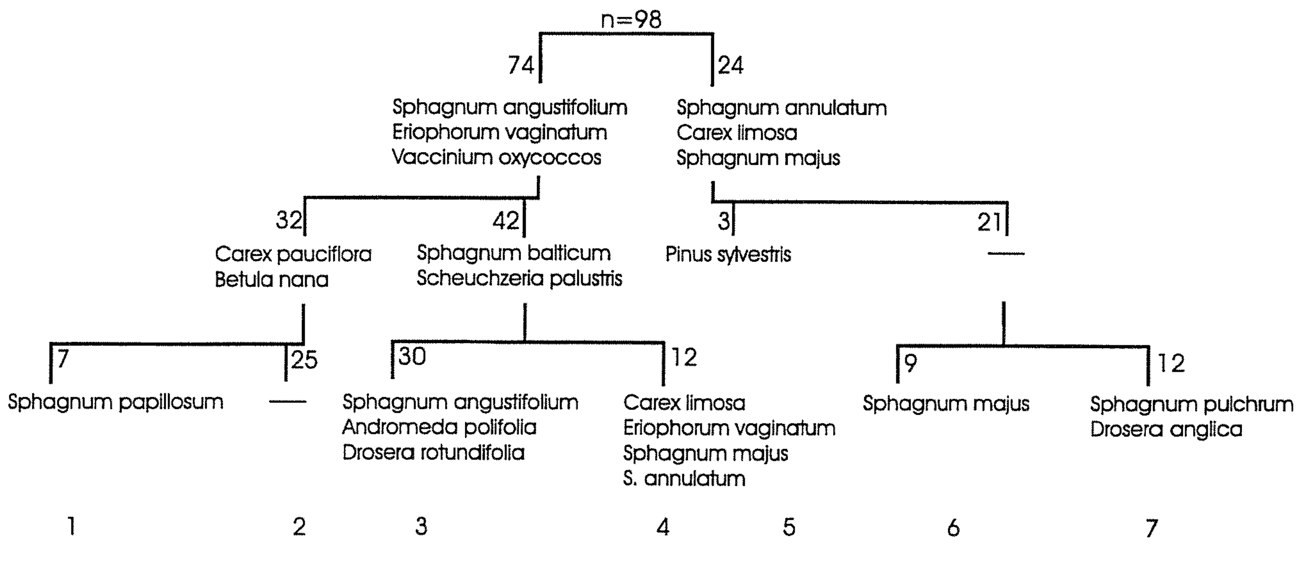


Fig. 2. TWINSPAN dendrogram of the vegetation in the sample plots. The figures show the number of sample plots in each group.

Table 1. Mean cover (C) and frequency (F) of plant species in the vegetation groups formed with TWINSPAN. The plant species are grouped as follows: I Hummock species, II Ombrotrophic lawn level species, III Minerotrophic lawn level species, IV Flark and hollow species after Eurola et al. (1994). The site types (Eurola et al. 1994) corresponding to different vegetation groups are as follows: KaN *Sphagnum papillosum* fen, RaR *Sphagnum fuscum* pine bog, LkN Small sedge bog, KuN Hollow bog, RiN *Sphagnum* flark fen, RiNoj Drained *Sphagnum* flark fen.

Group		1		2		3		4		5		6		7	
N		7		25		30		12		3		9		12	
		C	F	C	F	C	F	C	F	C	F	C	F	C	F
	Empetrum nigrum	0.2	14												
	Pinus sylvestris	0.2	28							0.2	100				
	Vaccinium uliginosum	0.2	14	2	32										
	Picea abies			0.2	4										
	Ledum palustre			0.2	4										
	Empetrum hermaphroditum			1	36										
	Melampyrum pratense			0.2	20										
	Calluna vulgaris			0.2	8										
	Pleurozium schreberi			0.2	4										
	Polytrichum strictum			0.2	12										
	Mylia anomala			0.2	20										
I	Vaccinium microcarpum			0.2	8	0.2	3			0.2	100				
	Vaccinium vitis-idaea			0.2	4										
	Sphagnum fuscum			32	68	0.5	9								
	Pohlia nutans					0.2	3								
	Rubus chamaemorus	0.2	14	2	72	0.2	3	0.2	8						
	Drosera rotundifolia	0.5	71	0.2	64	0.2	17			0.2	66	0.2	33	0.2	17
	Betula nana	0.5	70	1	68	0.2	3								
	Sphagnum angustifolium	20	86	60	100	41	80	0.2	8						
	Chamaedaphne calyculata	0.2	14	1	68	0.2	23	0.2	33						
II	Eriophorum vaginatum	0.2	14	5	96	0.5	63	3	75	0.2	33				
	Sphagnum magellanicum	10	57	1	36	0.2	27	0.2	8			0.2	11		
	Trichophorum cespitosum	0.2	14	0.2	12	0.2	6			6	100	1	33		
	Andromeda polifolia	1	100	2	100	2	97	1	92	1	100	1	89	0.2	58
	Vaccinium oxycoccos	1	100	1	96	1	100	1	100	0.2	66	0.2	56	0.2	16
	Sphagnum rubellum			4	20	0.2	9								
	Carex lasiocarpa	0.5	28												
	Eriophorum angustifolium	0.2	28												
	Carex globularis			0.2	12										
	Dactylorhiza maculata			0.2	12										
III	Carex pauciflora	4	71	2	80	0.2	10								
	Carex rostrata	1	57			0.5	10	0.2	8					0.2	25
	Sphagnum papillosum	70	86			3	9			0.2	66	7	33	9	50
	Carex magellanica							0.2	17						
	Carex limosa	1	42	0.2	8	0.2	26	1	67	0.2	33	2	89	5	100
	Scheuchzeria palustris	0.2	42	0.2	12	1	90	2	75	1	100	4	100	3	92
IV	Sphagnum annulatum	0.5	28	2	4			11	25	13	33	31	56	27	75
	Cladopodiella fluitans	0.2	14			0.2	9			0.2	66	0.2	22	0.2	50
	Sphagnum balticum			0.5	4	54	90	80	100	0.5	100	5	22	0.2	17
	Sphagnum lindbergii			1	4			2	8					16	25
	Sphagnum tenellum					1	6					7	33		

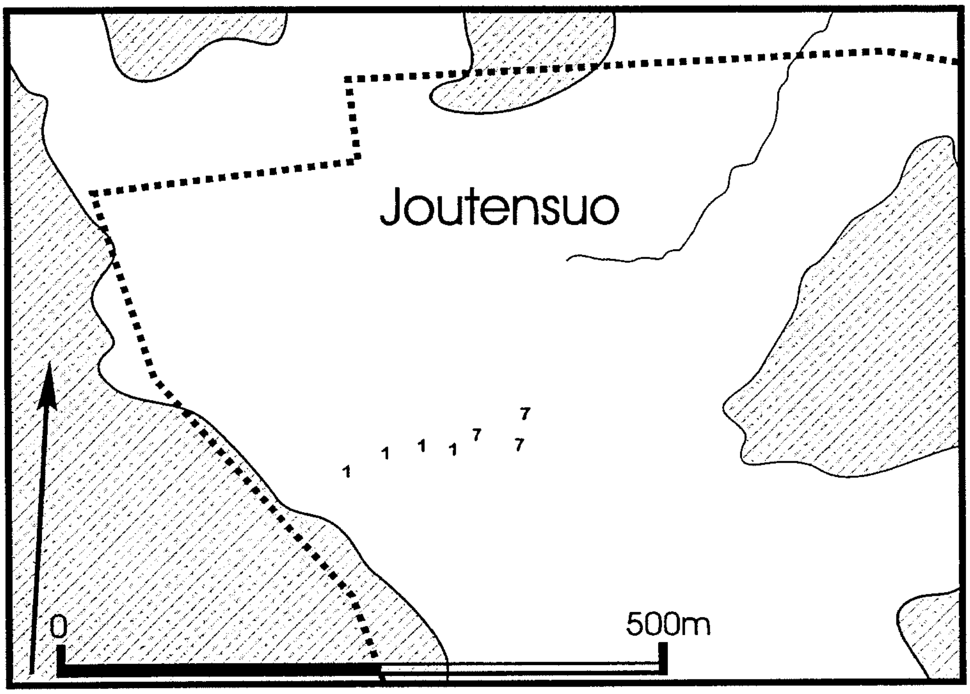
Group I		2		3		4		5		6		7			
N		7		25		30		12		3		9		12	
		C	F	C	F	C	F	C	F	C	F	C	F	C	F
IV	Sphagnum majus					1	6	7	33	0.2	33	41	78	16	42
	Warnstorfia fluitans							0.2	8					0.2	8
	Sphagnum compactum									80	100	9	33		
	Gymnocolea inflata									3	66	0.2	11		
	Drosera anglica									0.5	66	0.2	22	0.2	83
	Cetraria delisei									0.2	33				
	Mud surface									3	66				
	Sphagnum pulchrum											1	11	31	92
	Number of species in group	22		31		23		16		18		17		15	
	Mean number of species	10		11		7		7		12		7		8	
	Corresponding site type	KaN		RaR LkN		KuN LkN		KuN		RiNoj		RiN		RiN	

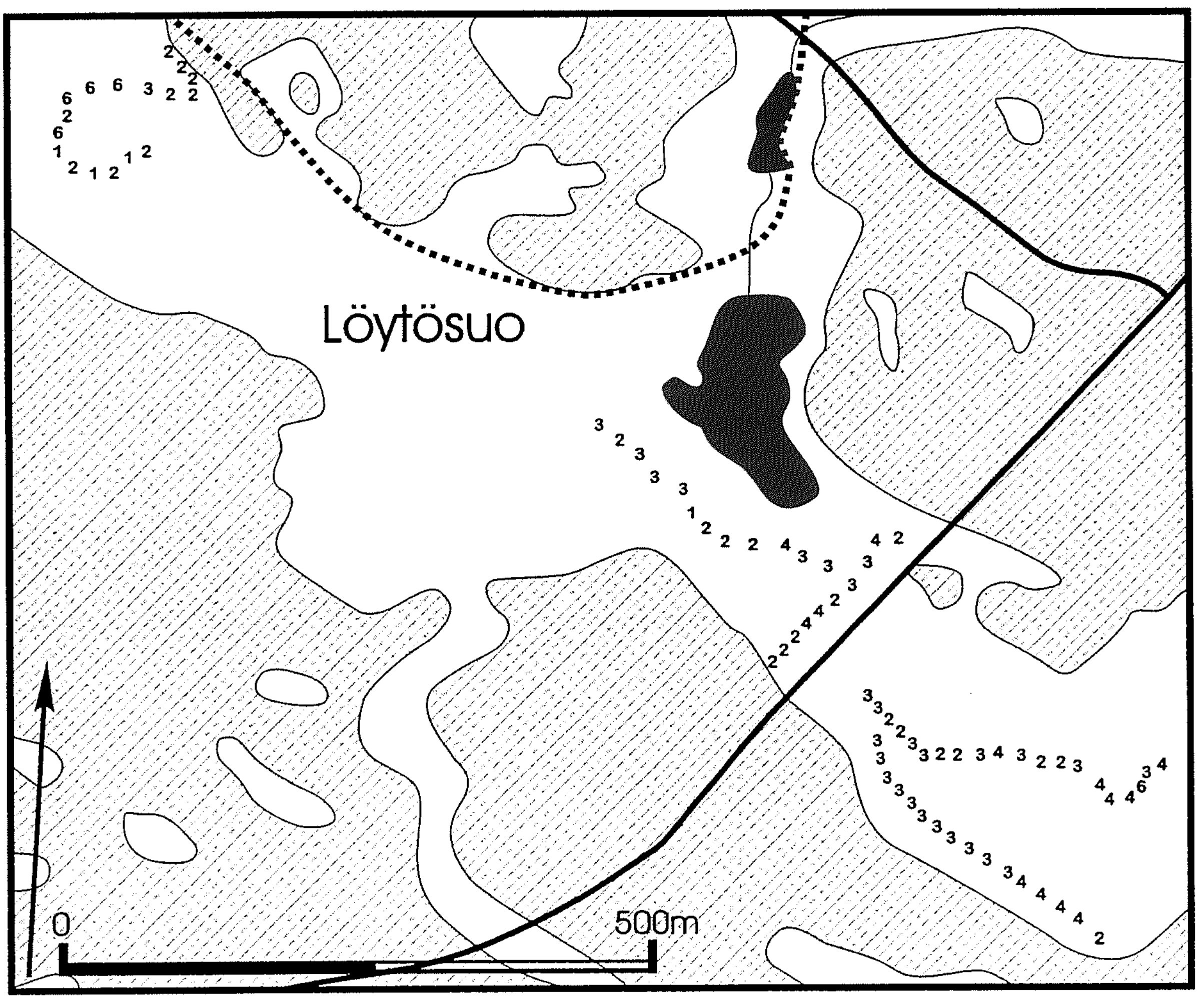
In group 1 there are seven lawn-level plots, in six of which the dominant species is *Sphagnum papillosum*. In one plot *S. angustifolium* dominates. In the field layer there are several minerotrophic species, *Carex lasiocarpa, C. rostrata, C. pauciflora* and *Eriophorum angustifolium*. Group 1 is clearly minerotrophic. The plots are located in the margin of Joutensuo mire and the western part of Löytösuo mire (Fig. 3). In the Finnish mire site classification group 1 corresponds to *Sphagnum papillosum* fens (Eurola et al. 1994).

In group 2 there are low hummock communities, 7 of which dominated by *Sphagnum fuscum* (*Sphagnum fuscum* pine bogs) and 18 with *S. angustifolium* (Small-sedge bogs). In the sparse field layer dominate dwarf shrubs and *Eriophorum vaginatum. Carex pauciflora* is constant but seldom dominant. Other minerotrophic species are lacking. The group is on the border of minerotrophy and ombrotrophy. The sample plots are located in the central parts of Löytösuo mire.

Group 3 contains various lawn communities. 17 of the plots are dominated by *Sphagnum balticum* with *S. angustifolium* as co-dominant in 11 plots (hollow bogs in the Finnish mire site classification). In 12 plots *S. angustifolium* is dominant with *S. balticum* as co-dominant in 9 plots. One plot is dominated by *S. papillosum* with *S. balticum* as co-dominant (small-sedge bogs in the Finnish mire site classification). In the field layer *Vaccinium oxycoccos, Andromeda polifolia, Scheuchzeria palustris* and *Eriophorum vaginatum* are most common species. In the sample plot with *Sphagnum papillosum, Trichophorum cespitosum* dominates in the field layer. In a few sample plots in Löytösuo mire there grow *Carex pauciflora* and *C. rostrata* nearby the pond Kolmisoppi, probably due to occasional flooding in the spring. The group is on the border of minerotrophy and ombrotrophy. Most of the plots of group 3 are situated in the middle parts of Löytösuo mire.

Group 4 contains hollow communities (hollow bogs in the Finnish mire site classification). In 11 sample plots *Sphagnum balticum* dominates without *S. angustifolium*. In the field layer *Scheuchzeria palustris, Carex limosa* and *Eriophorum vaginatum* dominate. These sample plots are clearly ombrotrophic. One sample plot in the group is dominated by *S. annulatum* var. *porosum*. There grows also *Carex rostrata*. This plot in Salmisuo is minerotrophic. All the other plots are situated in the central parts of Löytösuo mire.


Joutensuo
0
500m


Löytösuo
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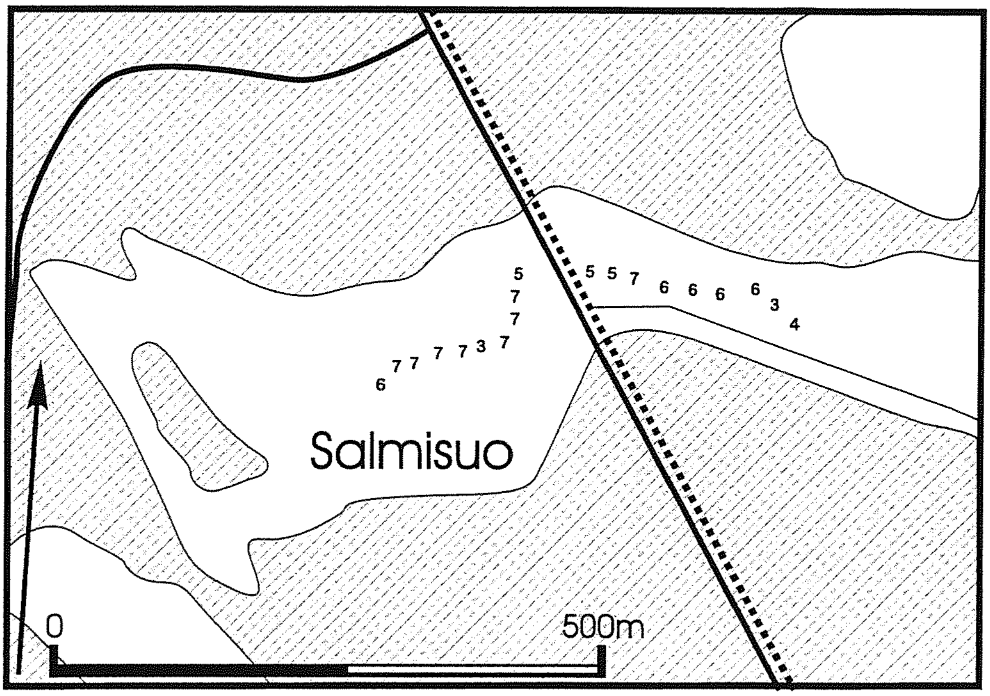

Fig. 3. Location of the sample plots in the studied mires. The numbers refer to the TWINSPAN groups. For other symbols see Fig. 2.

In group 5 there are only three sample plots. They are dominated by *Sphagnum compactum* and *Trichophorum cespitosum*. The plots are located nearby a road crossing Salmisuo mire, and probably the construction of the road and ditches along the road have caused disturbance. In dry periods these sites dry out and during wet periods they are flooded, which is also indicated by the presence of the lichen *Cetraria delisei* and the scarce occurrence of *Sphagnum papillosum*. Also seedlings of *Pinus sylvestris* indicate drying out as well as bare mud surfaces, which occur in our material only in this group (See Laitinen 1990). These sample plots correspond to drained *Sphagnum* flark fens (Eurola et al. 1994).

In group 6 there are hollow communities with various dominant species in ground layer: *Sphagnum majus* in 4 plots, *S. annulatum* var. *porosum* in 3 plots, *S. compactum* in one plot and *S. papillosum* in one plot. Also *S. tenellum* and *S. balticum* grow in some plots. *Scheuchzeria palustris* is growing on every sample plot. In the plot with *Sphagnum papillosum, Trichophorum cespitosum* co-dominates in the field layer. The group is between ombrotrophy and minerotrophy in the nutrient gradient. In the Finnish mire site classification they belong to hollow bogs and *Sphagnum* flark fens (Eurola 1994). Most of the sample plots of group 6 are located in the eastern part of Salmisuo mire and the western part of Löytösuo mire.

In group 7 there are the most wet sample plots. Also in this group the dominant moss species vary: *Sphagnum pulchrum* is dominant in 5 sample plots, *S. majus, S. annulatum* var. *porosum* and *S. lindbergii* in 2 plots each and *S. papillosum* in one plot. *Cladopodiella fluitans* is sparse but common in this group. *Carex limosa* is constant in the field layer, and *Drosera anglica* as well as *Scheuchzeria palustris* are very common. *Andromeda polifolia* and *Vaccinium oxycoccos* are less common and abundant than in other groups. Group 7 is minerotrophic and represents flark fen vegetation (Eurola et al. 1994).

In some sample plots *Carex rostrata* grows as an obvious relict in ombrotrophic sites, because its living roots penetrate deep in minerogenic peat layers.

DCA ordination of the sample plots shows only one clear gradient which is clearly connected with the depth of mire water on the sample plots (Fig. 4). There is no connection between the gradient and pH measurements of mire water in the sample plots.

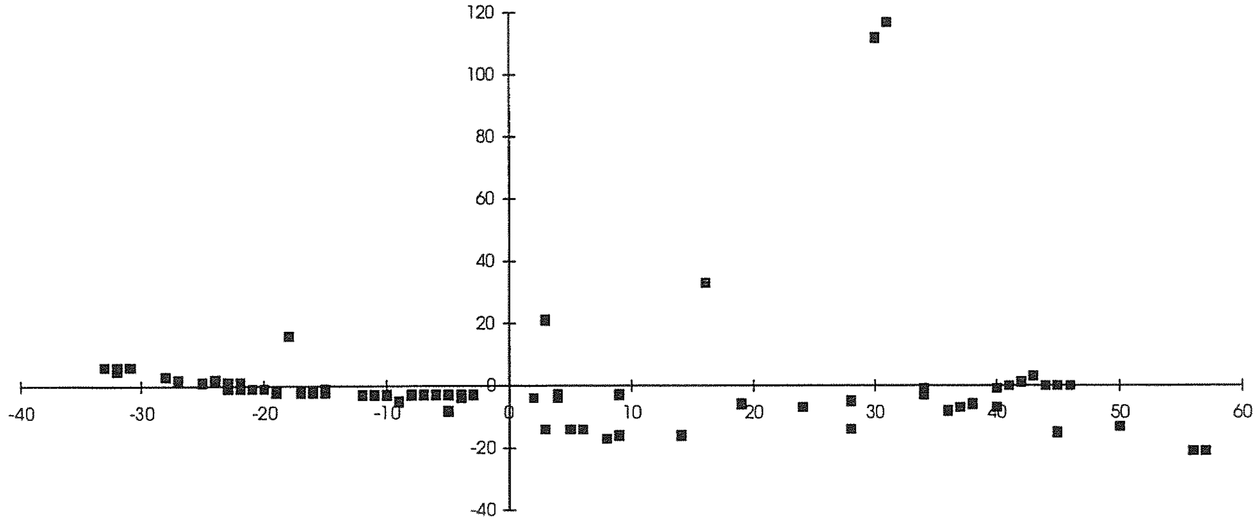

Fig. 4. DCA ordination of the vegetation of the sample plots.

Fluctuation of water table, snow cover and ground frost depth

During the first years of observation the hydrological conditions (water table and snow depth) have varied a lot between years. An example of the mean conditions on sample plots 94, 96 and 97 in Salmisuo shows the typical variation in a minerotrophic flark fen (Fig. 5).

The water table fluctuation shows that the temperature and rain conditions during the summers have greatly varied. The minimum level of water table varies from 20 to 12 cm below the mire surface, and the maximum level between 0 and 5 cm below the mire surface.

The duration of snow cover varies between years, the shortest period of snow cover being 188 days and the longest 204 days. The maximum snow depth varies from 82 cm to 109 cm. The snow cover increases towards the end of winter the melting of the snow in spring is very rapid.

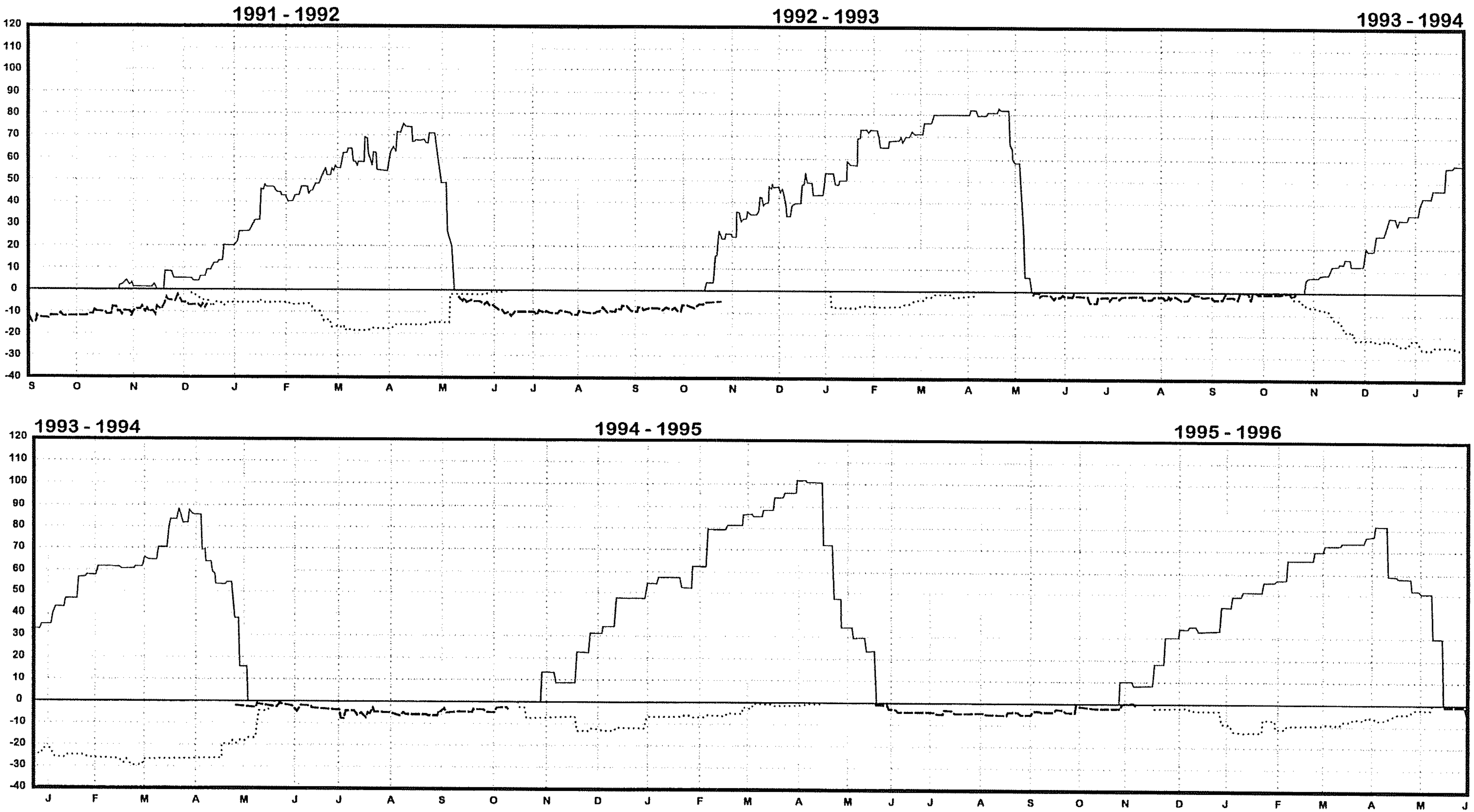

Fig. 5. The hydrological conditions in the years 1991-1996 as a mean of sample plots 94, 96 and 97 in Salmisuo mire, belonging to vegetation group 7. Thick black line = fluctuation of the mire water table, Thin black line = thickness of snow cover, Dotted line = ground frost depth.

Pollen stratigraphy of Löytösuo mire

The pollen diagram (Fig. 6) shows variation in the vegetation in and around the mire as follows: At the time when paludification of Löytösuo mire initiated pine was common, about 70% of the pollen belonging to it. Spores of *Polypodiaceae* s. lato were also relatively frequent. At the depth of 190 cm there is a decline in pine pollen frequency, and the frequency of birch pollen increased together with *Pteridium*. From 170 cm the pollen of Norway spruce appeared and rapidly became abundant. At the same level occurs decline in *Polypodiaceae* and *Pteridium*. From that level there is a gradual increase in pine pollen, and a gradual decline in birch pollen to the depth of 60 cm. The amount of *Alnus, Tilia* and *Ulmus* is continuously low, and only a few single pollen grains of *Corylus* and *Fagus* were observed.

The ground frost has been relatively thin due to the thick snow cover. When the snowfall occurs early in the autumn the mire can be almost without frost throughout the winter. Thus variation berween years is great. During the wintertime warm periods may cause decrease in the thickness of the snow cover causing more favourable conditions for deepening of the ground frost. The shortest registered duration of ground frost was 111 days and the longest 138 days. The maximum thickness of ground frost varied from 8 to 32 cm.

In the topmost 50 cm of the peat layer *Picea* is much less common than in the deeper layers. With *Pinus* there is a decline to 40% at the depth of 30 cm and a rapid increase up to 70% in the surface. *Betula* pollen increased up to 50% at the depth of 30 cm and then rapidly decreased till 20%.

Near the bottom there is a layer with relatively abundant *Scheuchzeria* pollen, but there is a great fluctuation in the frequencies of *Cyperaceae* pollen. These pollen reflect the development of the mire itself.

Different stages of the development of the vegetation in and around the mires have been determined on the basis of the climatological-stratigraphical scale by Khotinsky (1987) (Fig. 6). The pollen stratigraphy of Löytösuo is in accordance with those determined in the nearby Kostomuksha region (L. Filimonova, pers. comm. 1996).

Stratigraphy of peat and macrofossils of the Löytösuo mire

Both in hollow and ridge the ombrotrophic stage is obviously young. Only the uppermost 0.5 m of peat is developed in clearly ombrotrophic conditions (Fig. 7). Paludification started in homogeneous poor minerotrophic *Scheuchzeria - Carex rostrata* communities (Figs. 6, 7). At the same level also *Scheuchzeria* pollen is relatively abundant in the peat. Microrelief formation started after the accumulation of 70 cm of *Scheuchzeria* peat (Figs. 7, 8). The lawn development started with the increase of *Eriophorum vaginatum*. A little later the community included also *Sphagnum magellanicum*, and the formation of hummocks started. Then appeared *Sphagnum angustifolium* and *S. fuscum*, and *Carex rostrata* disappeared. In the present ombrotrophic hummock ridge *S. fuscum* and *S. angustifolium* dominate.

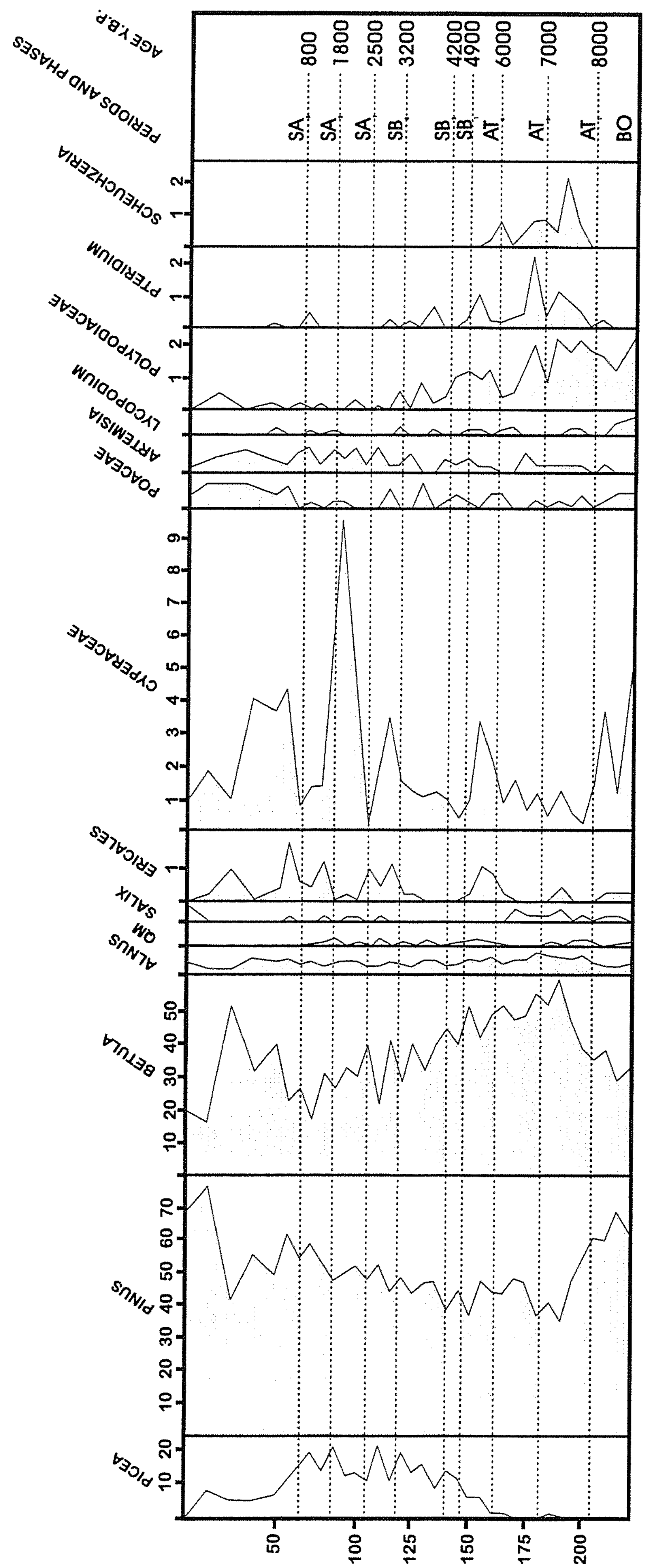

Fig. 6. Pollen diagram of Löytösuo mire.

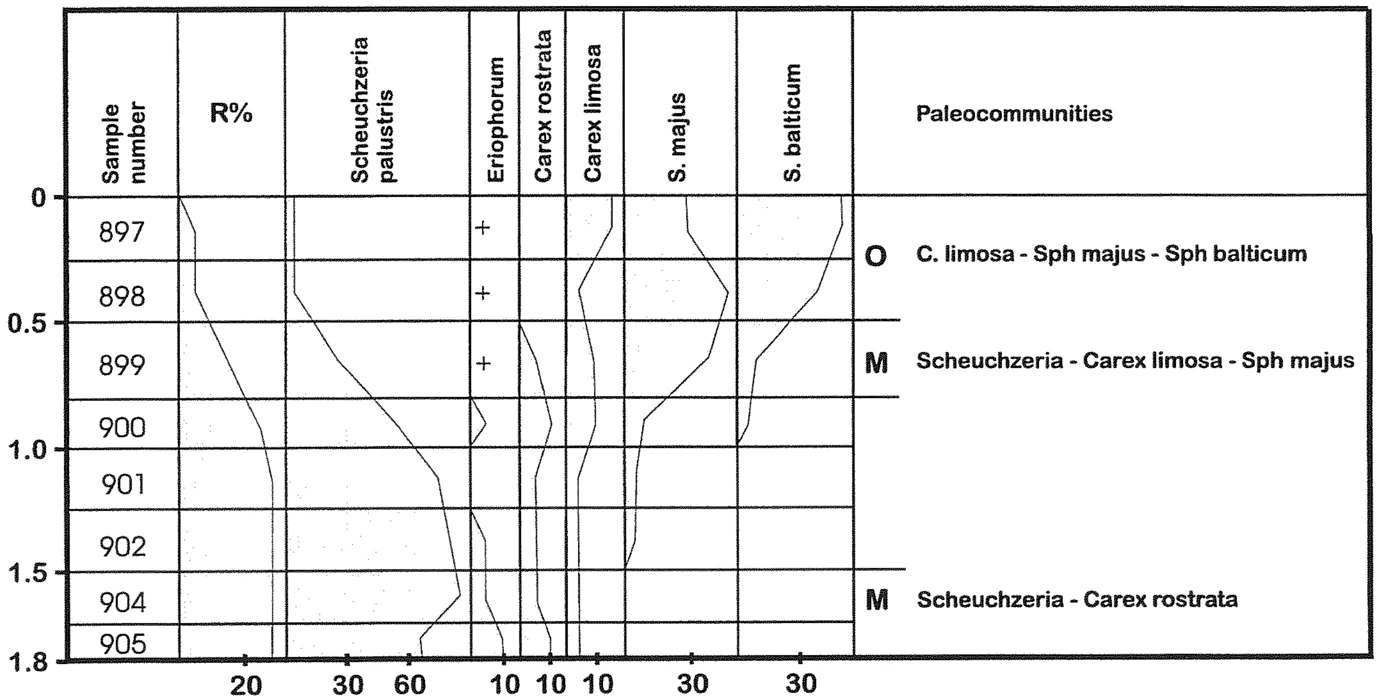

Fig. 7. Macrosubfossil stratigraphy of a hollow in Löytösuo mire.. R = degree of decomposition %, O = ombrotrophic, M = minerotrophic, OM = ombrominerotrophic.

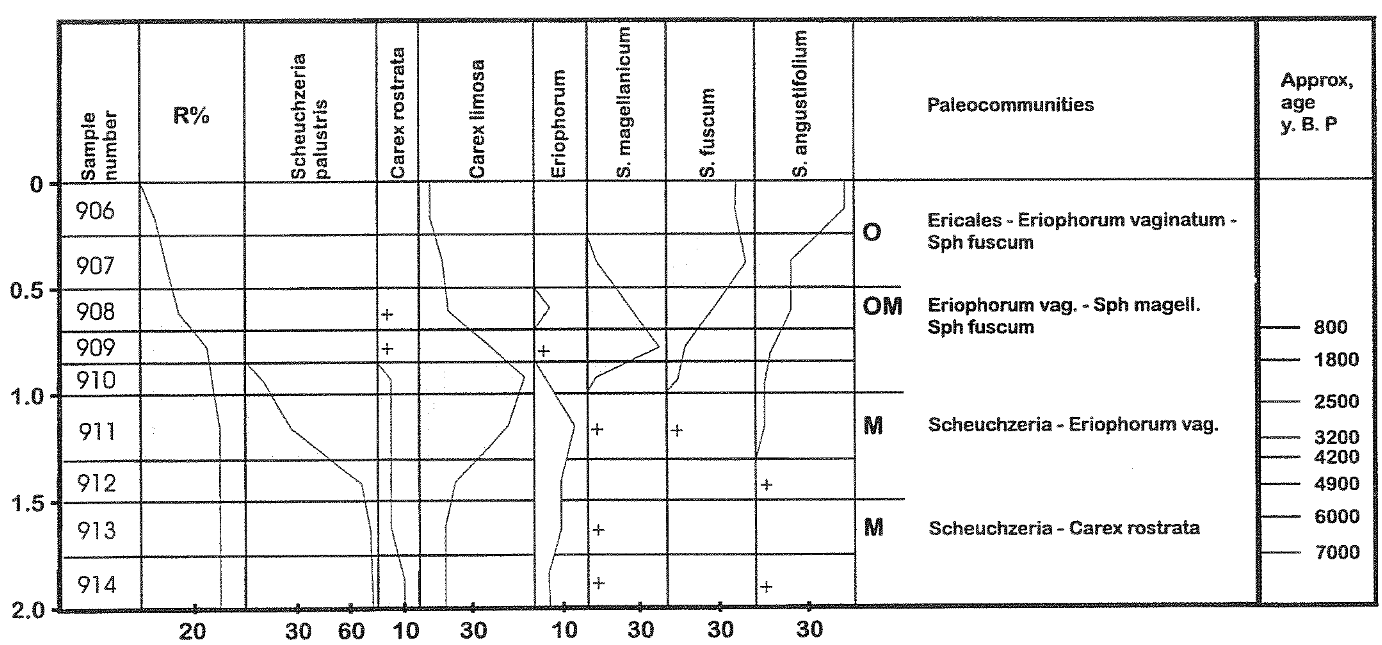

Fig. 8. Macrosubfossil stratigraphy of a hummock in Löytösuo mire.

Hollow formation started in minerotrophic *Scheuchzeria - Carex limosa - Sphagnum majus* communities with some *Carex rostrata* forming a layer 100 cm thick (Fig. 8). Later *C. rostrata* disappeared and *Sphagnum balticum* appeared in the community. In the present hollows *S. balticum and S. majus* dominate with some *S. annulatum* var. *porosum, S. tenellum* and *S. papillosum*.

Stratigraphy of peat and macrofossils in Salmisuo mire

Salmisuo has a lacustrine genesis. Its deposit in the central part has 0.5 metres lake sediments (gyttja with abundant plant macrofossils), and 3.2 metres of peat (Fig. 9). A small shallow lake began to fill in with *Typha - Warnstorfia exannulata* communities. They changed into *Nuphar - Equisetum - Warnstorfia exannulata* communities obviously very soon. After that, in the depth of 3.2 metres *Scheuchzeria palustris* and *Carex limosa* replaced the water plants, and the lake stage ended. Water from surrounding mineral soil was very poor, and *Warnstorfia exannulata* soon disappeared. After that wet short-sedge communities with *Scheuchzeria palustris* prevailed a long period. At the depth of 250 cm the hydrology of the mire changed and *Eriophorum vaginatum* appeared in the vegetation. After that began stages with *Sphagna*, first *Sphagnum papillosum*, later *S. majus* and *S. compactum*. In present vegetation a mosaic of *S. compactum*, *S. pulchrum* and *S. papillosum* patches dominate.

Discussion

Present vegetation

In all the studied sample plots the vegetation indicates low level of nutrients. The conditions are oligotrophic or ombrotrophic (Ruuhijärvi 1960, Eurola 1962). In DCA analysis the only factor explaining the differences in vegetation is moisture. The gradient of moisture conditions favouring different species of *Sphagnum* explains the floristic difference of communities (Lumiala 1944). Minerotrophic oligotrophic sites cannot be clearly separated from ombrotrophic sites on the basis of field and ground layer composition. Thus the borderline between minerotrophic and ombrotrophic habitats is not clear on the basis of the vegetation data. The chosen relevé size 1 m^2 was a compromise between the minimum area demands and site level demands and thus the results reflect both community level and site level giving microsite information (Galten 1987).

Most of the formed vegetation classes correspond to those described in other studies, e.g. in southern Finnish raised bogs (Paasio 1933) and southern Swedish mires (Osvald 1923). Group 7 with abundant *Sphagnum pulchrum* seems to be a rare community. Only Osvald (1923) and Warén (1926) have described communities resembling group 7, and Ruuhijärvi (1960) has a few examples of *Sphagnum* flark fens and *Sphagnum papillosum* fens with relatively abundant *S. pulchrum*. Plant communities of bogs and oligotrophic fens seem to be uniform in most of Fennoscandia (Økland 1989b). Only in the oceanic western coast of Norway and in the subarctic regions the vegetation is clearly different (Osvald 1925, Vorren 1979).

On the basis of our material it seems that in transitional mires it is very difficult to distinguish between aapamires and eccentric bogs on the basis of the vegetation. Also morphology gives very little information of the ecology of the mires.

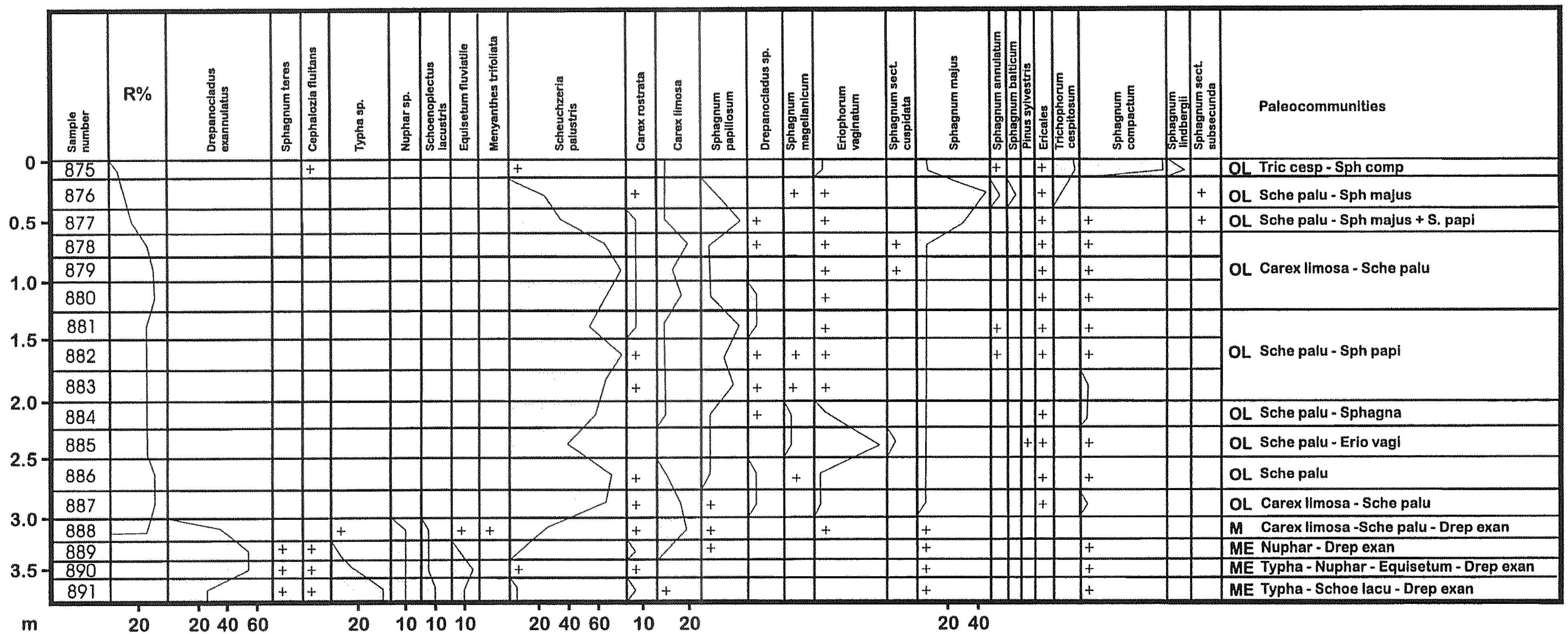

Fig. 9. Macrosubfossil stratigraphy of a flark fen in Salmisuo mire. R = degree of decomposition %, OL = minerotrophic oligotrophic, M = mesotrophic, ME = meso-eutrophic.

Obviously there is no ground water mound in the bogs (see e.g. Bragg 1995), but the ecology of different sites can probably be explained using the model of divergent succession of the vegetation (Sjörs 1990).

The studied mires are rather small and forests are surrounding them. Thus the snow cover is mainly result of snowfall and the compression during days when temperature is temporarily above zero. The effect of wind is small (cf. Sonesson 1969). The ground frost layer is thin due to the thick snow cover. During some winters ground frost may be totally lacking, if the permanent snow cover comes early in the autumn before the mires are frozen. No correlation between snow depth and ground frost thickness was observed. This is a difference when compared with areas where the snow cover is thin in western Finland (Eurola 1975). Also in the fjell vegetation the influence of low temperatures almost disappears when the thickness of snow cover is 80 cm or more even though the snow there is more consolidated (Eurola et al. 1980). In aapamires and eccentric bogs in Elimyssalo there is no significant difference in snow cover.

The fluctuation of ground water table seems vary every year. The lack of precipitation data prevents the analyse of relationship between rain and water table. But it seem to be correlated to rain (Lindholm & Markkula 1984, Økland 1989a) and during the warm periods without rain the groundwater table will sink.

Picea abies spread in eastern Kainuu approximately 5700 years B.P. (Elina 1981, cf. Aartolahti 1966) and in western Kainuu appr. 4500 B.P. (Tolonen 1983). In the pollen diagram this stage can be seen in the depth of 170 cm. At the same level begins the decline of birch. In the most recent peat layers there can be seen an increase in birch and graminoid pollen as well as decrease of spruce pollen at the depth 50-20 cm, obviously due to slash and burn cultivation started in the end of the 16th century, and a decline of birch and graminoid pollen and increase in spruce pollen in the surface corresponding to the cessation of slash and burn cultivation around the year 1850.

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Hydrology of Lake Kiitehenjärvi

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Abstract

The characteristics of the hydrological conditions of Lake Kiitehenjärvi, situated in North-West Karelia in the territory of Frienship Nature Reserve are presented. The items of the lake construction, the distribution of water masses in the depth zones, the composition of bottom sediments and water temperatures are discussed.

Key words: lake construction, bottom sediments, water temperatures, Lake Kiitehenjärvi

Location and morphometry

Lake Kiitehenjärvi lies in northwestern Karelia in the upper River Kivijoki, the largest tributary of the River Tsirkka-Kemi (the right tributary of the River Kem), at an altitude of 195 m above sea level. The surrounding terrain is formed by hills and ridges, some esker ridges being NW-SE oriented. The hills adjoining the lake are 35-87 m above the lake surface. The lake basin is north-south oriented, 35 km long and 20 km wide. It covers an area of 652,9 km^2 and the catchment area coefficient of the basin is 18,8%.

The total area of Lake Kiitehenjärvi is 105.5 km^2 and its water surface area is 95.5 km^2 (Grigoryev & Gritsevskaya 1959). Specific catchment area, determined by a basin area-unit surface area ratio, is 6.9. This index is considered to be low (Grigoryev 1958). The lake is 24.4 km long. Its maximum width is 12.1 km and its average width is 4.6 km. It has 27 tributaries, mainly creeks and streams, which flow out of bogs and forests lakes. Only five tributaries are over 10 km long.

The curved shoreline of Lake Kiitehenjärvi forms numerous bays and points which differ both in shape and size. The east shore with four narrow bays jutting out inland is most intensely rugged. The Kamalahti Bay, located in its northeastern part, is 6 km long, 10-12 m deep and 0.35 km wide at the lake-bay boundary. The Nilma Bay in southern part of the lake is 4.5 km long, 1.3 km wide and up to 10 m deep. The Kamennaya Bay is 8.0 km long, 0.6 km wide and about 15 m deep. The southeastern Bay is 10 km long, 0.7 km wide, 5-10 m deep in its southern and middle parts and up to 15 m deep in its northern part. Three northern bays are SW-NE oriented, and the southern bay is SE-NW oriented. The River Kivijoki flows out of the eastern end of the Kamennaya Bay.

The west shoreline is more gently curved. The Babya Bay, divided by a narrow, ca. 3.5 km long eskert into northern and southern parts, juts forth inland on the northwestern side of the shore. The Lake has 98 islands, most of which are relatively small, and only four islands have an area of more than 1 km^2. The total length of the shoreline, including the islands, is 257,6 km. Its development coefficient is 5.3. The lake surface is split by the islands and points into three pools: northern, central and southern which differ in size, depth and bottom topography. The esker ridge, which extends northwest across the northern part of the Nilma Bay, is up to 248 m high near the east shore. Its extension in the lake is the Island Neitisaari, and that on the west shore is the point stretching along the Babya Bay. Another esker ridge extends across the lake basin on the west shore of the Tetriniemi Point. It divides the lake into central and southern parts. The width of the lake between the western and eastern points is some 0.7 km and its depth is about 10 m.

The northern and central parts of the lake have high bouldery-stony, occasionally rocky shores, whereas in the areas, where the lake basin is cut by the esker ridges, the shore is sandy-pebble. Sandy beaches occur locally in the Nilma Bay, on the Island Neitisaari and in the Babya Bay. Low bouldery-stony, locally paludified shores predominate in the southern part of the lake. Low, paludified shores are also observed at the mouths of the tributaries and in the upper parts of the bays.

Bathymetry

The bottom of the lake basin is topographically complex. Here, relatively low underwater plateaus alternate with numerous boulder and rocky ridges as well as rocky ridges and rocky shoals that vary in altitude. The deepest (about 20 m) part of the lake lies northwest, north and northeast of the Neitisaari Island. The maximum depth of 28.7 m was observed 1.6 km SSE of the north point near the Kamalahti Bay. South of the Neitisaari Island, the bottom is relatively flat, and the depth of the lake gradually increases to 10-15 m. The bottom is topographically uniform between the archipelago and the Krestovy as well as Tetriniemi Points. Its altitude gradually increases to 10-12 m and even 18.8 m north of the Tetriniemi Point. The bottom is uplifted locally to form sand bars at a depth of 2.0-5.0 m. The southern part of Lake Kiitehenjärvi is as deep as 10-15 m, its maximum depth being 21.5 m. Some sand bars were encountered at a depth of 1.5-3.2 m. In the Kamalahti Bay, bottom depressions, observed at a depth of 10-15 m, alternate with elevations that developed in the form of sand bars and underwater rocks. Depths of up to 5.0 m predominate here, the maximum depth being 15.5 m and the average depth being 3.4 m. In the Nilma Bay, the bottom is topographically uniform, deepening towards the central part of the basin. A small, ca. 22.0 m deep depression was revealed at the northeastern end of the bay separated from its main water area by a shoal which forms part of an esker ridge. The predominant depths in the Kamennaya Bay and the Southeastern Bay are 5-10 m, but in many places small bottom depressions were revealed at a depth of 15-23 m and bottom elevations were found at a depth of 1.5-2.0 m. The average depth of the lake is 7.9 m. Its water volume is 0.7825 km^3, about 55% being at depths where maximum water transparency is 5 m. Around 1.0% of the water volume is in 20 m deep depressions.

Bottom sediments

Bottom sediments are represented by silt, which covers up to 46% of bottom area, as well as sand, rocks and iron ore units. Grey silt, which predominates to a depth of 15 m, turns dark-brown to brownish-orange at deeper places. In the southern part of the lake and in the Southeastern Bay dark-green to almost black silt covers small (up to 3 km^2) bottom areas. The silt layer varies in thickness from 10 to over 100 cm. It is mainly underlain by homogeneous clay. Stones, sand and ore units account for about 48% of bottom area. They are most common in the littoral zone and in the shallow parts of the sand bars and underwater plateaus. Ore occurs in the form of peas, concretions and crusts.

The lake sediments are depleted in organic matter which is dominated by forms resistant to bacterial decomposition. They are poor in iron and readily hydrolysable phosphorus. Ammonium is the predominant mineral form of nitrogen, its average amount being 6.66 mg per 100 g of dry ground. Organic nitrogen concentration varies from 0.15 to 1.38%. Nitrates are ubiquitous and vary from trace amounts to 1.26 mg/100 g. The manganese content of the sediments is 42-1281 mg/100 g, average content being 575 mg/100 g (Vasilyeva 1985).

Water temperatures

When discussing the thermal regime of Lake Kiitehenjärvi, it should be noted that it is a water body which has stable temperature stratification. The ice goes off in late May. In the bays affected by slope runoff and the water transported by the tributaries, the period of spring homothermy is short and temperature stratification is formed rapidly with a rise in temperature in water surface layers. In the open part of the lake the length of transition from homothermy to temperature stratification depends on the intensity of heat transport to the water surface and the effect of winds.

In warm years, a considerable amount of heat is accumulated in the lake in summer. In 1973, the summer was very warm, average daily air temperatures being 18.4°C in early June and 20-24°C in July and the absolute maximum being 29.2°C. In July, the water surface layer in the central part of the lake was heated to 23-24°C. The epilimnion with temperatures exceeding 20°C is a 6 m thick layer. In the 1 m thick metalimnion the difference in temperatures was 9.3°C. In the bottom layers, water temperature rose to 11°C. In the Kamalahti Bay, where the water is heated under limited wind mixing conditions, the layer with temperatures in excess of 20°C is 3 m thick. In the next 1 m thick layer the temperature jump was 6.4°C. At depths over 10 m water temperatures were below 10°.

In the cool summer of 1976, the average monthly air temperature in July was 13.9°C. In the central part of the lake the water warmed up to 12.8-13.0°C in the surface layer and to only 12.4°C near the bottom. In the Kamalahti Bay, the temperatures were 13.5°-13.4°C respectively.

As the lake warms up in summer, its bottom sediments accumulate heat from the water. In years of warm summer, some parts of the bottom at a depth of about 15 m have a long (up to 70 days in 1973) contact with water heated to over 10°. At a depth of around 2 m they are in contact with water warmed up to over 20°C (for 25 days in 1973). When it gets colder in autumn, bottom sediments give their heat away. Thus, in mid-October 1973, when the water temperature in the Nilma Bay was 7°C, the temperatures in the 0.7 m thick silt deposits varied in the following manner with the distance from the arbitrary water-bottom sediment boundary: 0.1 m - 7.25°C, 0.2 m - 8.4°C, 0.3 m - 9°C and 0.7 m - 9.5°C. As the sediments transfered heat, the water temperature rose in the ice period in the northern deep-water part of the lake by late April 1974 in the following way: 5 m - 0.90°C, 10 m - 1.60°C and 15 m - 3.32°C. In the Kamalahti Bay, the following temperatures were registered below the ice: 1.0m - 1.05°C, 3.0m - 2.62°C, 5.0m - 3.60°C, 7.0m - 3.92°C and 10m (near the bottom) - 4.35°C.

The annual water temperature amplitude was 25°C for the surface layer and about 6°C for the bottom layer in warm years (1972 and 1973), whereas in cold years the temperatures are 13-14 and 6-8°C respectively. The colour index of the lake water varies with season from 37 to 85. The central part of the lake has a transparency of 5 m in summer and 4 m in winter. In the bays, water transparency varies from 1.5 to 2.5 m in summer and from 0.7 to 2.8 m in winter.

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Vascular plants of the Kostomuksha Nature Reserve

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Abstract

The characteristics of vascular plants growing in the Kostomuksha Nature Reserve were studied. In all, 395 taxa are listed from the area. Boreal flora is predominant, whereas southern species are poorly represented. Arctoalpine plants, many of which grow near the southern boundaries of their distribution areas, are typical as well. Anthropochorous species are rare, and many occur near the boundary of the distribution area. Four species are listed in the Red Data Book of Russia and another five are mentioned in the regional Red Data Book of Karelia. A list of vascular plants and the frequency of each species is given.

Key words: vascular plants, boreal flora, threatened species, human impact

Introduction

The Kostomuksha Nature Reserve, which forms part (476 km^2) of The Nature Reserve Friendship, lies in the north taiga zone, as understood by Russian geobotanists and silviculturists (Yakovlev and Voronova 1959); in the Kem floristic area (Ramenskaya 1983); and in the biogeographic province Karelia pomorica occidentalis, according to Fennoscandian naturalists. The idea to set up a nature reserve was mainly based on zoological considerations such as the occurrence of forest reindeer in the study area and the presence of salmon in Lake Kiitehenjärvi. Besides, the aqueous and terrestrial ecosystems are fairly well preserved here. The few earlier floristic studies in this area have been made by Wainio (1878). Macrophytes of the Lake Kiitehenjärvi were studied by Klyukina in 1986. Therefore, a more precise survey of the flora in the nature reserve was needed. This work was done by the Karelian Research Centre, the Moscow State University and the Kostomuksha Nature Reserve.

Material and methods

The inventory of vascular plants in the Kostomuksha Nature Reserve began in 1985. The field work was carried out using the route-areal method. The term "local flora", understood as the flora of the key locality with an experimental station or dwelling-houses in its centre, was used in areal study (Tolmachev, 1974). To examine the plants, radial one-day itineraries were outlined, the greatest distance from the centre being no more than 10 km. In addition, route study was made in some parts of the nature reserve, primarily in the areas near the roads. In the text, the taxonomy follows (S. K. Cherepanov, 1995).

Results and discussion

The flora of the study area is dominantly boreal, southern and northern species being scarce. This is largely due to the prevalence of acid bedrock with scarce basic and ultrabasic (dolerite, komatite) dykes. Nevertheless, some findings are undoubtedly of botanical interest. The northern species that are worth mentioning include: *Woodsia alpina, Lycopodium dubium, Anthoxanthum alpinum, Carex rotundata, Alnus incana* subsp. *kolaënsis, Rumex lapponicus, Epilobium hornemannii* and hybrid (*E. h.* x *E. palustre*) as well as *Pinguicula villosa*. These occur here near their southern boundaries or grow at their southernmost isolated habitats. *Woodsia alpina* has also been reported from the Lake Onega and Lake Ladoga regions. The occurrence of the above mentioned species is connected with the Maanselkä ridge spurs (West Karelian Upland) on which the nature reserve is located. Some of them (*Lycopodium dubium, Anthoxanthum alpinum, Festuca richardsonii, Carex rotundata, Alnus incana* subsp. *kolaënsis*) are encoutered further south along the cold White Sea coast.

The number of species with southern connections is small as well: *Matteuccia struthiopteris, Milium effusum, Calamagrostis arundinacea, Melica nutans, Convallaria majalis, Salix cinerea, Alnus glutinosa, Fragaria vesca, Daphne mezereum and Viburnum opulus*. They all make up a boreo-nemoral, rather than nemoral (temperate), flora complex and are occasionally encountered farther northwards, some of them occurring as far as in the Arctic zone. Some southern species are locally abundant. *Milium effusum, Melica nutans* and some other plants sometimes play an important role in the composition of the field cover. Of utmost interest is the finding of*Alnus glutinosa*. In the northern part of the region it grows only near Louhi, whereas in Finland it is fairly common farther north close to the coast of the Gulf of Bothnia.

Species with eastern links are not numerous. These include: *Eriophorum gracile, Carex omskiana, C. rhynchophysa, Actaea erythrocarpa, Nymphaea tetragona, Viola selkirkii, and Lactuca sibirica*. Almost all of them are rare in the nature reserve. The last three species were revealed only in the River Kivijoki valley considered to be one of minor biogeographic channels through which "Siberian" species spread westwards.

Western plants are not numerous either. Among these are: *Lycopodiella inundata, Isoëtes lacustris, I. setacea, Juncus bulbosus, Luzula sudetica, Littorella uniflora* and *Lobelia dortmanna*. The two *Isoëtes* species and *Lobelia* dortmanna are included in the Red Data Books of the USSR (1984) and Russia (1988). They are common in the study area, but *Isoëtes lacustris* does not grow in any other Russian nature reserve and *Isoëtes setacea* and *Lobelia* dortmanna occur only in the Kivach Reserve also located in Karelia. This fact is given here to emphasize the role of the Kostomuksha Nature Reserve in the preservation of the above mentioned species in Russia. Another fairly scarce species listed in the Red Data Book of Russia is *Dactylorhiza traunsteineri*.

Other species listed in Regional Red Data Book (1995) as well as in the RDB of Russia are *Woodsia alpina, Ranunculus trichophyllus, Epilobium hornemannii, Myriophyllum verticillatum, Crassula aquatica* and *Littorella uniflora*. (See: Mäkirinta, 1997, this issue.)

Anthropochorous species, growing on former farmlands near the northern boundary of their distribution areas, are also of great interest. These are *Alopecurus geniculatus, Briza media, Polygonum bistorta, Centaurea jacea and C. phrygia* as well as *Leontodon hispidus*. Some of them *(Briza media, Polygonum bistorta* and *Alchemilla glabricaulis* (cf. Heikkinen 1969) are possible polemochores, distributed during the wartime 1939-1944.

As a result of human activities associated with the waterpumping station, railway and highway located in the nature reserve, local flora was enriched by new adventitive species reported from their northernmost Karelian localities. These include *Echinochloa crus-galli, Herniaria glabra, Gypsophila muralis, Daucus carota, Stachys palustris, Conyza canadensis* (all the above mentioned species were brought here a few years ago among fertile soil, which was transported from Middle Russia for the vegetable gardens near the waterpumping station), *Bromus arvensis* and *Arctium tomentosum*.

Of special interest are *Festuca trachyphylla* and *Gypsophila elegans* (presumably a plant which run wild). They were brought to Karelia from the west and so far they have been found only within the Kostomuksha Nature Reserve. This shows that human activities have a certain effect on local flora. A complete list of the vascular plants of the nature reserve is given in the Appendix.

The first results of our plant inventory were published earlier (Kravchenko 1990, 1993; Kravchenko & Belousova 1990).

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Appendix

A list of vascular plants, which occur in the nature reserve. c - common, f - fairly often found, r - rare and very rare species. The names are according to Hämet-Ahti et al. (1986). The names in brackets are by Cherepanov (1995).

Woodsia alpina* (Bolton.) S.F. Gray	r
Woodsia ilvensis (L.) R. Br.	r
Cystopteris fragilis (L.) Bernh.	r
Athyrium filix-femina (L.) Roth	c
Matteuccia struthiopteris (L.) Todaro	r
Dryopteris carthusiana (Vill.) H.P.Fuchs	f
Dryopteris expansa (C.Presl) Fraser-Jenkins et Jermy	f
Gymnocarpium dryopteris (L.) Newman	c
Thelypteris phegopteris (L.) Slosson (Phegopteris connectilis (Michx.) Watt)	c
Polypodium vulgare L.	r
Botrychium multifidum (S. G. Gmelin) Rupr.	r
Equisetum arvense L.	f
Equisetum fluviatile L.	c
Equisetum hyemale L.	r
Equisetum palustre L.	c
Equisetum pratense Ehrh.	f
Equisetum sylvaticum L.	c
Diphasiastrum complanatum (L.) Holub	f
Lycopodiella inundata (L.) Holub	r
Lycopodium annotinum L.	c
Lycopodium annotinum var. alpestre Hartman (L. dubium Zoega)	r
Lycopodium clavatum L.	f
Huperzia selago (L.) Bernh. ex Shrank & Mart.	r
Selaginella selaginoides (L.) Beauv. ex Schrank &Mart.	r
Isoëtes lacustris*,** L.	c
Isoëtes setacea*,** Durieu	c
Picea abies (L.) Karsten	c
Picea x fennica (Regel) Kom. (intermediate form of P. abies subsp. obovata)	c
Pinus sylvestris L.	c
Juniperus communis L.	c
Sparganium angustifolium Michx.	f
Sparganium emersum Rehman	f
Sparganium glomeratum Laest.	r
Sparganium gramineum Georgi	f
Sparganium minimum Wallr.	f
Potamogeton alpinus Balbis	f
Potamogeton berchtoldii Fieb.	r
Potamogeton gramineus L.	f
Potamogeton natans L.	r
Potamogeton perfoliatus L.	c
Scheuchzeria palustris L.	c
Alisma plantago-aquatica L.	f
Agrostis canina L.	c
Agrostis gigantea Roth	r
Agrostis capillaris L. (A. tenuis Sibth.)	c
Alopecurus aequalis Sobol.	f
Alopecurus arundinaceus Poiret	r
Alopecurus geniculatus L.	r

Alopecurus pratensis L.	r
Anthoxanthum odoratum L.	f
Anthoxanthum odoratum subsp. alpinum (Ä. & D. Löve) Jones & Melderis (A. alpinum Ä. et D. Löve)	r
Briza media L.	r
Bromus arvensis L.	r
Calamagrostis arundinacea (L.) Roth	r
Calamagrostis canescens (Weber) Roth	f
Calamagrostis epigeios (L.) Roth	f
Calamagrostis. stricta (Timm) Koeler (C.neglecta (Ehrh.) Gaertn.)	c
Calamagrostis purpurea (Trin.) Trin. subsp. phragmitoides (Hartman) Tzvelev (C. phragmitoides Hartman)	c
Dactylis glomerata L.	r
Deschampsia cespitosa (L.) Beauv.	c
Deschampsia flexuosa (L.) Trin. (Avenella flexuosa (L.) Drej.)	c
Echinochloa crus-galli (L.) Beauv.	r
Elymus caninus (L.) L.	f
Elymus repens (L.) Gould. (Elytrigia repens (L.) Nevski)	c
Festuca ovina L.	f
Festuca pratensis Hudson	r
Festuca richardsonii Hooker	r
Festuca richardsonii x rubra	r
Festuca rubra L.	f
Festuca trachyphylla (Hack.) Krajina	r
Hierochloë hirta (Schrank) Borbás subsp. arctica (C. Presl) G Weim. (H. arctica C. Presl)	f
Hordeum vulgare L.	r
Melica nutans L.	f
Milium effusum L.	f
Molinia caerulea (L.) Moench	c
Nardus stricta L.	f
Phleum alpinum L.	f
Phleum pratense L.	r
Phalaris arundinacea L. (Phalaroides arundinacea (L.) Rauschert)	f
Phragmites australis (Cav.) Trin. ex Steudel	c
Poa annua L.	f
Poa compressa L.	r
Poa nemoralis L.	r
Poa palustris L.	f
Poa pratensis L.	f
Poa subcaerulea Smith	r
Poa trivialis L.	f
Trichophorum alpinum (L.) Pers.) (Baeothryon alpinum (L.) Egor.)	f
Trichophorum cespitosum (L.) Hartman (Baeothryon cespitosum (L.) A. Dietr.)	f
Carex acuta L.	c
Carex aquatilis Wahlenb.	f
Carex brunnescens (Pers.) Poir.	f
Carex buxbaumii Wahlenb.	r
Carex cespitosa L.	c
Carex chordorrhiza L. fil.	c
Carex canescens L. (C. cinerea Poll.)	c
Carex dioica L.	f
Carex disperma Dewey	f

Carex echinata Murray	c
Carex flava L.	r
Carex globularis L.	c
Carex lasiocarpa Ehrh.	c
Carex ovalis L.	f
Carex limosa L.	c
Carex loliacea L.	f
Carex nigra (L.) Reichard	c
Carex nigra subsp. juncella (Fries) Lemke (C. juncella (Fries) Th. Fries)	f
Carex elata All. subsp. omskiana (Meinsh.) Jalas (C. omskiana Meinsh.)	f
Carex pauciflora Lightf.	c
Carex magellanica Lam. subsp. irrigua (Wahlenb.) Hiit. (C. paupercula Michx.)	c
Carex rhynchophysa Fisher, C.A. Meyer & Avé-Lall.	r
Carex rostrata Stokes	c
Carex rotundata Wahlenb.	r
C. rostrata x Carex rotundata	r
Carex vaginata Tausch	c
Carex vesicaria L.	c
Calla palustris L.	f
Eleocharis acicularis (L.) Roemer et Schultes	r
Eleocharis palustris (L.) Roemer et Schultes	c
Eriophorum angustifolium Honckeny (E. polystachion L.)	c
Eriophorum gracile Koch	r
Eriophorum latifolium	r
Eriophorum vaginatum L.	c
Rhynchospora alba (L.) Vahl	r
Schoenoplectus lacustris (L.) Palla (Scirpus lacustris L.)	f
Juncus alpinoarticulatus Chaix	f
Juncus alpinoarticulatus subsp. fischerianus ((Turcz.) Hämet-Ahti	r
Juncus alpinoarticulatus subsp. nodulosus (Wahlenb.) Hämet-Ahti (J. nodulosus Wahlenb.)	r
Juncus articulatus L.	r
Juncus bufonius L. s. l.	f
Juncus bulbosus L.	r
Juncus filiformis L.	c
Juncus stygius L.	r
Luzula multiflora (Retz.) Lej.	f
Luzula pallescens Sw.	r
Luzula pilosa (L.) Willd.	c
Luzula sudetica (Willd.) DC.	f
Tofieldia pusilla (Michx.) Pers.	r
Convallaria majalis L.	r
Maianthemum bifolium (L.) F.W. Schmidt	c
Paris quadrifolia L.	r
Corallorhiza trifida Châtel.	f
Dactylorhiza fuchsii (Druce) Soó	f
Dactylorhiza maculata (L.) Soó	c
Dactylorhiza traunsteineri*,** (Sauter) Soó s.l.	r
Goodyera repens (L.) R. Br.	f
Listera cordata (L.) R. Br.	f
Platanthera bifolia (L.) Rich.	r
Populus tremula L.	c
Salix aurita L.	c
Salix caprea L.	c

Salix cinerea L.	r
Salix lapponum L.	c
Salix myrsinifolia Salisb.	f
Salix myrtilloides L.	f
Salix pentandra L.	r
Salix phylicifolia L.	c
Salix starkeana Willd.	f
Alnus incana (L.) Moench	c
Alnus incana subsp. kolaënsis (Orlova) A. & D. Löve (A. kolaënsis Orlova)	r
Alnus glutinosa (L.) Gaertn.	r
Betula nana L.	c
Betula nana x B. pendula (B.x bottnica Mela)	r
Betula nana x B. pubescens (B. x intermedia Thomas)	r
Betula pendula Roth	c
Betula pubescens Ehrh.	c
Urtica dioica L.	f
Humulus lupulus L.	r
Polygonum bistorta L. (Bistorta major S.F. Gray)	r
Polygonum viviparum L. (Bistorta vivipara (L.) S. F. Gray)	f
Fallopia convolvulus (L.) Á. Löve	r
Polygonum lapathifolium L. (Persicaria scabra (Moench) Kitam.)	r
Polygonum aviculare L.	r
Rumex acetosa L.	r
Rumex acetosa subsp. acetosa	
Rumex acetosa subsp. lapponicus Hiit. (R. lapponicus (Hiit.) Czernov)	r
Rumex acetosella L.	f
Rumex thyrsiflorus Fingerh.	f
Rumex crispus L.	r
Rumex obtusifolius L.	r
Rumex obtusifolius cf. subsp. obtusifolius	
Rumex obtusifolius subsp. transiens (Simonkai) Rech. fil.	
Rumex obtusifolius subsp. sylvestris (Wallr.) Celak.	
Rumex longifolius DC.	f
Chenopodium album L.	r
Montia fontana L.	r
Cerastium fontanum Baumg. subsp.vulgare (Hartman) Greuter & Burdet) (C. holosteoides Fries)	f
Lychnis flos-cuculi L. (Coronaria flos-cuculi (L.) A. Br.)	r
Gypsophila elegans Bieb.	r
Gypsophila muralis L. (Psammophiliella muralis (L.) Ikonn.)	r
Herniaria glabra L.	r
Silene dioica (L.) Clairv.) (Melandrium dioicum (L.) Coss. et Germ.)	r
Silene vulgaris (Moench) Garcée (Oberna behen (L.) Ikonn.)	r
Sagina procumbens L.	r
Scleranthus annuus L.	r
Spergula arvensis L. s. l.	r
Spergularia rubra (L.) J. et C. Presl	r
Stellaria graminea L.	c
Stellaria media (L.) Vill.	f
Stellaria longifolia Willd.	r
Nuphar x intermedia (Ledeb.) Schuster	f
Nuphar lutea (L.) Smith	c
Nuphar pumila (Timm) DC.	r
Nymphaea candida C. Presl	f

Nymphaea tetragona Georgi	f
Actaea erythocarpa Fischer	r
Ranunculus peltatus Schrank (Batrachium peltatum (Schrank) Bercht. et C. Presl)	f
Ranunculus trichophyllus* (Batrachium trichophyllum (Chaix) Bosch)	r
Caltha palustris L.	f
Ranunculus acris L.	c
Ranunculus auricomus L.	r
Ranunculus lapponicus L.	r
Ranunculus repens L.	c
Ranunculus reptans L.	c
Thalictrum flavum L.	f
Trollius europaeus L.	r
Barbarea vulgaris R. Br. var. arcuata (Opiz ex J. et C. Presl) (B. arcuata (Opiz ex J. et C. Presl) Reichenb.)	r
Brassica rapa L. subsp. 'sylvestris' - oleifera DC. (B. campestris L.)	r
Capsella bursa-pastoris (L.) Medikus	r
Cardamine pratensis L.	r
Raphanus raphanistrum L.	r
Rorippa palustris (L.) Besser	r
Sinapis arvensis L.	r
Subularia aquatica L.	r
Drosera anglica Huds.	c
Drosera rotundifolia L.	c
Parnassia palustris L.	f
Alchemilla glabricaulis Lindb. fil.	r
Alchemilla gracilis Opiz	r
Alchemilla monticola Opiz	f
Alchemilla subcrenata Bus.	f
Potentilla palustris (L.) Scop. (Comarum palustre L.)	c
Filipendula ulmaria (L.) Maxim.	c
Fragaria x ananassa Duch.	r
Fragaria vesca L.	r
Geum rivale L.	r
Prunus padus L. (Padus avium Miller)	f
Potentilla anserina L.	r
Potentilla erecta (L.) Räusch.	f
Potentilla intermedia L.	r
Potentilla norvegica L.	r
Rubus arcticus L.	f
Rubus arcticus x R. saxatilis (R. x castoreus Laest.)	r
Rubus chamaemorus L.	c
Rubus idaeus L.	f
Rubus saxatilis L.	c
Rosa majalis Herrm.	r
Sorbus aucuparia L.	c
Lathyrus pratensis L.	f
Lupinus polyphyllus Lindley	r
Trifolium hybridum L.	r
Trifolium pratense L.	f
Trifolium repens L.	f
Trifolium spadiceum L.	r
Vicia cracca L.	f
Vicia sepium L.	f
Geranium pratense L.	r

Geranium sylvaticum L.	f
Callitriche cophocarpa Sendtner	r
Callitriche palustris L. (C. verna L.)	f
Empetrum nigrum L. subsp. hermaphroditum (Lange) Böcher (E. hermaphroditum Hagerup)	c
Empetrum nigrum L. subsp. nigrum (Hagerup) Böcher	f
Rhamnus frangula L. (Frangula alnus Mill.)	f
Viola arvensis Murray	r
Viola epipsila Ledeb.	c
Viola canina L. subsp. montana (L.) Hartman (V. montana L.)	f
Viola palustris L.	f
Viola selkirkii Pursh ex Goldie	r
Viola tricolor L.	r
Daphne mezereum L.	r
Epilobium adenocaulon Hausskn. (Epilobium ciliatum Rafin.)	r
Epilobium hornemannii* Reichenb.	r
Epilobium hornemannii x E. palustre	r
Epilobium montanum L.	r
Epilobium palustre L.	f
Epilobium angustifolium L. (Chamaenerion angustifolium (L.) Scop.)	c
Circaea alpina L.	r
Myriophyllum alterniflorum DC.	f
Myriophyllum verticillatum* L.	r
Hippuris vulgaris L.	f
Angelica sylvestris L.	f
Anthriscus sylvestris (L.) Hoffm.	f
Carum carvi L.	f
Chaerophyllum prescottii DC.	r
Cicuta virosa L.	f
Daucus carota L.	r
Heracleum sphondylium L. subsp. sibiricum (L.) Simonkai (H.sibiricum L.)	r
Pimpinella saxifraga L.	r
Peucedanum palustre (L.) Moench (Thyselium palustre (L.) Rafin.)	f
Cornus suecica L. (Chamaepericlymenum suecicum (L.) Aschers. et Graebn.)	c
Moneses uniflora (L.) A. Gray	f
Orthilia secunda (L.) House	c
Pyrola chlorantha Sw.	r
Pyrola minor L.	f
Pyrola rotundifolia L.	r
Arctostaphylos uva-ursi (L.) Sprengel	r
Andromeda polifolia L.	c
Calluna vulgaris (L.) Hull	c
Chamaedaphne calyculata (L.) Moench	c
Ledum palustre L.	c
Vaccinium oxycoccos L. (Oxycoccus palustris Pers.)	f
Vaccinium microcarpum (Rupr.) Hooker fil. (Oxycoccus microcarpus Rupr.)	c
Vaccinium vitis-idaea L.	c
Vaccinium myrtillus L.	c
Vaccinium uliginosum L.	c
Lysimachia vulgaris L.	f
Lysimachia thyrsiflora L. (Naumburgia thyrsiflora (L.) Reichenb.)	c
Trientalis europaea L.	c
Menyanthes trifoliata L.	c
Polemonium caeruleum L.	r

Echium vulgare L.	r
Galeopsis speciosa Miller	f
Galeopsis bifida Boenn.	r
Mentha arvensis L.	f
Myosotis arvensis (L.) Hill	r
Myosotis scorpioides L. (M. palustris (L.) Hill)	r
Prunella vulgaris L.	f
Scutellaria galericulata L.	c
Stachys palustris L.	r
Solanum tuberosum L.	r
Euphrasia nemorosa (Pers.) Wallr. (E. parviflora Schager.)	r
Euphrasia stricta Wolff ex Lehm. var stricta (E. brevipila Burn. et Gremli)	f
Rhinanthus minor (L.)	f
Rhinanthus serotinus (Schoenh.) Oborny	r
Linaria vulgaris Mill.	f
Melampyrum pratense L.	c
Melampyrum sylvaticum L.	c
Pedicularis palustris L.	f
Pedicularis sceptrum-carolinum L.	r
Scrophularia nodosa L.	r
Veronica chamaedrys L.	f
Veronica scutellata L.	r
Veronica longifolia L.	f
Veronica serpyllifolia L.	r
Pinguicula villosa L.	r
Pinguicula vulgaris L.	f
Utricularia intermedia Hayne	c
Utricularia minor L.	r
Utricularia vulgaris L.	f
Littorella uniflora* (L.) Ascherson	r
Plantago major L.	r
Plantago media L.	r
Galium album Mill.	f
Galium spurium L. (G. aparine L.)	r
Galium boreale L.	f
Galium palustre L.	c
Galium uliginosum L.	c
Linnaea borealis L.	c
Viburnum opulus L.	r
Knautia arvensis (L.) Coulter	f
Campanula patula L.	r
Campanula rotundifolia L.	c
Lobelia dortmanna*,** L.	c
Achillea millefolium L.	f
Achillea ptarmica L. (Ptarmica vulgaris L.)	r
Antennaria dioica (L.) Gaertner	f
Arctium tomentosum Miller	r
Artemisia absiuthium	r
Artemisia vulgaris L.	r
Centaurea jacea L.	r
Centaurea phrygia L.	f
Centaurea scabiosa L.	r
Cirsium arvense (L.) Scop.	r
Cirsium helenioides (L.) Hill (C. heterophyllum (L.) Hill)	f

Cirsium palustre (L.) Scop.	r
Conyza canadensis (L.) Cronq.	r
Gnaphalium sylvaticum L. (Omalotheca sylvatica (L.) Sch. Bip. ex F. Shultz)	f
Crepis paludosa (L.) Moench	r
Hieracium caesium (Fries) Fries	f
Hieracium cespitosum Dumort., coll.	f
Hieracium fennoorbicans Norrlin	r
Hieracium x glomeratum Froel.	r
Hieracium incurrens Norrlin	r
Hieracium laevigatum Willd., coll.	r
Hieracium lapponicum Fries	f
Hieracium lateriflorum Norrlin	r
Hieracium pilosella L. (Pilosella officinarum F. W. Shultz Bip. (coll.))	r
Hieracium praealtum Vill. ex Gochn. (Pilosella praealta Vill. ex Gochnat)	r
Hieracium prenanthoides Vill., coll.	r
Hieracium rigidum C. Hartm.	f
Hieracium subpellucidum (Norrlin) Norrlin	r
Hieracium umbellatum L.	c
Hieracium vulgatum Fries, coll.	f
Lactuca sibirica (L.) Maxim.	r
Leontodon autumnalis L.	r
Leontodon hispidus L.	r
Leucanthemum vulgare Lam.	f
Matricaria matricarioides (Less.) (Lepidotheca suaveolens (Pursh) Nutt.)	r
Senecio vulgaris L.	r
Solidago virgaurea L.	c
Sonchus arvensis L.	r
Tanacetum vulgare L.	r
Taraxacum officinale Wigg., coll.	f
Tripleurospermum inodorum Schultz Bip. (T. perforatum (Mérat) M. Laínz)	r
Tussilago farfara L.	r

* - included in the Red Data Book of Karelia
** - included in the Red Data Book of Russia

On the aquatic flora and vegetation of the northern half of the isoetid Lake Kiitehenjärvi in the Kostomuksha Nature Reserve

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Abstract

Lake Kiitehenjärvi has an area of 103 km^2 and its water is clear (Secchi disc value about 4 m) and extremely poor in nutrients (conductivity in open areas about 15-18 $\mu S/cm$ and tot.-P about 2-5 mgl^{-1}). The flora and vegetation of the northern half of Lake Kiitehenjärvi are of considerable interest and diversity. The lake is characterized by a well developed, extensive isoetid vegetation in which the species content is higher than average for lakes of this type. Eight isoetid species were found. *Isoetes lacustris, I. echinospora, Lobelia dortmanna, Eleocharis acicularis, Ranunculus reptans* and *Subularia aquatica* are common and often abundant, *Littorella uniflora* is quite common and mostly abundant and *Crassula aquatica* is rare. The subatlantic *Littorella uniflora* grows only under the ice border and is at the northeastern extreme of its distribution in Fennoscandia. The isoetid vegetation was grouped by the TABORD program into six syntaxa (variants) and three main types: 1. *Isoetes lacustris* type, 2. *Isoetes lacustris-Lobelia dortmanna* type and 3. *Isoetes echinospora* type. The *Isoetes lacustris-Lobelia-Littorella* variant (IlacLoLitV) represents a southwestern type in Fennoscandia, while the others are of a continental and northern character.

The helophyte flora (total 10 species) consists of the most common species for lakes of this kind. Only four helophytes are common: *Equisetum fluviatile, Phragmites australis, Lysimachia thyrsiflora* and *Carex rostrata,* the other six species being rare or quite rare. The well developed isoetid vegetation is often growing at a certain depth under very dense stands of the tall helophytes *Equisetum* and *Phragmites,* forming an isoetid vegetation with helophytes, which is typical of Finnish lakes.

The often mixed nymphaeid and elodeid vegetation is sparse (11 species, including nymphaeids, elodeids, two *Utricularia* species and one macroalga, *Nitella flexilis*), and consists mainly of *Nuphar lutea, Sparganium angustifolium, Myriophyllum alterniflorum, Potamogeton perfoliatus* and *Ranunculus peltatus,* reflecting the poor nutrient status of the water. Four syntaxa were formed by the TABORD program.

The aquatic bryophytes are numerous, but they are sparse in the nymphaeid and elodeid vegetation and sometimes also in the isoetid vegetation. The most common and abundant species in the water are of the genera *Warnstorfia* and *Fontinalis*, but the the number of bryophytes and the vascular plants is high in the geolittoral zone (more than 100 species).

41 species of water plants (and one hybrid) were reliably recorded in the 25 areas examined below the mean water level in the northern half of the lake, but the correct number is obviously higher, about 50. The relatively high to moderate plant diversity of Lake Kiitehenjärvi, which is very poor in nutrients, is due to the regular and relatively small water level fluctuation and long shoreline, which create many habitats for the species.

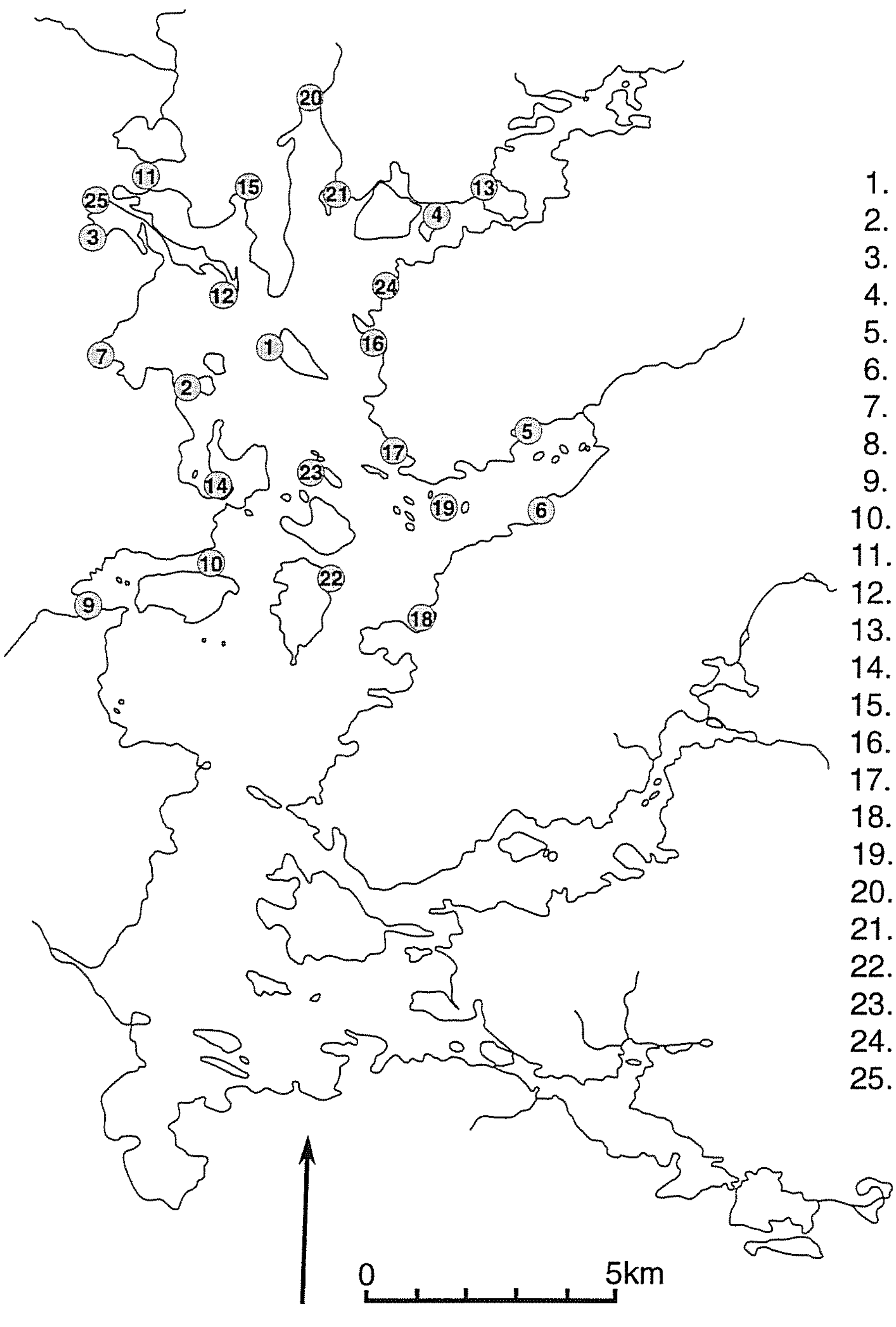
Key words: Aquatic flora, species construction, vegetation types, vegetation analyses, Lake Kiitehenjärvi

The area studied

Lake Kiitehenjärvi is located in the Kostomuksha Nature Reserve in Russian Karelia (with coordinates 64° 27'N and 30° 12'E) 195 m above sea level. It has an area of 95 km^2, according to Russian records (Kashevarov 1989), a length of 25 km in a NW-SE direction and a breadth of 15 km. Planimetric measurements performed by our group on a Russian topographic map 1: 50,000 (1984) show the water area to be 103.6 km^2 and the shoreline curvimetrically to be about 230 km (Fig. 1). The lake has many long bays extending towards the east. There are 98 islands, many of them large (e.g. Leininšoari, Karankošoari and Jyvätšoari, which are more than 100 ha each; there are no Russian names for these islands on the map). The mean depth seems to be roughly 8 m, and the maximum depth in the northern part of the lake is 26 m. The water in the large, open areas is clear (Pt color 30 mgl^{-1}), with a Secchi disc transparency of about 4 m, but at the heads of the long bays, in the presence of water from the surrounding bogs, it is less than 3 m in places. The water is very poor in nutrients, conductivity being only 15-18μS/cm (at +20°C) and nitrogen and phosphorus values are very low (in the open areas only 2-5 mgl^{-1} P and 100-400 mgl^{-1} N), except in some places at the heads of the bays and at the mouths of some streams, (analyses from the summers 1990 and 1991, performed partly by the Water and Environment District of Kainuu and partly by the authors 1992 and 1993; (see also Oikari & Markkanen 1994). The mean maximum ice thickness is about 65-70 cm and the duration of the ice cover about 6.5 months (Suomen kartasto/Atlas of Finland 1986).

The bedrock consists of Archaean gneisses and granites, migmatite and granodiorite (Durov 1989). These rock types do not contribute much to the trophic status of the vegetation, and the lake is surrounded by a normal or poor heath forest vegetation and peatlands. The lake is characterised by oligotrophic vegetation in the water and at the shoreline (Kashevarov 1989). There is a long, low, narrow esker, Tulliniemi, in the NW corner of the lake, and wide sandy shore areas exist in the surroundings and in many places on the eastern shores and on the shores of Neitisaari (50 ha), located in the centre of the northern stretch of open water. There are large areas of sand and sandy shores especially in the southern half of the lake, mainly on its western shore (Durov 1989). The main soil type is stony till, and stony shores with numerous large rocks are typical. (The Russian name of the lake, Kamennoye means 'stony'.)

Our research programme for the year 1993 included an examination of the vegetation in the northern half of this lake. A base camp was set up on the large, sandy island of Neitisaari (in Russian o. Devitchij) in the middle of the northern open water area.



1. Neitisoari W
2. Viitasoaret W
3. Nakrislaksi W
4. Kattilasoaren salmi
5. Munankilaksi N
6. Munankilaksi S
7. Matalalaksi S
8. Ristilaksi S
9. Karankolaksi
10. Karankosoari NE
11. Hukkasalmi
12. Tullinniemi SW
13. Ryönänsalmi
14. Sappulaksi SE
15. Terassiempeä
16. Kirvesranta
17. Kaiskunniemi S
18. Talvilaksi
19. Voisoari
20. Kovalaksi
21. Kovasoari E
22. Leininsoari NE
23. Makarinsoari W
24. Märkävoara NW
25. Nakrislaksi N

Fig. 1. Lake Kiitehenjärvi with the 25 special investigation areas in the northern part of the lake.

Methods

Excursions were made with a motor boat from the base camp to 25 special investigation areas, chosen in advance at regular distances apart on the map. Each area consisted of 400 m of shore line and the water area in front of it as far as the lower limit of vegetation. Five large vegetation relevés (5 m^2 or more) were studied along the depth gradient in different parts of each area analysed, the flora was listed and all the species abundance values were calculated. The equipment used included a special bottom sampler, a bottom scoop (model Mäkirinta 1978), and a bottom drag (model Maristo 1941). Our simple water telescope was a plastic pail with a transparent glass bottom.

The vegetation data collected from the 25 special areas were analysed using computer-based multivariate programs: the clustering and classification program TABORD (van der Maarel et al. 1978) and the ordination program ORDINA/PCA or principal components analysis (Roskam 1971). The detailed clustering, ordination and classification procedures follow Mäkirinta (1989).

The shoreline of the lake in the map (Fig. 1) is redrawn from the Russian topographic map 1:50 000 (1984), and the Karelian names of the places are after Jyrinoja (1965). The nomenclature of the vascular plants follows Hämet-Ahti et al. (1986) and that of the aquatic bryophytes Koponen et al. (1995).

Results

Vegetation dominated by isoetids

The species

Lake Kiitehenjärvi is dominated by plants of the isoetid life form. Altogether eight isoetid species were found. Common and often abundant isoetid species are *Isoetes lacustris, I. echinospora, Lobelia dortmanna, Ranunculus reptans, Eleocharis acicularis* and *Subularia aquatica,* while *Littorella uniflora* is quite common and abundant in places, and *Crassula aquatica* is rare.

The distribution of *Littorella uniflora* in NW Europe is clearly subatlantic with an optimum in the SW part of Fennoscandia (Hulten 1971). It has been found only in a few places in Russian Karelia, all much more southern than Lake Kiitehenjärvi. The find by Raspopov (1971) in Lake Onega was for a long time the most northeasterly record for this species, but in 1991 it was found by the author Mäkirinta in two smaller lakes near Petrozavodsk. The nearest locality to Lake Kiitehenjärvi for *Littorella* is Lake Lentua in Finland (Hanhela & Vainio 1987), but its northernmost locality in Finland is Lake Kitkajärvi, close to the Arctic Circle, where it is quite common and abundant (Mäkirinta 1984).

The occurrence of six isoetid species along the depth gradient is presented in Figs. 2 and 3. The very shallow water and the ice zone are favoured by *Isoetes echinospora* and *Lobelia dortmanna,* while *Littorella uniflora* and *Isoetes lacustris* will be mostly disturbed by ice, as in Finland (Mäkirinta 1978) and northern Sweden (Lohammar 1965). *I. lacustris* is also to be found in the ice zone in Lake Kiitehenjärvi, quite often at low abundances. Being rooted between the stones, it is protected from disturbance by ice movement and the surge of the waves. *Littorella* is unable to overwinter in these holes, however, on account of the long duration of the ice cover.

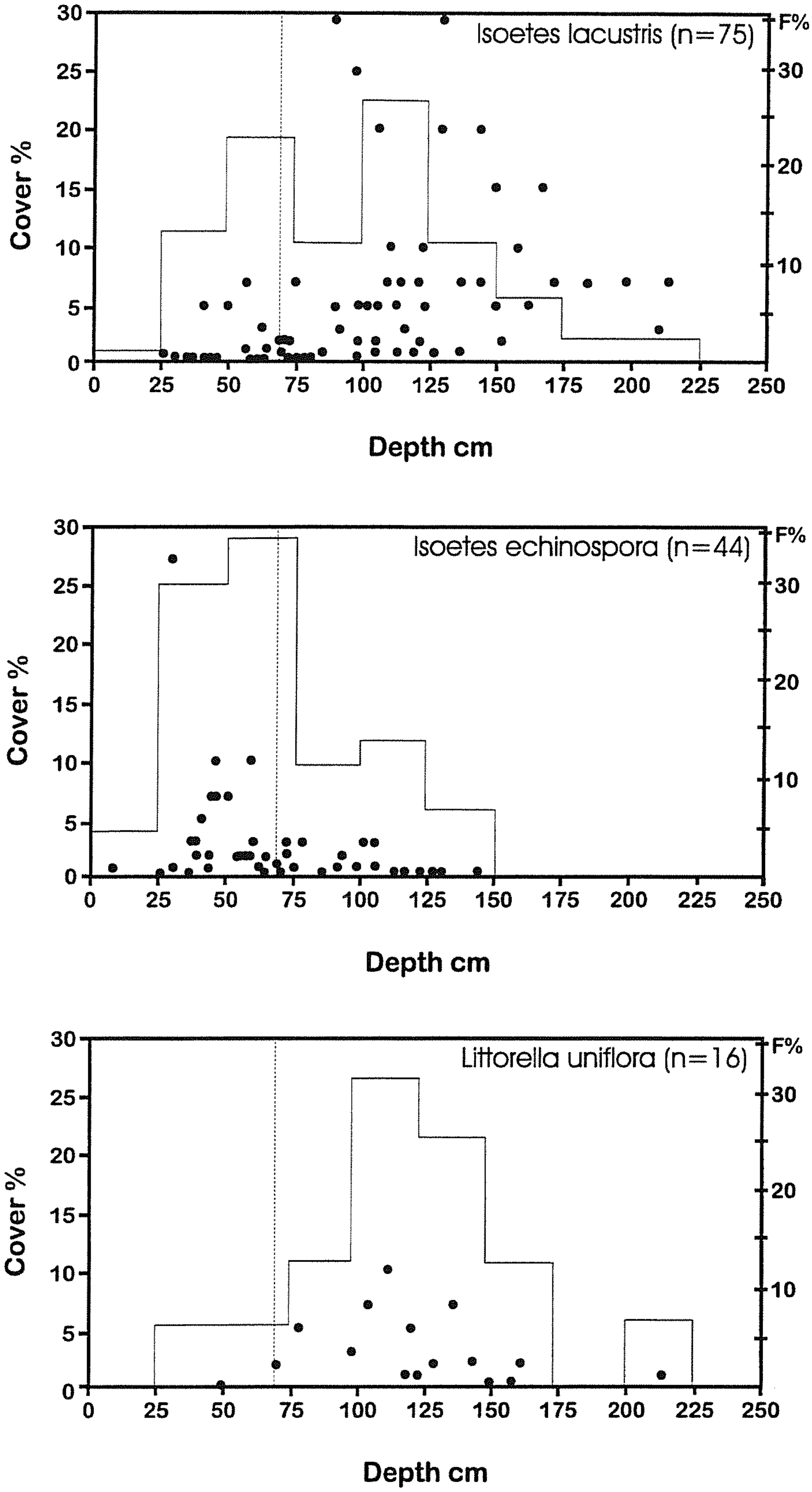


Fig. 2. Abundance (in cover%, left scale, and frequency in depth zones of 25 cm (in %, right scale) of three isoetid species, Isoetes lacustris, Isoetes echinospora *and* Littorella uniflora, *along the depth gradient in the relevé material. The occurrence of each species in the whole isoetid vegetation material (91 relevés) is expressed with a presence number (n) after the species name. Broken line = ice border.*

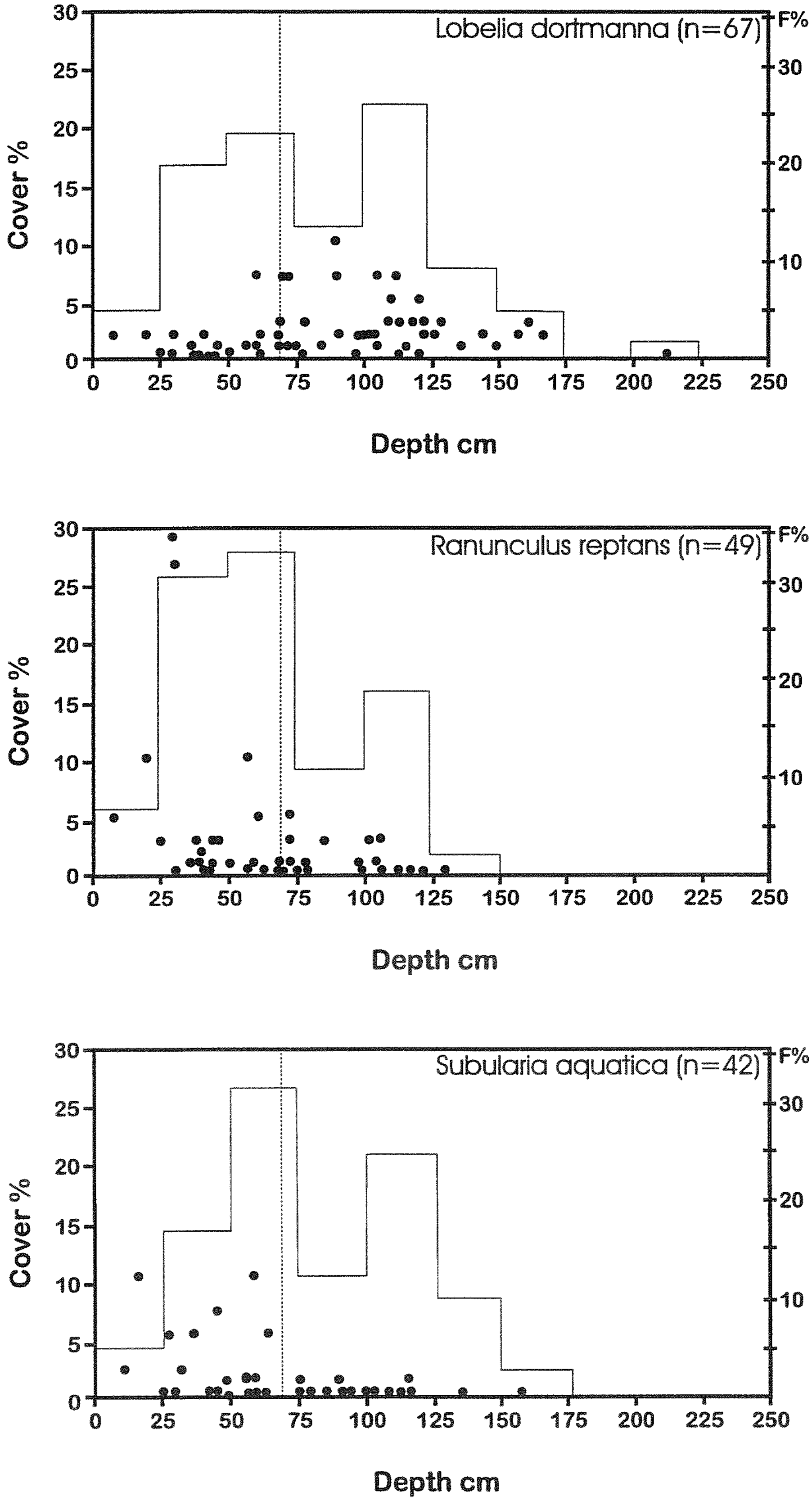


Fig 3. Abundance (in cover%, left scale) and frequency in depth zones of 25 cm (in %, right scale) of three isoetid species, Lobelia dortmanna, Ranunculus reptans *and* Subularia aquatica, *along the depth gradient in the relevé material. The occurrence of each species in the whole isoetid vegetation material (91 relevés) is expressed with a presence number (n) after the species name. Broken line = ice border.*

Ranunculus reptans and *Subularia aquatica* are also very common in the ice zone and reach their optimum abundance there. Most isoetids seem to gain in some way from the ice cover, whereas they are quite rare around the zero level (MW) and higher in the geolittoral zone. *Ranunculus reptans* grows in many places above the mean water level and on low shore banks. These isoetids constitute a pioneer vegetation which can be practically a permanent stage in the erosion zone, and even in deeper zones, if the bottom is hard enough and poor in nutrients. There are places on the wide sandy shores where isoetids can be absent if the sand is too loose or erosion by the waves and ice too strong. Nutrients, especially nitrogen, are washed out more effectively in the ice zone than in the ice-free areas (Renman 1993), so that the ice zone will be still poorer in nutrients.

The maximum depths for the isoetid species are determined partly by the nature of the bottom and the intensity of the illumination. Most isoetids are light-demanding species (see Mäkirinta 1978a,b), and therefore they cannot grow in very deep zones not even in moderate clear water like that of Lake Kiitehenjärvi. The species may be arranged in order of increasing demand with respect to light intensity as follows: *Isoetes lacustris, Littorella uniflora, Lobelia dortmanna, Ranunculus reptans, Eleocharis acicularis, Isoetes echinospora, Subularia aquatica* and *Crassula aquatica*. The sequence is about the same as in Lake Kukkia (Mäkirinta 1978a,b) and Lake Kitka (Mäkirinta 1984) and in many other Finnish (Maristo 1941) and Swedish lakes (Lohammar 1965, Mäkirinta 1989). The detailed differences that occur are dependent on the species composition and local environmental conditions.

The syntaxa

The isoetid species, together with the other aquatic species in these stands, form six vegetation units (syntaxa) in our relevé material from Lake Kiitehenjärvi (91 rel.) when processed using the TABORD clustering and classification program (Table 1). These were termed 'basic clusters' in the analysis phase and were established later in the classification procedure as 'variants' (for the procedure: see Mäkirinta 1989). The six variants were combined into three larger communities (associations) as follows:

A. *Isoetes lacustris* Community (IlacC)
  1. *Isoetes lacustris* var. (IlacV)
B. *Isoetes lacustris-Lobelia dortmanna* Community (IlacLoC)
  2. *Isoetes lacustris-Lobelia* var. (IlacLoV)
  3. *Isoetes lacustris-Lobelia-Littorella* var. (IlacLoLitV)
  4. *Isoetes lacustris-Lobelia-Isoetes echinospora* var. (IlacLoIechV)
C. *Isoetes echinospora* Community (IechC)
  5. *Isoetes echinospora-Ranunculus reptans* var. (IechRrV)
  6. *Isoetes echinospora-Ranunculus reptans-Subularia* var. (IechRrSaqV)

The numbered variants grow along the depth gradient (beginning from the deepest water) on average as follows: 1-3-2-4-5-6. The distribution of six diagnostic isoetid species along the depth gradient illustrate partly the same situation (Figs. 2 and 3).

Table 1. Isoetid vegetation (IsVeg) in Lake Kiitehenjärvi, grouped by the TABORD program into 6 basic clusters (=variants 1-6) and 3 community types (A-C). The relevé material (91 rel.) was collected from 25 areas in the northern half of the lake. The scores for the species (C.A) are marked for Constancy and Abundance in % for the cluster.

Community type	A.Ilac	B.IlacLo			C.Iech	
Variant (basic cluster)	1.Ilac	2.IlacLo	3.IlacLoLit	4.IlacLoIech	5.IechRr	6.IechRrSaq
Number of relevés à 5 m²	16	27	12	13	12	11
	C.A	C.A	C.A	C.A	C.A	C.A
Is						
Isoetes lacustris	100.8	100.7	100.7	77.+	42.+	45.1
Lobelia dortmanna	13.8	100.3	100.4	92.1	58.+	64.1
Littorella uniflora	6.+	7.+	100.4	.	8.+	.
Isoetes echinospora	38.+	4.+	8.+	77.1	93.3	100.4
Ranunculus reptans	31.+	37.+	38.+	85.4	83.2	100.2
Eleocharis acicularis	6.+	26.+	58.+	69.1	75.+	55.+
Subularia aquatica	44.+	13.+	42.+	31.+	25.+	100.4
Crassula aquatica	.	.	.	.	.	9.2
El						
Myriophyllum alterniflor.	.	7.+	.	.	33.6	9.+
Ranunculus peltatus	.	4.+	.	.	8.+	.
Callitriche palustris	.	.	.	.	.	9.+
Cer						
Utricularia vulgaris	.	.	.	.	.	9.+
Ny						
Nuphar lutea	.	.	.	.	8.+	27.3
Nuphar lutea x pumila	.	4.+	.	.	.	.
Sparganium angustifolium	38.+	.	.	15.+	75.1	55.2
Br						
Warnstorfia trichophylla	6.+	7.+	.	.	8.+	9.+
Scorpidium scorpioides	6.+	4.+	.	.	.	9.+
Fontinalis antipyretica	.	4.+	.	8.+	8.+	.
Warnstorfia procera	.	.	.	.	.	18.+
Fontinalis dalecarlica	.	4.+	.	.	.	.
Campylium polygamum	.	.	.	8.+	.	9.+
He						
Phragmites australis	6.+	26.+	8.+	69.2	8.+	.
Equisetum fluviatile	.	11.+	.	31.+	50.+	9.+
Eleocharis palustris	.	.	.	23.+	17.1	.
Carex rostrata	.	.	.	.	8.1	.
Caltha palustris	.	.	.	.	.	9.1

Variants 1-3 show floristic compositions similar to those in the Finnish Lake District, although variant 3, with *Littorella uniflora,* is quite rare in Finland and its optimum area is in the southwest. Variants 4-6 show northern and continental characteristics corresponding (4.) to the *Ranunculus reptans* variant of the IlacLoC and (5.-6.) the two variants of the *Isoetes echinospora* subcommunity of the *Lobelia* type, *Isoetes echinospora* being more and *Lobelia* less abundant here than in the south or southwest of Finland and Sweden (Mäkirinta 1989).

In the classification of the Central European phytosociological school (Dierssen 1975) these 6 variants will obviously be grouped into three associations: Isoeto-Lobelietum (most relevés, if not all of the variants 1-4), *Isoetetum echinosporae* (some relevés of variants 5-6) and *Eleocharitetum acicularis* (a few releves of variants 5-6 with *Eleocharis acicularis* dominant).

The individual relevés do not follow the gradient scheme exactly, because the vertical dimension of each variant is quite large, while at the same time other ecological factors and also depth, contribute to the ecological basis for the variants and communities. Depth in itself may not be very important, but some correlated factors, in particular illumination conditions, may be decisive (Mäkirinta 1978a,b). Soil properties are also of importance. Thus the vegetation variant with *Littorella uniflora* (IlacLoLitV) is found growing on substrates with finer mineral fractions than elsewhere.

Principal components analysis, PCA (ORDINA program, see Roskam 1971), illustrates the occurrence of the isoetid vegetation syntaxa (variants) in a two-dimensional space in which the depth gradient is located diagonally between principal components I and II (Fig. 4). The ecological background to the first axis (vector) is not only depth but mainly the light intensity factor ('light climate'; Mäkirinta 1978b), but bottom quality plays a considerable part, too.

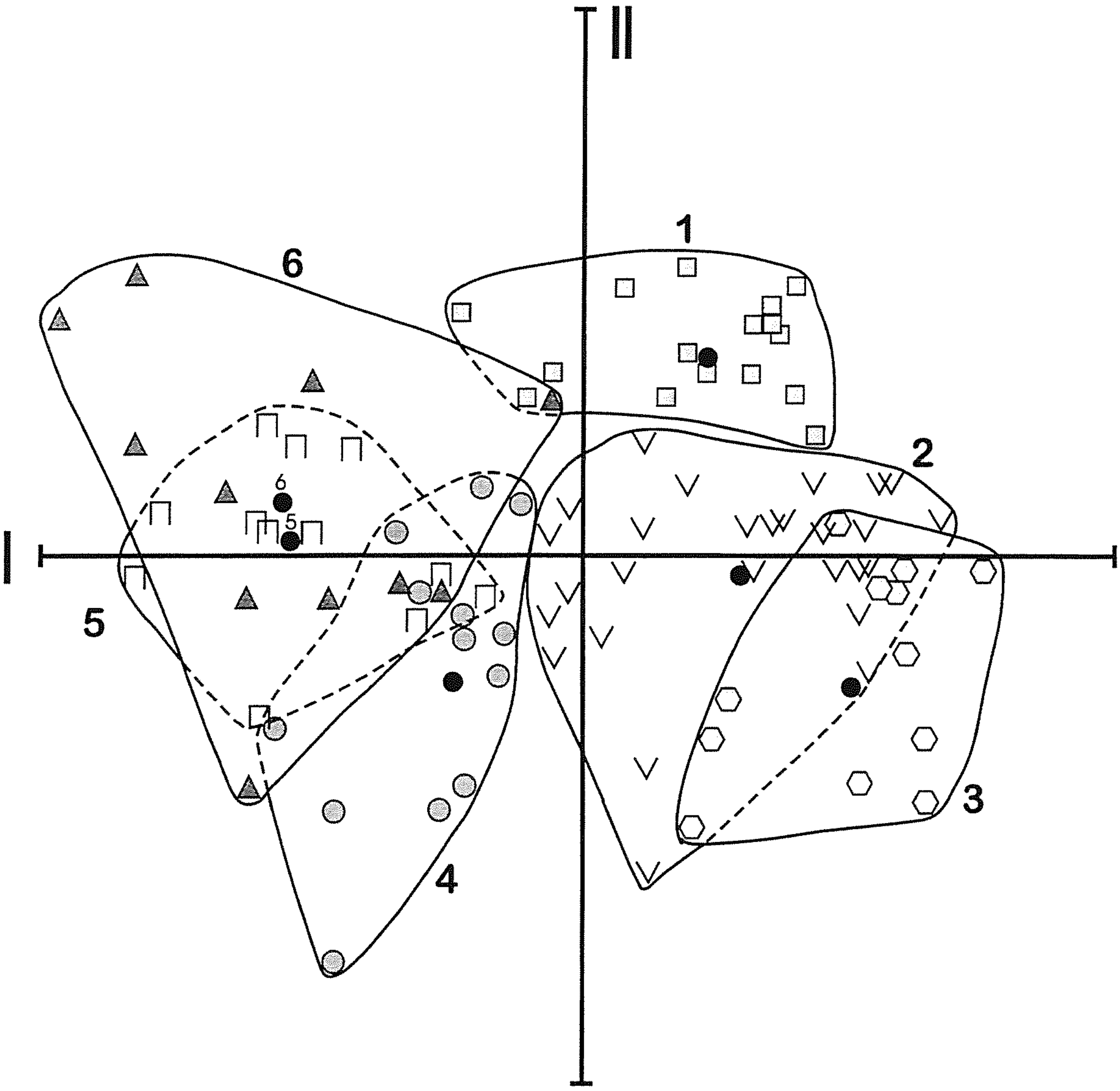


Fig. 4. Principal components analysis (PCA) of the 6 basic clusters of the isoetid vegetation made by the TABORD program: areas with lines and their centres with black points. For the numbered cluster names, see Table 1 and text.

Nymphaeid and elodeid vegetation

The species and syntaxa

The often mixed nymphaeid and elodeid vegetation is sparse, mainly with *Nuphar lutea, Sparganium angustifolium, Myriophyllum alterniflorum, Potamogeton perfoliatus* and *Ranunculus peltatus*, reflecting the poor nutrient status of the water. This kind of vegetation is sometimes found growing together with a poorly developed isoetid synusie, mostly with some *Isoetes echinospora* and *Ranunculus reptans. Myriophyllum alterniflorum* occasionally forms a weakly developed stratum in the isoetid vegetation described above.

The nymphaeid and elodeid vegetation is restricted to sheltered bays and coves, and is totally lacking on the shores of the larger open water areas (Table 2: floristic area types). The nutrient-poor water, hard bottom and wave action do not favour their growth.

A solution involving two main types was arrived at in the classification of stands: 1. *Nuphar lutea-Sparganium (angustifolium)* type and 2. *Myriophyllum alterniflorum* type. In addition, two rare types were found: 3. *Hippuris vulgaris* type (the main species of which is here a wholly submersed elodeid!) and 4. *Potamogeton natans* type. Types 1-3 represent vegetation of nutrient-poor water and the 4. *Potamogeton natans* type (mostly as one-species stands) a type characteristic of soft bottoms and common in many other kinds of lake (see Maristo 1941).

Helophyte vegetation

The species

The helophyte flora consists of the most common species for lakes of this kind (Table 2): mainly 4 species in the water: *Equisetum fluviatile, Phragmites australis, Lysimachia thyrsiflora* and *Carex rostrata,* while *Schoenoplectus lacustris, Eleocharis palustris, Carex lasiocarpa, C. acuta, C. elata* ssp. *omskiana* and *Caltha palustris* are rare or quite rare (the last species growing down to 30 cm below the mean water level).

The syntaxa

Sparse stands of *Phragmites australis* and *Equisetum fluviatile* and mixed stands of these two species are common on various types of shore (see the floristic area types in Table 2), but stands of these helophytes (and occasionally of some other helophytes) are often so light and/or fractionated that the shore appears from a distance to be entirely devoid of vegetation. As nymphaeids, and especially elodeids, are mostly lacking in these stands, this kind of helophyte vegetation in the hydrolittoral may be called a *Phragmitetum subpurum* (Raspopov 1971) or *Phragmitetum nudum* (Mäkirinta 1989). The light-demanding isoetids described above can grow in abundance in places below this, forming what may be called an isoetid vegetation with *Phragmites* and/or *Equisetum* reeds (Table 1, especially the variant IlacLoIechV of the IlacLo type; see Mäkirinta 1978a, 1989). The most extensive *Phragmites* stand (about 10 ha) is found on the sandy SW shore of the island of Neitišoari, but really dense reeds can be seen only in a few places even here.

Carex vegetation is common, mainly with *C. rostrata* and less frequently with *C. acuta* or *C. elata* ssp. *omskiana* or other species, but the stands, located on both sides of the mean water line, are not large. The total species content can be markedly high on the shore banks, located well above the mean water level.

Table 2. Aquatic flora of the 25 special areas of the northern half of Lake Kiitehenjärvi (41 species), grouped by the TABORD program into two floristic areal groups. The species are ordered in life form groups and their frequencyies are expressed in percentages (F%) and their abundances in cover percentages (A% = average percent coverage in all the relevés of the type group).

Floristic type group		1.IsVeg+NyVeg	2.IsVeg+open water
Special areas studied		10	15
Frequency% . Abundance%		F.A	F.A
Is	*Crassula aquatica*	10.+	.
	Eleocharis acicularis	90.2	87.2
	Isoetes echinospora	100.4	60.2
	Isoetes lacustris	100.4	93.5
	Littorella uniflora	.	60.2
	Lobelia dortmanna	90.2	93.4
	Ranunculus reptans	100.4	87.2
	Subularia aquatica	90.3	67.2
Ny	*Nuphar lutea*	100.3	7.+
	Nuphar lutea x pumila	20.+	.
	Potamogeton natans	10.+	13.+
	Sparganium angustifolium	90.2	27.1
El	*Callitriche palustris*	10.+	.
	Hippuris vulgaris mf. *submersa*	10.1	.
	Myriophyllum alterniflorum	40.1	13.+
	Potamogeton gramineus	10.+	.
	Potamogeton perfoliatus	20.1	7.+
	Ranunculus peltatus	20.+	.
Cer	*Utricularia vulgaris*	10.+	.
	Utricularia intermedia	10.+	.
Cha	*Nitella flexilis*	10.+	.
Alg	*Batrachospermum* sp.	.	7.+
Br	*Campylium polygamum*	10.+	7.+
	Dichelyma falcatum	.	7.+
	Fontinalis antipyretica	10.+	20.1
	Fontinalis dalecarlica	30.+	7.+
	Hygrohypnum ochraceum	.	7.+
	Leptodictyum riparium	.	7.+
	Scorpidium scorpioides	10.+	.
	Sphagnum spp.	10.1	.
	Warnstorfia procera	20.1	.
	Warnstorfia trichophylla	30.+	.
He-h	*Equisetum fluviatile*	100.3	73.2
	Phragmites australis	80.2	93.3
	Schoenoplectus lacustris	10.1	.
He-s	*Caltha palustris*	20.1	.
	Carex acuta	20.+	33.1
	Carex elata ssp. *omskiana*	10.+	.
	Carex lasiocarpa	30.1	13.+
	Carex rostrata	90.3	47.1
	Lysimachia thyrsiflora	80.2	53.1
	Eleocharis palustris	30.+	10.+

Floristic area types

The 25 special areas were grouped by the TABORD program into two types on the basis of their floristic composition (originally type groups, Table 2): 1. an isoetid vegetation with nymphaeid vegetation (or synusie), and 2. an isoetid vegetation in open water. The first type is located in sheltered bays and shores and is the richer one, with many species and life forms, while the second type, located on open shores, consists mainly of isoetids and some helophytes, but with the well developed nymphaeids are lacking, except for *Sparganium angustifolium* seedlings and/ or a few developed plants with floating leaves in some places. All the aquatic species found in the 25 special areas are listed in Table 2.

Species richness and ecological conditions

The scarcity of elodeids (Table 2) may be caused by the lack of nutrients, as the many measurements made in July 1993 showed the water to be neutral or close to neutral almost everywhere. This may explain why *Sphagnum* mosses do not thrive in the lake itself even though they are growing in abundance on the peatlands of the adjacent shore. No acidification of the lake as a consequence of acid emissions via the air (from industries at Kostomuksha) can be detected with certainty on the basis of the lake vegetation.

The aquatic flora of the northern half of Lake Kiitehenjärvi comprises 41 species (and one hybrid) which are constantly growing with their roots under the water or floating in or on the water (Table 2), although the correct figure may be higher, around 50 species (9 more species, e.g. aquatic bryophytes, were recorded outside the 25 special areas). A few dozen more species are found on the upper part of the shore, in the geolittoral zone, which is covered by water only during the flood season. This geolittoral flora is not easy to delimit. The whole flora of the geolittoral of Lake Kiitehenjärvi, as far as we know (1995), amounts to well over one hundred species. Most of these species are bryophytes. The number is high, since only 308 vascular plant species are recorded for the whole nature reserve (Elina & Volkov 1993). The flora of the lake covers only the indigenous species, and there are also a few introduced aliens on the shores.

The majority of the relatively rich isoetid flora of this lake consists of the same species as are found in the larger lakes of the Finnish Lake District, but the occurrence of *Littorella uniflora* and *Crassula aquatica* is somewhat more frequent than usual. The elodeid flora here is just as scarce as the water chemistry would lead us to expect (mainly *Myriophyllum alterniflorum, Potamogeton perfoliatus* and *Ranunculus peltatus*) and nymphaeids (mainly *Nuphar lutea* and *Sparganium angustifolium*) are also quite rare, even though they are typical species (especially *Sparganium angustifolium*) of poor lakes with large open water areas. Most species are growing only in sheltered places and on soft bottoms. The helophytes of the lake consist of all the species one could expect to find in a large lake with poor nutrient status (see Table 2). *Phragmites* forms surprisingly large stands in places; obviously because the shores are very sandy and adequate for the growth of its rhizomes.

The relatively minor water level fluctuations during the year (only about 50 cm) create suitable conditions for the occurrence and success of a stable vegetation. The fluctuations also seem to be very regular. The beginning of the outlet river consists of two channels (amounting together to a considerable width). This obviously prevents high flood peaks. On the other hand, the quite shallow beds of the river prevent any extreme drops in water level during dry periods or in winter. The relatively small catchment area of the lake has much the same effect.

Summary

Lake Kiitehenjärvi is a large lake (area 103 km^2, shore line 230 km), highly oligotrophic, clear and poor in nutrients. The pH in the open areas in the summer is about 7.0, the Pt colour value (humus) is about 20 mgl^{-1}, transparency about 4.0 m, conductivity of the water only 15-18 μS/cm at +20°C, total phosphorus content 2-5 mgl^{-1} and total nitrogen 100-400 mgl^{-1}. In some bays and special places the Pt, P and N values are somewhat higher and the transparency lower.

The vegetation of Lake Kiitehenjärvi is of considerable interest. The lake is characterized by a well developed, extensive isoetid vegetation in which the species number is higher than average for lakes of this highly oligotrophic type. The same can be said of the six syntaxa of the isoetid vegetation, which are partly of the normal *Isoetes-lacustris-Lobelia dortmanna* type (with 2 variants) characteristic of this continental area and partly of a northern variant (IlacLoIechV) and the *Isoetes echinospora* commonunity type (with 2 variants), which all are abundant with *Isoetes echinospora* and a southwestern variant (IlacLoLitV) abundant with *Littorella uniflora* (Table 1). The isoetid vegetation of the shallow areas is very often growing together with helophytes.

The helophyte flora (10 species) consists of the usual species for this kind of lake. Only 4 species are common in the water: *Equisetum fluviatile, Phragmites australis, Lysimachia thyrsiflora* and *Carex rostrata.* Of these, *Phragmites australis* forms surprisingly extensive but sparse stands on wide, sandy shores. The other six helophytes are rare or quite rare.

The often mixed nymphaeid and elodeid vegetation is sparse, mainly with *Nuphar lutea, Sparganium angustifolium, Myriophyllum alterniflorum, Potamogeton perfoliatus* and *Ranunculus peltatus*, reflecting the poor nutrient status of the water. This vegetation is sometimes found growing together with a poor developed isoetid synusie. *Myriophyllum alterniflorum* forms occasionally a weak or well developed stratum in the isoetid vegetation.

The aquatic bryophytes are also growing sparse in the nymphaeid and elodeid vegetation and are not entirely lacking from the isoetid vegetation.They seldom make up an independent, dense vegetation. The most abundant species in the water are of the genera *Warnstofia* and *Fontinalis*. The number of other bryophytes on the geolittoral zone is high.

The species assemblage of the upper geolittoral is relatively rich for a watershed lake in a remote area (more than 100 species). A total of 41 water plant species (and one hybrid) were recorded with certainty in the 25 areas examined in the northern half of the lake, but the correct number is obviously higher, about 50. The relative high to moderate plant diversity of Lake Kiitehenjärvi, where poorness in nutrients is the dominant characteristic throughout, is clue to regular and relatively small water level fluctuations as well as the large size of the lake and the long shoreline, which create many habitats for the species.

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Flowering dynamics of some plant communities in the Kostomuksha Nature Reserve

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Abstract

The flowering dynamics was studied in eight different plant communities. In this article results of four communities (lingonberry-blueberry pine forest, blueberry spruce forest, sedge-shrub mire and grass-cereals meadow) are discussed. Altogether 77 flowering plant species were observed. On the basis of ten-day sums of flowering species, flowering curves of the communities were created. It was noticed that flowering curves correlated with weather conditions, the community of the spruce forest being the last to break out into blossom. The blooming peaks were usually observed from 1 to 20 July.

Key words: boreal, forest and meadow, flowering curves, Karelia, Russia

Introduction

The flowering dynamics of all community constituents is one of the most important manifestations of the seasonal growth of a community. Flowering dynamics, otherwise called the rhythmic pattern of flowering, is connected in an intricate manner with the inherited flowering rhythms of the species in the coenosis studied and with the climatic and ecological conditions. Therefore, the flowering patterns of coenoses, differing in constituent species, vary from year to year depending on climatic conditions. At the same time, the flowering of each species usually coincides with the period of its highest biological activity. Therefore, some characteristics of flowering pattern, in particular flowering maximum, correlate with other biological characteristics of the coenosis itself and external ecological conditions. Concept of "curves of flowering" unites several qualitatively excellent curves: coming into bloom, flowering and finishing to flower species. Flowering curves are one method for of the analyzing plant communities and their characteristics in different geographical zones (Golubev 1969).

Study area

The Kostomuksha Nature Reserve is situated in a belt of enlightened forests, in Kuitozersko-Leksozerskii floristic region of a northern taiga subzone (Ramenskaya 1960). This subzone is characterized by floristic poverty, large amount of wetlands and prevalence of pine forests of various types. Pine forests make 83,7 % of all forest area in the reserve and spruce forests cover 16,0 % (Anon. 1986). Pine forests of green moss group are prevailing. Spruce forests grow on richer, damp and drained soils. The most typical among spruce forests are associations of blueberry and grasses, growing along brooks. Mires are mainly oligo- and mesotrophic and make 15,0 % of the land area. Meadows are rare and basically of anthropogenic origin. Their flora is especially rich in grasses and other plants.

In 1986, permanent sample sites (0,04 x 0,09 ha) were laid out in some plant communities of the Kostomuksha Nature Reserve to carry out phytophenological studies and other investigations (Kashevarov, 1989). Research work was mainly done on eight sample sites located along the phenological route in the northern part of the reserve and at two separate sample sites. These sample sites represent the following plant communities: lingonberry-blueberry, lichen and heather-lingonberry pine forests; blueberry spruce forest, blueberry spruce forest with a fragment of brook spruce forest, brook spruce forest and grassy birch forest derived from blueberry spruce forest; sedge-shrub and sedge-*Sphagnum* mires; and grass meadow of anthropogenic origin.

Material and methods

On the sample sites of the phenological route, all year round elementary meteorological observations (extreme temperatures of air and on a soil surface, quantity of precipitation) were conducted. The extreme temperatures of air were defined with the help of minimum and maximum thermometers, installed at 2 meters height. Average temperature was received from the nearest meteorolocical station (Kalevala).

The grass-shrub cover was studied phytophenologically. In the course of our investigations the main phenological phases of plants, the beginning of flowering, mass flowering and the end of flowering, were differentiated (Shcherbinovsky 1954; Beideman 1974). The plants were determined according to Ramenskaya & Andreeva (1982).

The flowering curves were drawn with the method proposed by V. Golubev (1969). The method of drawing flowering curves for plant communities consists essentially of a synthetic representation of the rhythmics of flowering based on tree indices: number of species breaking out into blossom, flowering and finishing flowering. Ten-day sums of species were used for this purpose.

Results

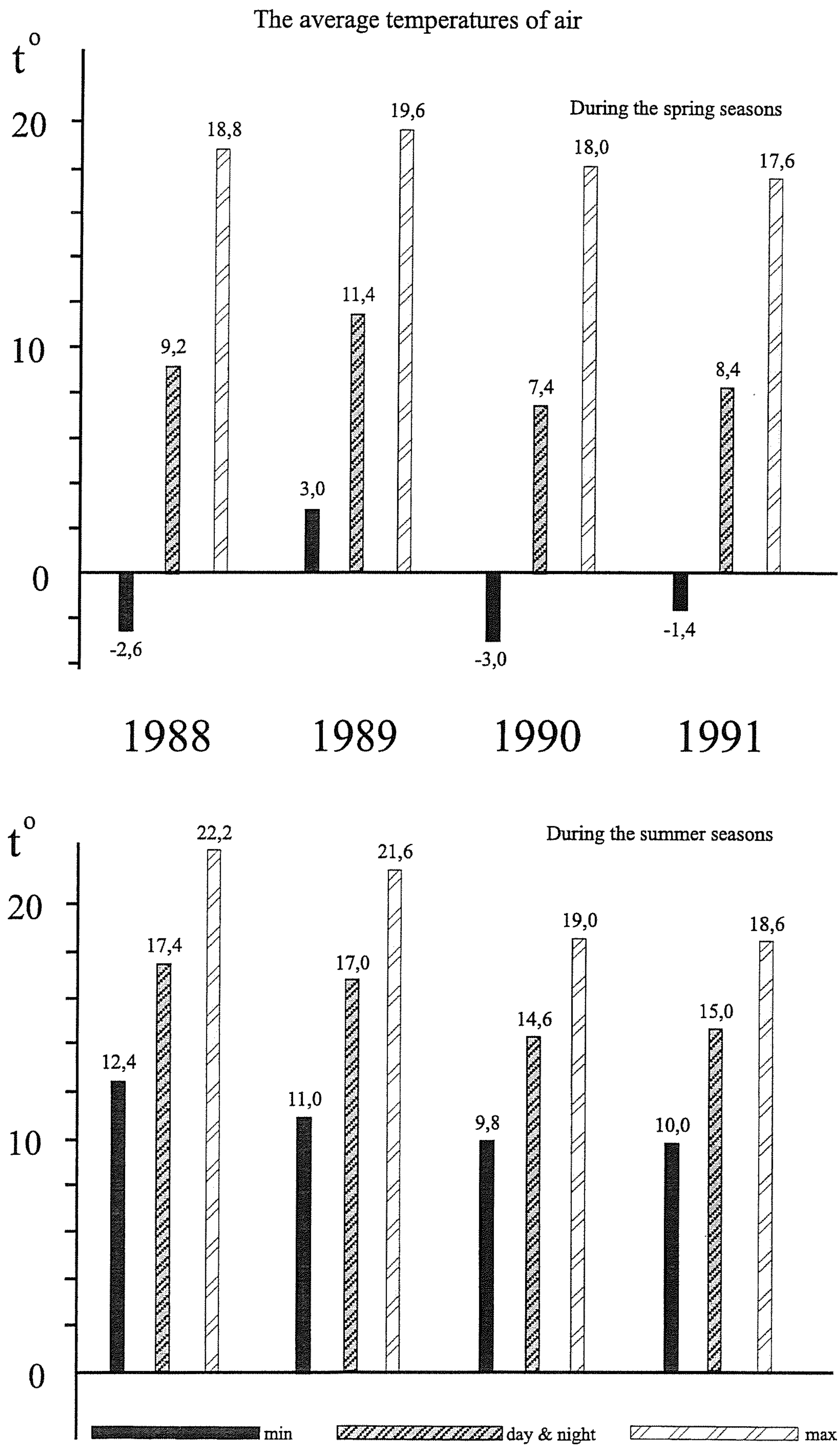
Ten to thirteen flowering species were reported in the lingonberry-blueberry pine forest (table 1). The grass-shrub cover is dominated by *Vaccinium myrtillus, Vaccinium vitis-idaea* and *Melampyrum pratense.* Eight to ten flowering species were revealed in the spruce forest. *Vaccinium myrtillus* is the most abundant plant in the grass-shrub cover. Up to 15 plant species were found in the sedge-shrub mire of the study area. This phytocoenosis is dominated by *Trichophorum caespitosum, Calluna vulgaris* and *Rubus chamaemorus* being subdominant. Species composition was most diverse in the grass meadow. Fifty to sixty species were observed there. This community comprises *Anthriscus sylvestris, Heracleum sibiricum, Carex acuta* and *Carex nigra, Anthoxanthum odoratum, Alchemilla subcrenata, Geranium sylvaticum, Veronica chamaedrys* and *Rhinanthus serotinus* among others.

Table 1. Flowering plants of grass-shrub vegetation in the bilberry-blueberry pine forest (1), blueberry spruce forest (2), sedge-shrub mire (3) and grass meadow (4).

Anthoxanthum odoratum L.	-	-	-	4
Phleum pratense L.	-	-	-	4
Agrostis stoloniferaL.	-	-	-	4
Deschampsia flexuosa (L.) Trin.	1	2	-	4
Deschampsia cespitosa (L.) Beauv.	-	-	-	4
Briza media L.	-	-	-	4
Dactylis glomerata L.	-	-	-	4
Poa angustifolia L.	-	-	-	4
Festuca rubra L.	-	-	-	4
Elytrigia repens (L.) Nevski	-	-	-	4
Eriophorum vaginatum L.	-	-	3	-
Trichophorum caespitosum (L.) A.Dietr.	-	-	3	-
Carex nigra (L.) Richard.	-	-	-	4
Carex acuta L.	-	-	-	4
Carex lasiocarpa Ehrh.	-	-	3	-
Carex globularis L.	-	-	-	4
Calla palustris L.	-	-	3	-
Luzula pilosa (L.) Willd.	1	2	-	4
Maianthemum bifolium (L.) F.W.Schmidt	-	-	-	4
Goodyera repens (L.) L.Br.	1	2	-	-
Platanthera bifolia (L.) Rich.	-	-	-	4
Dactylorhiza maculata (L.) Soo	-	-	3	4
Urtica dioica L.	-	-	-	4
Rumex acetosa L.	-	-	-	4
Stellaria palustris Retz.	-	-	-	4
Stellaria graminea L.	-	-	-	4
Trollius europaeus L.	-	-	-	4
Ranunculus repens L.	-	-	-	4
Drosera rotundifolia L.	-	-	3	-
Drosera anglica Huds.	-	-	3	-
Rubus chamaemorus L.	-	-	3	-
Rubus saxatilis L.	-	-	-	4
Potentilla erecta (L.) Raeusch.	-	-	-	4
Filipendula ulmaria (L.) Maxim.	-	-	-	4
Alchemilla subcrenata Bus.	-	-	-	4
Trifolium pratense L.	-	-	-	4
Trifolium repens L.	-	-	-	4
Vicia cracca L.	-	-	-	4
Vicia sepium L.	-	-	-	4
Lathyrus pratensis L.	-	-	-	4
Geranium sylvaticum L.	-	-	-	4
Empetrum sp.	1	-	3	-
Viola tricolor L.	-	-	-	4
Viola palustris L.	-	-	-	4
Chamaenerion angustifolium (L.) Scop.	-	-	-	4
Anthriscus sylvestris (L.) Hoffm.	-	-	-	4
Heracleum sibiricum L.	-	-	-	4
Cornus suecica (L.)	1	-	-	4
Moneses uniflora (L.) A.Gray	-	-	-	4
Ledum palustre L.	1	-	3	-
Andromeda polifolia L.	-	-	3	-

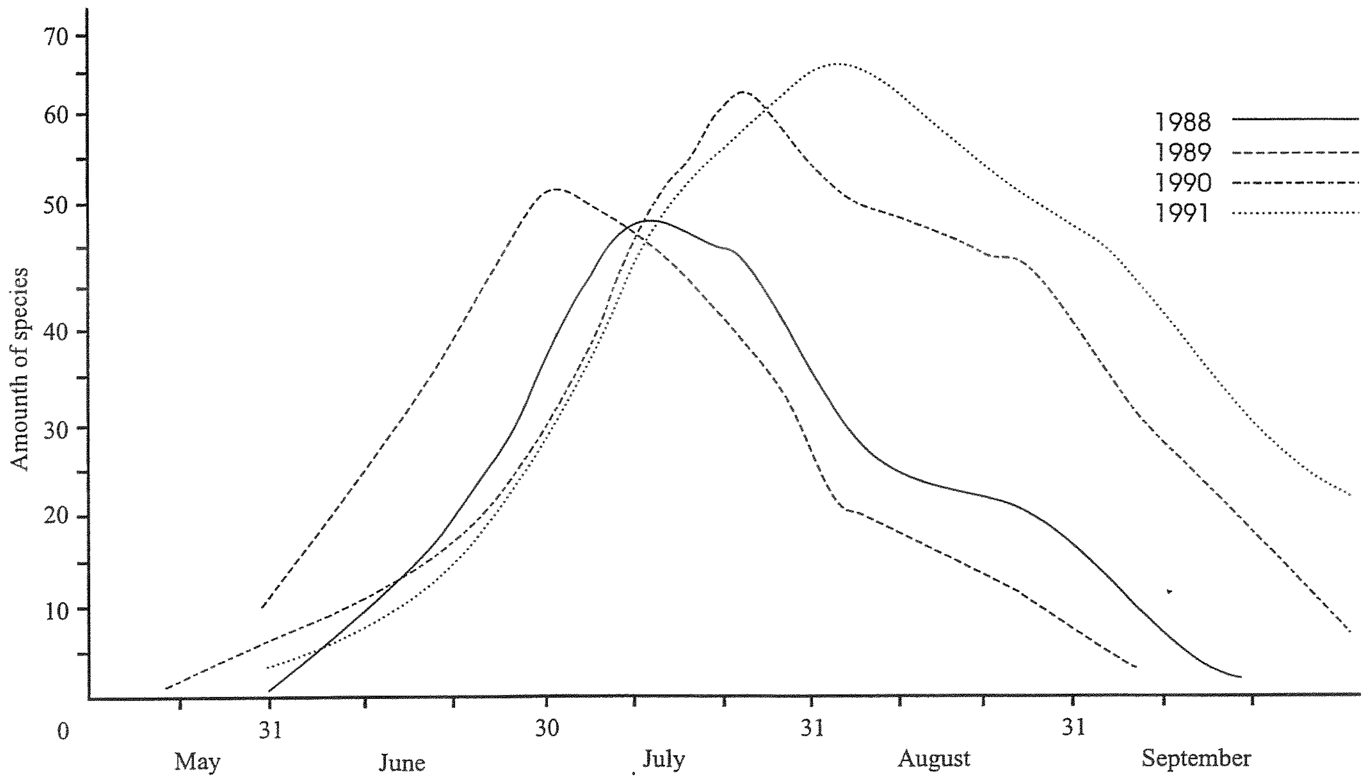
Chamaedaphne calyculata (L.) Moench.	-	-	3	-
Calluna vulgaris (L.) Hull.	1	-	3	-
Vaccinium vitis-idaea L.	1	2	-	4
Vaccinium myrtillus L.	1	2	3	4
Vaccinium uliginosum L.	1	-	3	4
Oxycoccus quadripetalus (L.) Gilib.	-	-	3	-
Trientalis europaea L.	1	-	-	4
Menyanthes trifoliata L.	-	-	3	-
Galeopsis speciosa Mill.	-	-	-	4
Veronica chamaedrys L.	-	-	-	4
Melampyrum pratense L.	1	2	-	4
Melampyrum sylvaticum L.	-	-	-	4
Euphrasia brevipila Burn.et Gremli	-	-	-	4
Rhinantus serotinus (Schonh.) Oborny	-	-	-	4
Galium mollugo L.	-	-	-	4
Linnaea borealis L.	1	2	-	-
Knautia arvensis (L.) Coult.	-	-	-	4
Campanula rotundifolia L.	-	-	-	4
Solidago virgaurea L.	1	2	-	4
Achillea millefolium L.	-	-	-	4
Leucanthemum vulgare (L.) Lam.	-	-	-	4
Cirsium arvense (L.) Scop.	-	-	-	4
Centaurea jacea L.	-	-	-	4
Taraxacum officinale Wigg.	-	-	-	4
Hieracium pratense Zahn.	-	-	-	4
Hieracium umbellatum L.	-	-	-	4

Flowering curves were used to elucidate the relationship between the growth of the plant community and the weather. Fairly high temperatures were recorded during the vegetative periods of 1988-89, but there were some cold spells such as a snowfall on 2 June and frosts between 7 and 17 June in the spring of 1988. Cold periods were followed by warm weather with a maximum temperature of +30°C (Fig.1).


The average temperatures of air
t°
20
10
0
During the spring seasons
18,8
9,2
-2,6
19,6
11,4
3,0
18,0
7,4
-3,0
17,6
8,4
-1,4
1988
1989
1990
1991
t°
20
10
0
During the summer seasons
22,2
17,4
12,4
21,6
17,0
11,0
19,0
14,6
9,8
18,6
15,0
10,0
min
day & night
max

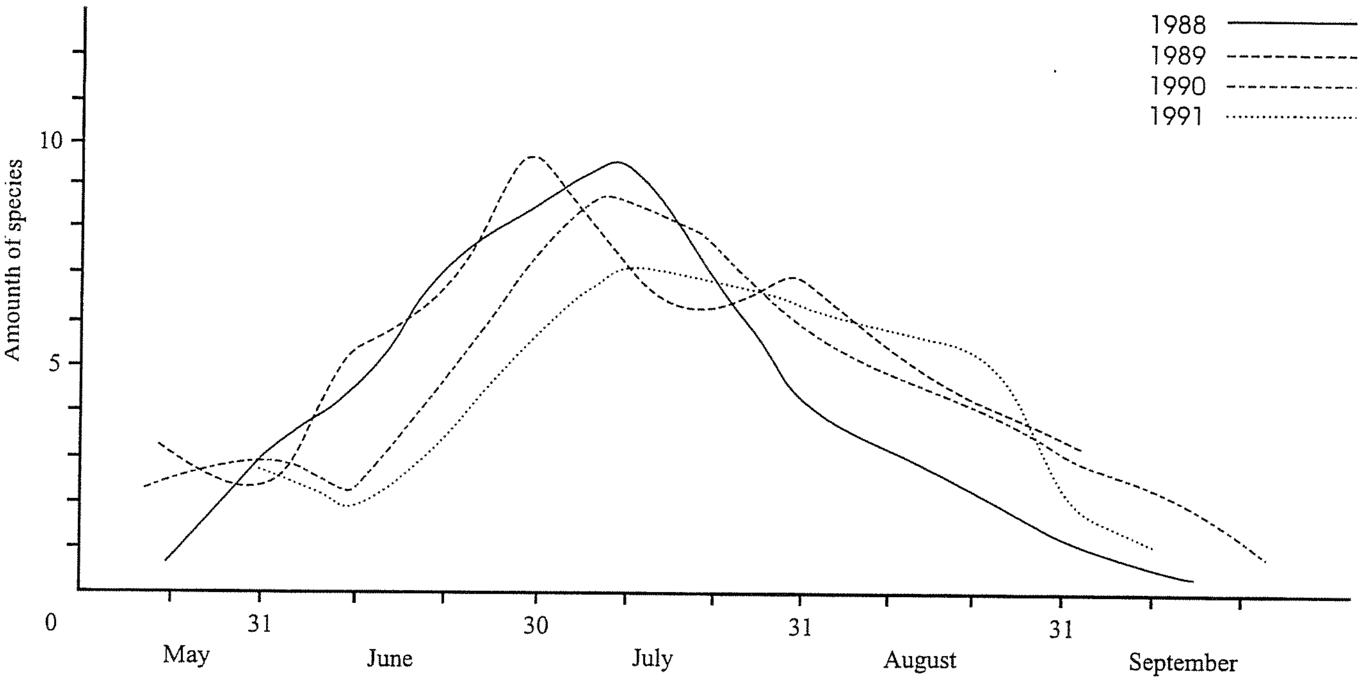
In 1988, the summer was neither early nor late and relatively long. The beginning of the summer was especially warm and dry. The absolute maximum temperature of the season was +36°C. The spring of 1989 came earlier and was warmer than that of 1988. Frosts stopped earlier than in 1988. In late May, positive temperatures became stable. In 1989, spring and summer arrived earlier than in 1988. Besides, the summer of 1989 was longer than that of 1988. The summer of 1989 was similar in the course of temperatures to that of 1988, but temperatures were much higher from 1 to 5 August 1989.

Because weather conditions were favourable during those years, the flowering curves of all the above plant communities show the early blooming of spring-flowering species (early to mid of May), especially in the spring of 1989. The blooming phase was reached first in the mire plant communities. The maximum number of the flowering species was also observed earlier (1-20 June) than in other plant communities. This is due to some biological characteristics of mire vegetation and high temperatures (Fig.5). The plants growing in the spruce forest were the last to break out into blossom which is due to the microclimatic conditions of this phytocoenosis. Blooming peaks were slightly more distinct for the spruce forest in 1988, when air temperatures were fairly high (Fig.4). In the pine forest the flowering peak was observed from 1 to 10 July (Fig.3). Maximum biological activity was recorded at the same time in the meadow. This period lasted from 1 to 20 July because of high plant diversity (Fig.2). It should be noted that in those years many plants that are the first to break out into blossom grew 10-15 days faster. This was especially noticeable in 1989.



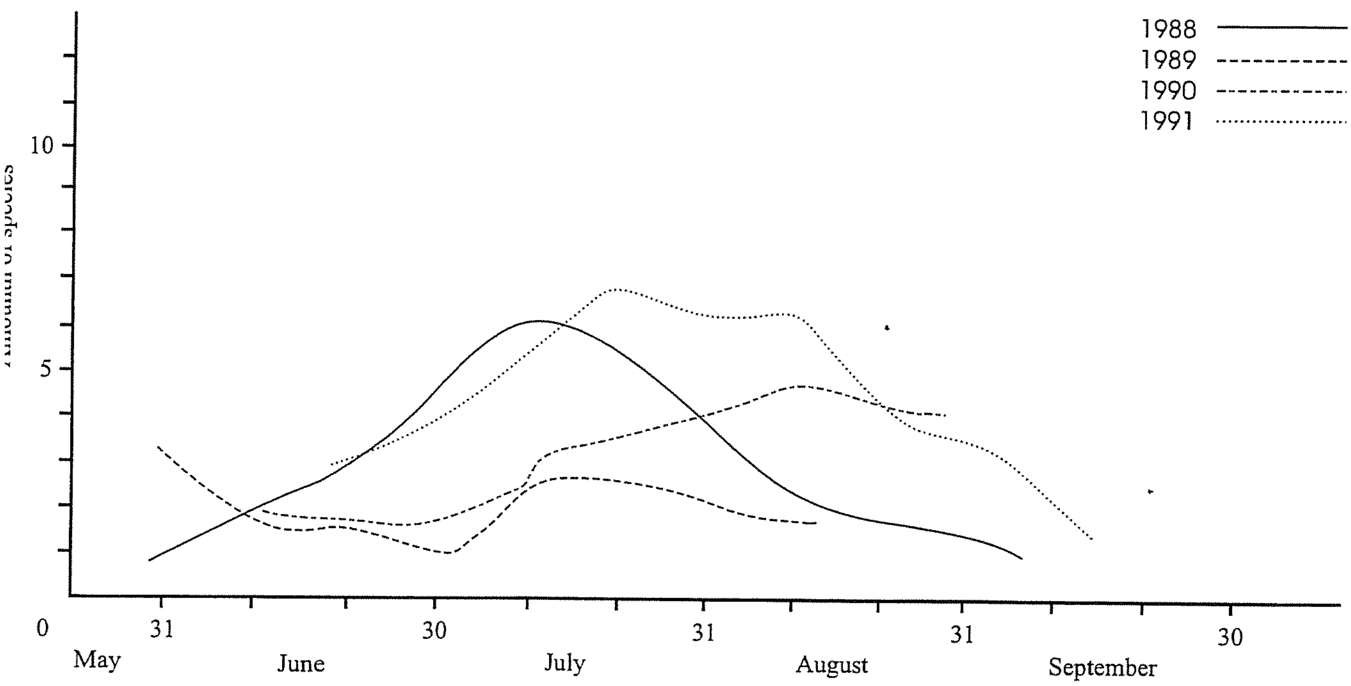
Amount of species	May			June			July			August			September		
Years	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
1988	2,3	7,0	8,0	9,1	9,5	7,8	6,3	4,5	4,2	1,8	1,4	1,5	0,2	-	-
1989	-	6,2	8,0	9,0	9,9	7,6	5,8	6,0	28	22	1,1	-	-	-	-
1990	4,0	4,1	4,8	7,0	9,1	12,7	12,0	10,1	6,0	5,1	5,3	5,1	5,2	-	-
1991	-	-	3,9	6,8	7,5	8,3	7,0	5,8	4,4	3,5	3,0	2,6	1,5	-	-

Fig. 2. The florescence curve of the grass shrub cover in carex shrub swamp.



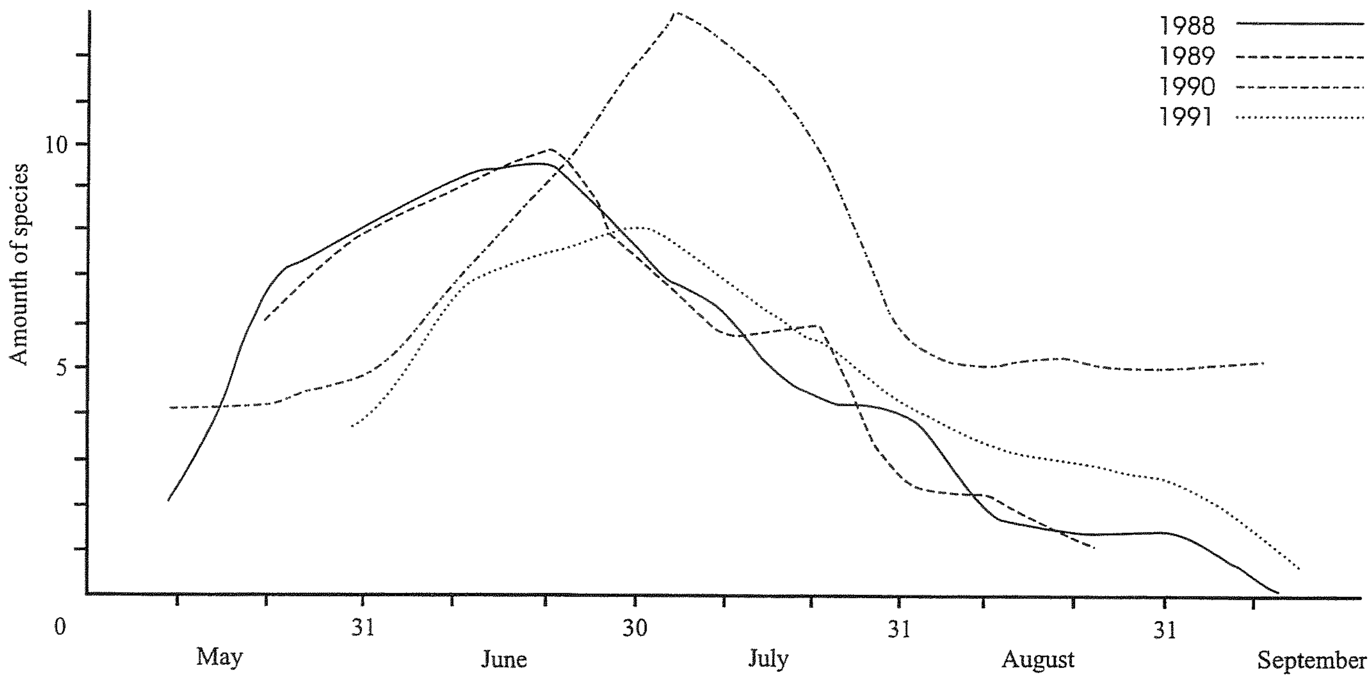
Amount of species	May			June			July			August			September		
Years	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
1988	-	-	1,0	1,9	2,8	4,4	6,0	5,5	4,0	2,3	1,7	1,3	-	-	-
1989	-	-	3,1	1,8	1,6	1,0	2,3	2,6	2,2	1,7	-	-	-	-	-
1990	-	-	-	1,8	1,6	1,7	2,5	3,4	4,0	4,6	4,2	-	-	-	-
1991	-	-	-	-	3,0	3,8	5,1	6,7	6,1	6,1	4,2	3,3	1,8	-	-

Fig. 3. The florescence curve of the grass shrub cover in a billberry spruce forest.



Amount of species	May			June			July			August			September		
Years	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
1988	-	0,8	3,0	4,3	7,0	8,8	9,5	7,1	4,3	3,2	2,2	1,2	0,1	-	-
1989	-	3,0	2,3	5,3	6,6	9,6	7,3	6,2	6,8	5,3	4,1	3,2	-	-	-
1990	-	2,6	3,0	2,4	4,5	7,4	8,8	8,0	6,2	5,0	4,1	3,0	2,3	1,0	-
1991	-	-	2,8	2,0	3,3	5,6	7,2	7,0	6,5	5,9	5,4	2,0	-	-	-

Fig. 4. The florescence curve of the grass shrub cover in a lingberry-bilberry pinery.



Amount of species	May			June			July			August			September		
Years	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
1988	-	-	1	10	20	37	50	46	34	22	19	10	1	-	-
1989	-	2	11	25	40	53	48	38	20	15	10	3	-	-	-
1990	-	-	7	11	18	30	50	64	53	49	45	30	20	9	8
1991	-	-	4	8	16	30	49	59	66	60	52	45	32	23	-

Fig. 5. The florescence curve of the grass shrub cover in a meadow of anthropogenous origin.

The years 1990 and 1991 were colder and more humid. The spring of 1990 was similar to that of 1989, but in 1990 spring temperatures were lower. In 1991, spring came late and was cool: cold weather with frost persisted from 1 to 20 June. The snow, which fell on 8-9 May, did not go off even in the afternoon. In some places air temperatures declined to -10°C. The summer seasons of 1990 and 1991 were cold and rainy, but in early and late summer air temperatures increased.

Unfavourable weather conditions resulted in retarded plant growth. Some species began blooming two weeks later than in 1989 and 4-5 days later than the average flowering dates. This could be clearly traced in the flowering curves of the plant communities of the spruce forest and on the mire. The weather also caused a shift in the flowering peaks of all the above plant communities to later dates. A slight rise in air temperature in August 1990 brought about another small blooming peak in the plant community of the meadow and spruce forest.

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Notes on the lichen flora of the Kostomuksha Nature Reserve

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Abstract

The results of a lichen inventory made in the Kostomuksha Nature Reserve on the basis of field studies in 1990-1993 are presented. The list of lichens consists of 124 species and 4 infraspecific taxa, which belong to 45 genera. The frequency of each taxon is indicated, and the substrates characteristic of all the taxa are presented. Our biogeographic analysis has shown that the reserve has boreal-euryholarctic lichen flora with many hypoarcticmontane species.

Key words: Flora, Karelia, lichens, Russia, taiga

Introduction

The Kostomuksha Nature Reserve is located on the east-facing slope of the West Karelian Upland in Russian Karelia and covers an area of 47600 ha. Its maximum altitude is about 250-280 m above sea level. The area has a rugged topography and the relative altitude varies from 20-30 to 100 m. Its main topographic characteristics have resulted from denudational-tectonic events and from glacial deposition processes. Denudational-tectonic landforms, characterized by an alternation of ridges and depressions occupied by mires and lakes, are predominant.

The climate of the study area is characterized by a relatively mild winter, a short and cool summer, considerable cloudiness and a high air humidity. The annual precipitation in that area is about 650 mm. The proximity of seas and the permanent air from the Atlantic Ocean and the Arctic region have a remarkable impact on the weather conditions of the area. Daily temperatures above +10° total 1 000-1 200 degrees, and the length of this period is 85-90 days.

The main soil types observed in the reserve are podzol, mire-podzol and mire types. Sod-podzol soils are scarce. The predominant type of vegetation are forests, which cover about 70% of the area. Mires of lacustrine origin, dominated by oligotrophic and mesotrophic types, occupy 15-20% of the area. The lake and riverside meadow communities are scarce.

According to the scheme of Karelian forest types made by Yakovlev and Voronova (1959), the forests of the study area form a part of the spruce-pine mesic forests growing on the West Karelian Upland. They are represented by the types characteristic of the northern taiga subzone (Tsinzerling 1932). Feather moss pine stands mixed with spruce predominate (81%). Their grass-dwarf shrub storey dominated by bilberry (*Vaccinium myrtillus*), crowberry (*Empetrum nigrum*) and marsh tea (*Ledum palustre*) is well developed. Pure spruce stands are less common (16%), and birch forests are scarce (less than 1%).

The forests of the reserve are characterized by the predominance of primaeval coniferous (primarily pine) stands - a feature typical of mature and overmature forests. The pine stands are sparse. Medium-aged pine trees prevail in the northern part of the reserve. Lichen woodlands and rocky types dominate on ridge tops, whereas mesic types prevail on hillslopes. Pine stands are dominant in the upper and middle parts of the slopes, whereas spruce trees prevail in the lower part. *Sphagnum* pine stands grow near the base of the slopes adjacent to the mires. In the River Kivijoki valley spruce forests are predominant. Deciduous trees account for about 20% of the mesic forests that belong to this formation. In the southern part of the reserve the prevalence of mature and overmature pine stands (49.4%) is obvious. Young trees are abundant (36.0%), whereas medium-aged and maturing trees are scarce (14.6%). Partially forested oligotrophic sphagnum mires occur in closed depressions over the entire study area.

The nature reserve belongs to the Kem floristic province (Ramenskaya 1983), which is characterized by boreal vegetation with few plants with arctic or temperate affinities. In all, 395 vascular plant species have been reported (Kravchenko & Belousova 1990, Kravchenko 1993) from the reserve.

Until recently, no special lichen studies have been conducted in the reserve area. Only two species, *Cladonia arbuscula* and *C. rangiferina*, often referred to in descriptions of mire vegetation, are known from the literature (Elina & Kuznetsov 1977). Our investigations began in 1990. The goal of them is to make a comprehensive inventory of the lichen flora in the area and to assess the effect of the pollutants discharged by the Kostomuksha ore refinery on its growth (Potasheva 1993).

The Finnish botanists used to include the study area in the biogeographic province Karelia pomorica occidentalis (Länsi-Viena). E. A Vainio apparently travelled through our study area in 1877 on his collecting trip to Kontokki (now Kostomuksha town), Kostamus (old Kostomuksha, now uninhabited), Luvajärvi (Luvozero) and further north, Uhtua (Kalevala). However, in his lichen flora (Vainio 1881, 1883, 1921, 1922) there are few definite records from the area, though more data is found in his collections in Turku. Anyway, many of the lichen records here are new to the province Karelia pomorica occidentalis.

Material and methods

Field investigations were carried out in the northern part of the nature reserve, including the Lake Kiitehenjärvi shore, the River Kivijoki valley and some localities in the central and south-eastern part of the area (Fig. 1. Sites 10-16, 20, 23-25, 33-38, 43-49, 71-73, 79, 102-119, 143-148, 150-153, 167-169, 185-186, 194-195, 207-208, 219-220). An emphasis was placed on the study of lichen cover in coniferous, deciduous and mixed forests, but extensive material was also collected in raised and transitional mires, cutting areas, burned-out forests as well as some artificial habitats such as drainage systems, embankments etc.

Lichen samples were taken from a variety of substrates such as tree and shrub bark, soil, stumps, windfallen trees and branches, rock outcrops as well as erratic boulders and stones. The lichen material collected is preserved in the herbaria of the Forest Research Institute, Petrozavodsk, and the Kostomuksha Nature Reserve. The lichen specimens were not fully analysed because it was difficult to determine many crustose species and sterile macrolichens.

Results

A list of lichens from the study area is presented below. Genera and species are given in alphabetical order. The nomenclature of specific and intraspecific taxa follows Santesson (1993). The geographic elements of flora to which each taxon belongs are classified according to Oxner (1940-1942), Makarevich (1963, 1971), Golubkova (1966, 1983) and Trass (1970).The following abbreviations are used: AA = arctic-alpine, HAM = hypoarcticmontane, B = boreal, N = nemoral, EHA = euryholarctic and M = montane species. The numbers of sample sites correspond to numbers of 1 km^2 of planning compartment net work on the map (Fig 1). The substrate to which each taxon is confined, as well as the type of its habitat and location are indicated. To evaluate the frequency of each species, the following indications are used: very common = over 30 records, common = 16-30 records, scattered = 6-15 records, rare = 3-5 records and very rare =1-2 records.

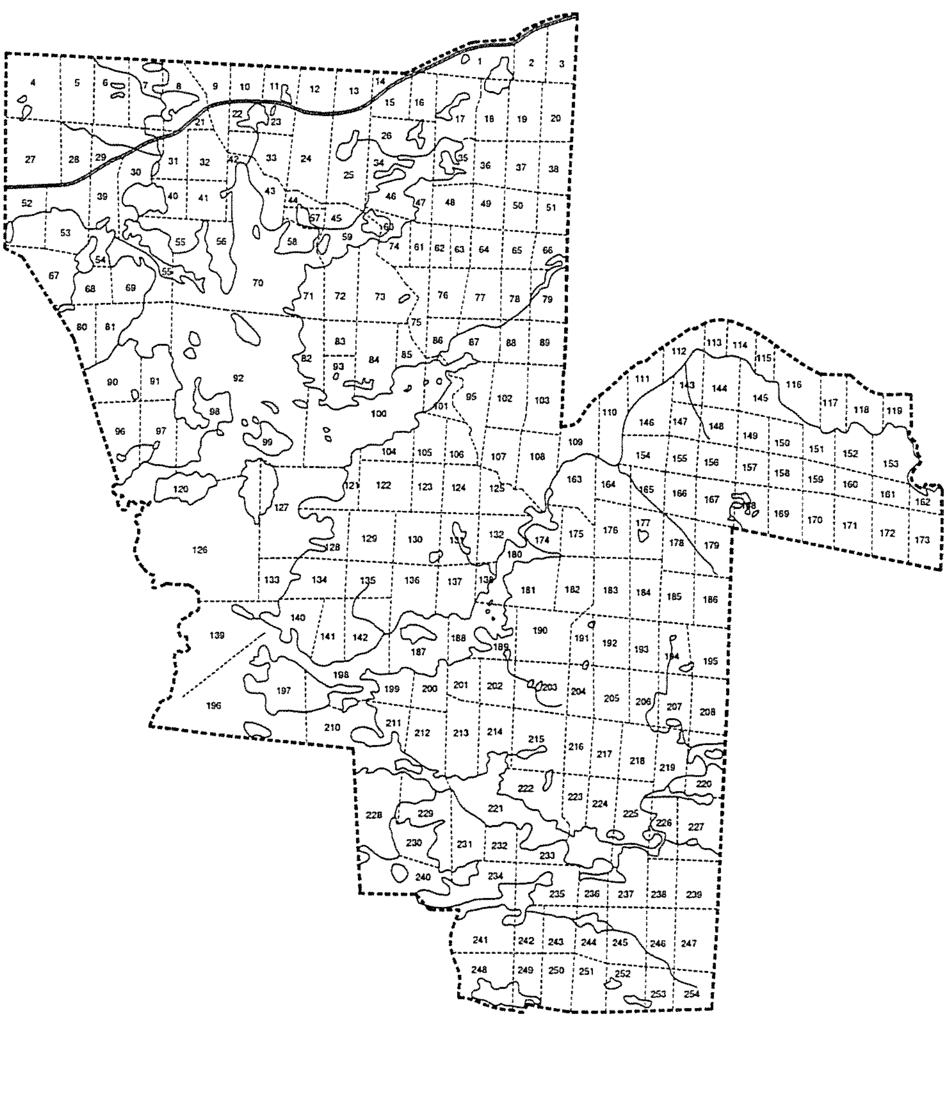

Fig. 1. Forestry map of Kostomuksha Nature Reserve. The numbers of quadrats equal to the site numbers in the text.

The list of lichens from the Kostomuksha Nature Reserve

Alectoria sarmentosa (Ach.) Ach. -EHA. Pine and birch trunks and spruce branches in bilberry pine and spruce stands. Ubiquitous. Common.

Arctoparmelia centrifuga (L.) Hale - HAM. Site 71. On boulders. Rare.

Arthonia radiata (Pers.) Ach. - N. Site 72. Kuikiniemi. On black alder.

Aspicilia cinerea (L.) Körb. - EHA. Site 72. Makrovaara. On field stone.

Baeomyces carneus Flörke - HAM. Site 15. Sandy path in pine forest.

B. placophyllus Ach. - AA. Site 35. Road cut. On soil.

B. rufus (Huds.) Rebent. - B. Site 47. Dry draining trench. On soil.

Bryoria capillaris (Ach.) Brodo & D. Hawksw. -B. On spruce branches, pine and birch trunks. Ubiquitous. Scattered.

B. fremontii (Tuck.) Brodo & D. Hawksw. - B. Sites 10, 23, 25. Pine trunks and spruce branches in cowberry pine stands; Sites 33, 38, 48, 49, 71, 72. Pine trunks in crowberry-bilberry pine forests; Sites 152-153. Pine trunks in crowberry-lichen pine stands.

B. furcellata (Fr.) Brodo & D. Hawksw. - B. Coniferous and deciduous (birch) trees bark; wood (rarely). Common.

B. fuscescens (Gyeln.) Brodo & D. Hawksw. - EHA. Spruce branches as well as pine and birch trunks in various types of pine and spruce forests. One of most common species in the reserve.

B. lanestris (Ach.) Brodo & D. Hawksw. - B. Sites 48, 49, 71, 72. Pine and birch trunks in mesic pine forests. Scattered.

B. simplicior (Vain.) Brodo & D. Hawksw. - HAM. Sites 71-72. Pine bark in crowberry-blueberry and sphagnum pine stands. Very rare.

Buellia disciformis (Fr.) Mudd - EHA. Deciduous tree bark. Scattered over entire study area.

B. punctata (Hoffm.) A. Massal. - B. Sites 10, 35, 48, 72. Old pines bark in crowberry-bilberry pine forests.

Calicium trabinellum (Ach.) Ach. -B. Site 72. Pine-spruce forest, spruce trunk.

C. viride Pers. - EHA. Site 15. Crowberry-bilberry spruce stand, on spruce trunk.

Cetraria chlorophylla (Willd.) Vain. - B. Spruce branches as well as pine and birch trunks in bilberry pine and pine-spruce stands. Over entire study area. Common

C. ericetorum Opiz. s.lat. - B. Site 10. On sandy soil, in open places. Scattered.

C. islandica (L.) Ach. - B. Soil, stumps and butts of trees in pine forests. Over entire nature reserve. Common

C. sepincola (Ehrh.) Ach. - EHA. Birch and spruce branches as well as pine trunks. Over entire study area. Scattered.

Chaenotheca chrysocephala (Turner ex Ach.) Th. Fr. - B. Site 72. Base of spruce trunk in pine-spruce forest.

C. ferruginea (Turner & Borrer) Mig. - B. Sites 36 and 48. Pine bark in crowberry-bilberry pine stands.

Chrysothrix chlorina (Ach.) J.R. Laundon - EHA. Site 72. The Lake Kiitehenjärvi shore. On rock surface.

Cladonia amaurocraea (Flörke) Schaer. - HAM. Mossy and bare stones and boulders along lake shores and river banks; in humid habitats in pine forests; Site 35. Kamalahti bay, Lake Kamennoye; Site 102. Canyon; Site 109. Upper River Kamennaya. Site 207. Crowberry-lingonberry pine forest.

C. arbuscula (Wallr.) Flot. -B. Soil, mossy stones and rocks, stumps, fallen trunks, base of old pine and spruce trees in forests, cutting areas, burned-out forest, hummocks on raised and transitional mires. Widespread in the reserve. Actively involved together with *C. rangiferina* and *C. stellaris* in moss-lichen layer formation in coniferous forests.

C. arbuscula ssp. mitis (Sandst.) Ruoss -B. Typically together with previous species on soil. Common.

C. bacilliformis (Nyl.) Glück - EHA. On soil, rotten wood as well as old pines and birches bark in coniferous and mixed forests and in cutting areas. All over study area. Common.

C. botrytes (K.G. Hagen) Willd. - B. Rotten wood, stumps, old pines and birches bark in various forest types, abandoned cutting areas and dry peatlands. Ubiquitous. Common.

C. carneola (Fr.) Fr. -B. Site 10. Rotten wood on raised mire margin.

C. cenotea (Ach.) Schaer. - B. Base of pine and birch trunks, spruce roots, stumps and windfallen branches in coniferous and apamixed forests. Common.

C. cervicornis (Ach.) Flot. ssp. verticillata (Hoffm.) Ahti - EHA. On peat and sandy soil in open localities. Over entire study area. Scattered.

C. chlorophaea (Flörke ex Sommerf.) Spreng. - EHA. On soil in forests, cutting areas and mires. All over nature reserve. Common.

C. coccifera (L.) Willd. - B. Sites 33, 48, 152. On soil among other *Cladonia* in pine stands, burned-out forest and cutting areas. Scattered.

C. coniocraea (Flörke) Spreng. - B. Coniferous and deciduous trees bark (common by birch trunks), rotten wood and mossy stones in bilberry pine and pine-spruce stands. All over study area. Common.

C. cornuta (L.) Hoffm. - B. Soil, windfallen branches, mossy boulders and stones, base of old coniferous and deciduous trees in dry coniferous forests, old cutting areas and burned-out stands. Ubiquitous. Very common.

C. crispata (Ach.) Flot. -B. Soil, mossy stones and boulders, base of old pine in bilberry and lichen pine stands. All over nature reserve. Common.

C. deformis (L.) Hoffm. - HAM. Soil, mossy boulders, base of old coniferous and deciduous trees, rotten wood; stumps and windfallen branches in various types of coniferous and mixed forests. Ubiquitous. Very common.

C. digitata (L.) Hoffm. - B. Site 48. Base of pine trunk in crowberry-bilberry pine stand; Site 152. Windfallen branches in old burned-out pine forest.

C. fimbriata (L.) Fr. - EHA. Bases of pine, birch and willow trunks, rotten stumps, windfallen branches and humus-covered stones in forests, on abandoned agricultural land and on open mires. All over study area. Very common.

C. furcata (Huds.) Schrad. - EHA. On soil among Bryidae in dense forests. All over entire study area. Scattered.

C. gracilis (L.) Willd. - EHA. Site 15. Crowberry-bilberry spruce stand, mossy hummock; Site 33. Ehrimanvaara. Amongst mosses in rock debris. Site 46. Area cut out for high-voltage overhead lines. Peat soil; Site 102. Canyon. Base of birch tree growing on rocky ridge.

C. macilenta Hoffm. ssp. floerkeana (Fr.) - B. Site 102. Canyon. On rock scarp among other lichens and mosses. Same site, mossy boulder; Site 152. On soil together with other *Cladonia* in old burned-out pine forest.

C. macilenta Hoffm. ssp macilenta - B. Site 48. Birch stump.

C. macrophylla (Schaer.) Stenh. -HAM. Site 102. On thin soil covering rock.

C. phyllophora Hoffm. - B. Site 25. Crowberry-lichen pine forest, windfallen branches; Site 33. Ehrimanvaara. Mossy stone surface on meadow; Site 119. Sandy soil among other *Cladonia* in old burned-out pine forest; Site 219. Mossy stone in bilberry spruce stand.

C. pleurota (Flörke) Schaer. - B. On the ground, fine earth-covered stones. All over study area. Scattered.

C. pyxidata (L.) Hoffm. - EHA. Soil and rotten wood. Over entire nature reserve. Common.

C. rangiferina (L.) Weber ex F.H. Wigg. - B. Soil, mossy boulders, bases of old pine and spruce boles, stumps and windfallen branches in forest, old burned-out stands, cutting areas and mires. Very common..

C. squamosa Hoffm. - B. On soil, mossy stones. Site 25. Crowberry lichen pine forest. Same site. Lingonberry pine forest. Site 102. Canyon.

C. stellaris (Opiz) Pouzar & Vezda - B. Commonly together with *C. arbuscula* and *C. rangiferina* on soil in lichen and bilberry pine stands. Less abundant than *C. arbuscula* and *C. rangiferina*. Common.

C. sulphurina (Michx.) Fr. - B. Rotten wood on sandy soils in open forests, dry peatlands, old burned-out stands and cutting areas. All over nature reserve. Scattered.

C. turgida Hoffm. - B. Site 15. Crowberry-bilberry spruce forest, vertical boulder surface; Site 109. Among other *Cladonia* on boulder surface in crowberry-bilberry pine stand.

C. uncialis (L.) Weber ex F.H. Wigg. - B. Commonly together with *C. arbuscula*, *C. rangiferina* and *C. stellaris*. On soil. All over study area. Scattered.

Evernia mesomorpha Nyl. -B. Sites 48, 49, 71, 72. Pine bark in crowberry-bilberry pine stands. Rare.

E. prunastri (L.) Ach. - N. On birch trunks.Site 108. Bank of River Kamennaya; Site 186. Crowberry-bilberry pine forest.

Hypocenomyce scalaris (Ach.) Choisy - B. Base of pine trunks, stumps in pine stands and old burned-out forests.

Hypogymnia physodes (L.) Nyl. -B. On trees trunks and branches, mossy boulders and rocks; stumps and rotten wood in various forest types. The most common species in the reserve.

H. tubulosa (Schaer.) Hav. -B. Spruce branches; pine and birch trunks, commonly together with previous species; in various forest types. Ubiquitous. Common.

Icmadophila ericetorum (L.) Zahlbr. - HAM. Site 25. Rotten wood in crowberry-bilberry pine forest.

Imshaugia aleurites (Ach.) S.L. F. Meyer - B. Tree trunks and branches, lignum in various types of coniferous and mixed forests. Ubiquitous. Very common.

Lecanora allophana Nyl. -N. Site 167. On old aspen trunk.

L. chlarotera Nyl. - N. Site 169. On aspen trunks in aspen stand.

L. circumborealis Brodo & Vitik. - B. Corticolous, on Picea. Rare.

L. dispersa (Pers.) Sommerf. - EHA. Site 35. On crushed stones.

L. fuscescens (Sommerf.) Nyl. - AA. Site 72. Pine tree in *Sphagnum* pine stand.

L. hypopta (Ach.) Vain. - HAM. Site 72. Rotten boards in abandoned sheds.

L. populicola (DC.) Duby - B. Site 167. Aspen trunk in bilberry pine-spruce forest.

L. pulicaris (Pers.) Ach. - B. Pine and birch bark as well as rotten wood in coniferous and mixed forests. Over entire study area. Scattered.

L. rupicola (L.) Zahlbr. - EHA. Site 35. Boulders in rocky lichen pine stand.

L. symmicta (Ach.) Ach. - B. Site 10. Pine bark in crowberry-lingonberry pine forest.

Lecidella euphorea (Flörke) Hertel in Hawksw., P. James & Coppins - EHA. Site 72. Lignicolous.

Lepraria incana (L.) Ach. s.lat. - EHA. Bases of old pine and spruce trees in mesic forests. Over entire study area. Scattered.

Lobaria pulmonaria (L.) Hoffm.-N. Site 25. Mustakivilampi lake shore. Old willow trunk in bilberry spruce stand; Site 49. Mire margin, dying-off willow trunks in crowberry-blueberry spruce forest: Site 114. Saarikoski rapids Willow-tree in pine-spruce forest; Site 117. Bank of river Kivijoki, willow trunk in stream flood basin; Site 119. Fallen willow tree in bilberry spruce forest; Sites 150-151. Middle reaches of River Kivijoki. Old willow-trees in spruce stands, Site 167. Willow-tree in stream spruce stand; Site 186, 207. At bases of old willow-trees in bilberry spruce forests. Site 208. Aspen trunk in humid blueberry spruce forest; same site, birch trunk; Site 219. Stump of windbroken birch tree in rocky crowberry-lichen pine forest.

Melanelia olivacea (L.) Essl. - B. Deciduous trees bark; rotten wood (more seldom) in forests, on mires. Over entire nature reserve. Scattered.

M. sorediata (Ach.) Goward & Ahti. - HAM. Site 114. Saarikoski Shore boulder.

M. stygia (L.) Essl. - AA. Site 71. Crowberry-bilberry pine stand. On boulders.

Micarea melaena (Nyl.) Hedl. - B. Pine trunks in mesic forests. All over nature reserve. Scattered.

M. lignaria (Ach.) Hedl. - B. Site 48. On rotten wood in crowberry-bilberry spruce forest.

Mycobilimbia tetramera (De Not.) Clauzade, Diederich & Roux - B. Site 72. Rotting windfallen branches.

Mycoblastus sanguinarius (L.) Norm. - HAM. Spruce branches, pine and birch trunks, stumps and rotten wood in various forest types. Ubiquitous. Common.

Nephroma arcticum (L.) Torss.-AA. On soil among mosses, moss-covered boulders and stones in bilberry pine and spruce stands as well as humid bilberry spruce forest. Ubiquitous. Scattered.

N. bellum (Spreng.) Tuck. - B. Site 73. Spruce-pine forest. On aspen trunk.

N. resupinatum (L.) Ach. - B. Sites 47, 116, 207. Bilberry spruce forest. On grey alder.

Ochrolechia alboflavescens (Wulf.) Zahlbr. - AA Site 72. Crowberry-bilberry pine stand. On pine bark.

O. androgyna (Hoffm.) Arnold - AA. Corticolous, on coniferous and deciduous trees. Common.

O. arborea (Kreyer) Almb. - B. Pine bark in pine stands. Distinctly less common than previous species.

O. frigida (Sw.) Lynge - AA. Site 148. On moss-covered rock.

Parmelia saxatilis (L.) Ach. - EHA. Bare and mossy boulders. Ubiquitous. Common.

P. sulcata Taylor - EHA. On trees bark, windfallen branches and mossy stones. Ubiquitous. Common.

Parmeliopsis ambigua (Wulfen) Nyl. - B. Corticolous, lignicolous. In various habitats. One of most common species in the reserve.

P. hyperopta (Ach.) Arnold - B. Spruce branches, bases of birch and pine trunks, stumps and rotten wood in forests and mires (on *Ledum*, *Empetrum* bark). All over the study area. Very common.

Platismatia glauca (L.) W.L. Culb. & C.F.Culb. - B. Spruce branches, pine and birch trunks. Ubiquitous. Common.

Peltigera aphthosa (L.) Willd.-HAM. On soil among mosses; moss-covered boulders, stones, rocks, base of Juniperus communis stem. Ubiquitous. Common.

P. canina (L.) Willd. - EHA. Terricolous and corticolous (esp. aspen butts). Ubiquitous. Common.

P. didactyla (With.) J.R. Laundon - B. Site 119. Old burned-out pine forest, sandy soil.

P. leucophlebia (Nyl.) Gyeln. - B. Site 48. Crowberry-bilberry pine forest. On mossy boulder.

P. malacea (Ach.) Funck - EHA. Site 102. Canyon. Moss-covered vertical surface of rocky scarp.

P. rufescens (Weiss) Humb. - EHA. Site 111. Bank of River Kivijoki. Lingonberry pine stand, on sandy soil.

Pertusaria amara (Ach.)Nyl. - N. Corticolous. On willow, birch, aspen. Scattered.

Physcia aipolia (Ehrh. ex Humb.) Fürnr. - EHA. Site 72. Kuikiniemi. Aspen trunk near abandoned shed.

P. stellaris (L.) Nyl. - EHA. Same site as previous.

Pseudevernia furfuracea (L.)Zopf. - EHA. Site 20. On pine trunk in *sphagnum* pine stand; Site 35. On spruce branch in crowberry-bilberry pine forest. Very rare.

Ramalina farinacea (L.) Ach. - N. Site72. Bilberry pine forest, on birch trunk.

Rhizocarpon geographicum (L.) DC. - EHA. Exposed stones and rock surfaces. Ubiquitous. Common.

Rinodina sophodes (Ach.) A. Massal. - EHA. Site 49. Mire margin. Old willow trunk in crowberry-blueberry spruce forest.

Stereocaulon alpinum Laurer - AA. Site 102. Canyon. Rocky scarp. Site 114. Bank of River Kamennaya. Rocky lichen pine forest. Fine earth-covered stones.

S. condensatum Hoffm. - B. Site 72. Makrovaara. Sandy soil.

S. grande (H. Magn.) H. Magn. - AA. Site 15. On soil among mosses in crowberry-bilberry pine stand; Site 33. Ehrimanvaara. Mossy stone on meadow.

S. paschale (L.) Hoffm. - EHA. On fine-earth covered stones and boulders among mosses in bilberry and lichen pine stands.

S. saxatile H. Magn. - M.Sites 15, 79, 114, 152, 208. Sandy soil and stones in open areas; fine earth-covered stones and boulders among mosses in dry pine forests. Scattered.

S. tomentosum Fr.-B. Site 47. Gravel embankment.

Trapeliopsis flexuosa (Fr.) Coppins & P. James - B. Site 47. Water intake area. Pine trunk in crowberry -bilberry pine stand.

T. granulosa (Hoffm.) Lumbsch - B. Site 152. Old burned-out pine forest. Exposed, fine earth-covered quartz rocks.

Umbilicaria cylindrica (L.) Delise ex Duby - AA. Site 33. Ehrimanvaara. On bare stone in a meadow.

U. deusta (L.) Baumg. - HAM. Surface of boulders and stones and on rock exposures in well illuminated places. All over nature reserve. Scattered.

U. hyperborea (Ach.) Hoffm. - AA. Site 15. On bare stone.

Usnea filipendula Stirt. - B. Pine and birch bark in crowberry-bilberry pine forests. Ubiquitous. Common.

U. glabrescens (Nyl. ex Vain.) Vain. - B. Site 48. Spruce branch in crowberry-bilberry pine stand.

U. hirta (L.) Weber ex F.H. Wigg. - B. Bark of coniferous and deciduous trees, stumps and fallen trunks. Common.

U. lapponica Vain. - B. Site 35. Spruce branch in crowberry-bilberry pine stand.

U. subfloridana Stirt. - B. Spruce branches; pine and birch trunks. Ubiquitous. Common.

Vulpicida pinastri (Scop.) J.E. Mattsson & M.J. Lai - B. On trees bark, stumps and rotten wood. Forests, cutting areas, *sphagnum* mires. Ubiquitous. Common.

Xanthoparmelia conspersa (Ach.) Hale - EHA. Site 72. Makrovaara. Pile of stones in pine forest.

Xanthoria candelaria (L.) Th. Fr. - EHA. Site 72. Makrovaara. On field stone.

X. parietina (L.) Th. Fr. - EHA. Site 169. Aspen trunk in aspen stand; Site 207. On stone in crowberry-lichen pine stand.

X. polycarpa (Hoffm.) Th. Fr. ex Rieber - EHA. Site 72. Makrovaara. Treated wood.

Xylographa parallela (Ach.:Fr.) Behlen & Desberg - HAM. Site 71. Exposed wood in bilberry spruce forest.

The preliminary list of lichens of the Kostomuksha Nature Reserve consists of 123 species and 5 infraspecific taxa that belong to 45 genera. The genera *Cladonia, Lecanora, Bryoria, Peltigera* and *Stereocaulon* have the greatest number of species. The flora of the nature reserve is dominated by typical taiga forest plants growing at moderate Holarctic latitudes. They occur primarily in habitats unaffected by human activities. Thus, the taxonomic structure of the lichen flora studied reflects the predominance of ecosystems unaffected or slightly affected by human activities.

Based on preliminary geographic analysis, the flora was divided into six elements: AA - 11species (8.6 %), HAM - 13 (10.2 %), B - 63 (49.2 %), EHA - 33 (25.8 %), M - 1 (0.8 %) and N - 7 (5.5 %). The flora of the nature reserve is dominated by boreal species, widespread in Holarctic coniferous forests (Trass 1970, Golubkova 1983) that belong to the families Cladoniaceae and Parmeliaceae. An important role in flora formation is played by an euryholarctic element which combines the species, more or less common in various Holarctic vegetation-climatic zones (Oxner 1940-1942, Makarevich 1963). Hypoarcticmontane species concentrated in the northern Holarctic at the arctic-boreal zone boundary, have also a marked inflience on the lichen flora. They occur as far as the southern Holarctic boundary and even penetrate the broad-leaved forest zone (Trass 1970). The number of species with distinct southern and northern links is relatively small. The lichen flora of the study area can thus be defined as boreal-euryholarctic, hypoarcticmontane species being fairly abundant.

It can be seen from the literature that the lichen diversity observed is largely due to the amount of suitable substrates (Makarevich 1958, Hale 1967, Ahti 1977). The orographic complexity of the study area is responsible for a variety of ecological conditions such as rock surfaces, soils, living plants and plant remains. Based on the above types of substrate, lichens fall into four main ecological groups: 1) epiphytic (corticolous) 2) epixylic (lignicolous 3) epilithic (saxicolous) and 4) terricolous (epigeic), including muscicolous). There are only 17 species (13.2 %) that grow on bare, well illuminated stones, boulders and rocks. These include obligatory saxicolous lichens of the genera *Rhizocarpon, Umbilicaria* and *Aspicilia* as well as some *Lecanora, Melanelia* and *Stereocaulon* species. This is due to the fact that in the study area the rocks are poorly exposed and that this lichen group is not studied throughly.

Terricolous lichens growing on sandy, humus and peat soils as well as fine earth are far more common (55 species, 42.6 %). More than one-third of these are lichens such as *Cladonia* spp., *Peltigera* spp. and some species of the genus *Stereocaulon* that grow on primary soils covering large stones, boulders and rocks. Some lichens, primarily those of the genera *Cladonia, Cetraria* and *Peltigera,* play an important role in the formation of ground layer in light coniferous forests. One species (*Ochrolechia frigida*) was revealed on the sod of the moss covering a rock scarp. Epiphytic lichens are best represented in the lichen flora of the study area. 74 species (57.4 %) were found on the bark of coniferous and deciduous trees as well as on shrubs and dwarf shrubs.

The ligneous element is considerably less diverse. 32 species (24.8 %) were collected on stumps, windfallen branches and dead trees. Two species (1.6 %), *Lecanora hypopta* and *Xanthoria polycarpa,* were found on treated wood. Some species colonize a wide types of substrates (trees bark, windfallen branches and mossy rock surfaces). *Hypogymnia physodes, Parmelia sulcata, Parmeliopsis* spp. and some *Cladonia* species, widespread in the nature reserve, predominantly on woody substrates. Several old-growth forest species are frequent, e.g. *Bryoria fremontii* and *Lobaria pulmonaria.* Both species are referred to in the Red Book of Russian Federation (1988). *Lobaria pulmonaria* is scattered over the entire nature reserve. It is found at the bases of old willow and aspen trees (birch is a less common substrate) in mesic types of coniferous forests mixed with deciduous species). *L. pulmonaria* prefers humid habitats such as the base of inclined trunks etc. (some data on the occurrence of this species in the study area were kindly presented by B.N. Kashevarov of the Kostomuksha Nature Reserve). *Bryoria fremontii* is a fairly common epiphyte growing on pine spruce and sometimes birch in pine, spruce and mixed forests. It is more abundant in well illuminated habitats and is often found on dead trees.

It should be noted in conclusion that this paper is the first attempt to review the lichen flora of the study area. Because the lichens of the nature reserve are not studied well enough both areally and in terms of species diversity, it would be premature to analyse them in more detail. Our lichen study is now in progress. Further analysis of the materials collected will increase our knowledge of the lichen flora in the nature reserve.

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The species composition, abundance and biomass of phytoplankton in some small lakes of the Nature Reserve Friendship

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Abstract

86 algal species and varieties of seven systematic groups (Cyanophyta - 3, Chrysophyta - 18, Bacillariophyta - 31, Xanthophyta - 1, Pyrrophyta - 9, Euglenophyta - 3 and Chlorophyta - 21) were found in the phytoplankton of the lakes studied. Thirty-nine algal species were revealed in winter, 30 in summer and 54 in fall. Diatoms were responsible for the taxonomic diversity of plant plankton in all seasons. The representatives of several othes systematic groups, were present in algal communities in different lakes. In winter, diatoms were typically predominant, dinoflagellates and green algae being less abundant. Diatoms and chrysomonads dominated summer plankton, whereas diatoms, chrysomonads and green algae prevailed in autumn.

In winter, the amount of phytoplankton in the lakes studied is 66 cells/l and 0.2 g/m³. The corresponding values are 235,000 cells/l and 0.2 g/m³ in summer as well as 0.5 - 5.500 000 cells/l and 0.1-2.9 g/m³ in autumn. Most of the species found were oligo-b- and b-mesosaprobic forms, indifferent for water pH and salinity.

Key words: phytoplankton, species composition, number, biomass

Introduction

Data on the plankton algae of the lakes located in the Friendship Park are scanty (Limatainen 1994). Phytoplankton was studied in 1993 in some small Russian and Finish lakes. In these studies, species composition, ecological and geographic characteristics, abundance and biomass of plankton algae were determined.

Material and methods

The lakes investigated were Nikolampi (11), Nimetön 1 (4), Nimetön 2 (5), Nimetön 3 (6), Pitkäjärvi (7), Kiitehenjärvi (8), Särkilampi (3), Sininenlampi (10), Fenozero (1), Mustakivilampi (2) and Ahvenlampi (9) in Russia (Fig. 1) as well as

Ristonlampi (12) and Elimysjärvi (13) in Finland (Fig. 1). Phytoplankton samples were collected in winter (9-11 and 24 March), summer (29 July) and autumn (16 and 24 September) 1993. The number of stations in each lake was restricted to one, samples being taken in the central part of the lakes in winter and summer and near the shore in fall. Phytoplankton was sampled using a Ruttner type sampler from the horizons given in Table 1. The volume of samples was 0.2 l in winter, 1.0 l in summer and 0.25 l in autumn. Winter samples were conserved with special fixers (Tikkanen 1986) and other samples with iodine-formalin fixers (Kuzmin 1975). The samples were then treated using conventional methods (Fedorov 1979). Algal biomass was calculated assuming that the cell shape is roughly equal to a similar geometric body (Fedorov 1979, Kuzmin 1984). The conversion to wet weight was done by assuming cell density to be 1 g/m^3. Algae were identified under a light microscope using various determination tables (Zabelina, Kiselev et al. 1951; Gollerbach, Kosinskaya & Polyansky 1953; Matvienko 1954; Kiselev 1954; Popova 1955; Dedusenko-Shegoleva & Matvienko 1959; Korshikov 1953; Tikkanen 1986) and floras (Kosinskaya 1960, Vetrova 1986.) The most advanced systems, generally accepted in ecology and biogeography of species, were employed to characterize phytoplankton ecologically and geographycally (Makrushin 1974, Proshkina-Lavrenko 1953, Anon. 1977, Hustedt 1939, Sladecek 1973).

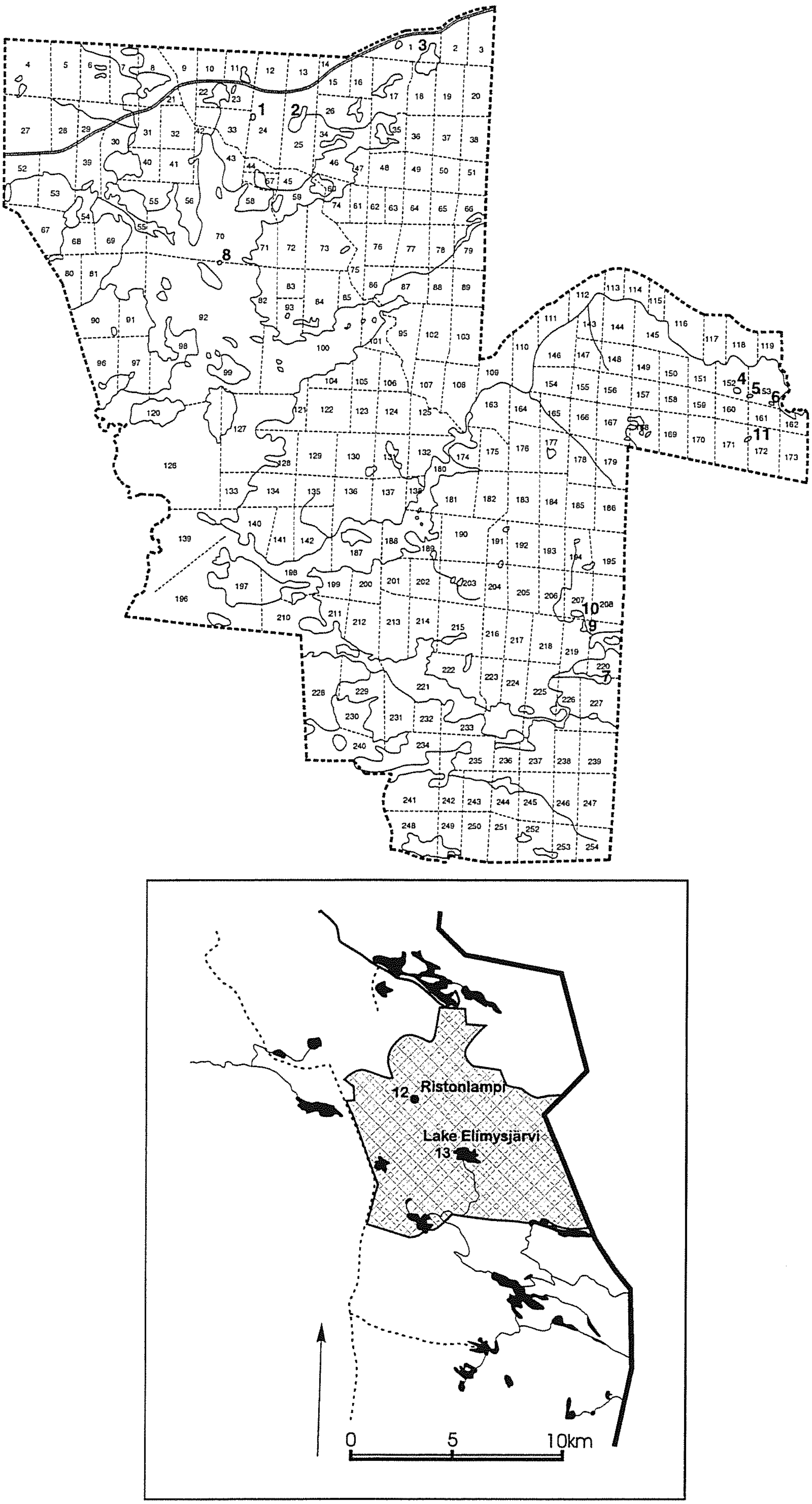

Fig. 1. The location of the studied lakes in the Kostomuksha Nature Reserve and Elimyssalo Nature Reserve.

Table 1. Number (10^3cell/ l) and biomass (g.m^3) of phytoplankton in some lakes

Lake Date, depth	Bacil- lario- phyta	Chry- so- phyta	Pry- ro- phyta	Chlo- ro- phyta	Others	Total
			Number/ biomass			
			Winter			
Ristonlampi 0.5m 24.3.93.	1,9 0,00148	0,6 0,00017	0 0	0,6 0,00327	0,6 0,00023	3,7 0,00515
Elimysjärvi 0.5m 24.3.93.	1,3 0,00627	0 0	39,3 0,03208	22,0 0,03292	3,5 0,00532	66,1 0,08058
Nikolampi 1.0-1.3m 10.3.93.	32,0 0.04632	0,4 0.00001	0,8 0.00300	2,0 0.00250	0 0	35,2 0.05183
Nimetön 1 1.0-1.3m 11.3.93.	18,0 0,02721	0 0	0 0	0 0	0 0	18,0 0.02721
Nimetön 2 1.0-1.3m 9.3.93.	2,0 0.00171	1,0 0.00054	0 0	1,0 0.00032	0 0	4,0 0.00257
Nimetön 3 1.0-1.3m 11.3.93.	5,1 0.00447	0 0	11,7 0.016097	1,7 0.00514	5,0 0.01513	23,5 0.18571
Pitkäjärvi 1.0-1.3m 11.3.93.	12,5 0,02190	0 0	5,0 0,01745	2,5 0,00174	0 0	20,0 0.04109
Kiitehenjärvi 0.1m 11.3.93	6,75 0,03410	0 0	2,25 0,01158	0 0	0 0	9,0 0,04568
			Summer			
Särkilampi 0.5m 29.7.93	118,0 0,0970	111,25 0,09408	1,0 0,00637	3,0 0,01098	0,5 0,00174	235,25 0,20406
			Autumn			
Sininenlampi 0.5m 24.9.93	24,0 0,03176	150,0 0,08361	6,0 0,03345	164,0 0,03060	0 0	344,0 0,17942
Fenozero 0.5m 16.9.93.	444,0 1,25659	26,0 0,01446	0 0	206,0 0,00666	0 0	676,0 1,27771
Mustakivilampi 0.5m 16.9.93.	40,0 0,03657	40,0 0,01368	0 0	13,0 0,02168	4,0 0,00003	97,0 0,07196
Ahvenlampi 0.5m 24.9.93.	12,0 0,0108	5600,0 2,85768	10,0 0,03480	0 0	0 0	5622,0 2,90328

Results and Discussion

39 species were found in the winter phytoplankton of lakes Ristonlampi, Elimysjärvi, Nikonlampi, Nimetön 1, 2 and 3, Pitkäjärvi and Kiitehenjärvi. Slightly more species were reported from Ristonlampi and Nikolampi (Tables 2 and 3). In all lakes studied diatoms were more diverse. In winter, diatoms generally dominated in terms of number and biomass in Ristonlampi, Nikolampi, Nimetön 1 and 2, Pitkäjärvi and Kiitehenjärvi. Pyrophytic algae contributed substantially to phytoplankton cell numbers in Elimysjärvi, Nimetön 3, Pitkäjärvi and Kiitehenjärvi. Also Cryptomonas algae were abundant in lakes Elimysjärvi and Pitkäjärvi. *Peridinium goslaviense* was found in Nimetön 3 and *Peridinium inconspicuum* as well as *Glenodinium sp.* in Kiitehenjärvi. Of Green algae species *Chlamydomonas monadina* was abundant in Elimyslampi and Phacotus angustus in Ristonlampi. Euglenoidea (*Trachelomonas oblonga*) were common in Lake Nimetön 3 in winter.

Table 2. Number of species in different taxonomic groups in some lakes of the Friendship Nature Reserve

	Bacillario-phyta	Chryso-phyta	Chloro-phyta	Pyrro-phyta	Cyano-phyta	Eugleno-phyta	Xanto-phyta	Total number of species
Lake			Winter					
Ristonlampi	8	1	2	-	1	-	-	12
Elimyslampi	1	1	2	3	1	1	-	9
Nikolampi	11	1	3	1	1	-	-	17
Nimetön I	3	-	-	-	-	-	-	3
Nimetön II	1	1	1	-	1	-	-	4
Nimetön III	4	-	1	2	-	1	-	8
Pitkäjärvi	3	-	1	1	-	-	-	5
Kiitehenjärvi	2	-	-	2	-	-	-	4
Total	20	3	6	7	1	2	-	39
			Summer					
Särkilampi	11	8	6	2	1	1	1	30
			Autumn					
Sininenlampi	5	6	7	2	-	-	-	20
Fenozero	14	4	4	-	-	-	-	22
Ahvenlampi	4	8	1	2	-	-	-	15
Mustakivilampi	5	11	7	-	1	-	-	24
Total	20	16	14	3	1	-	-	54

Table 3. List of the observed phytoplankton species in some small lakes in winter 1993 + denotes for observed species, - not observed

	Lakes*							
Species	1	2	3	4	5	6	7	8
Cyanophyta								
Synechocystis aquatilis Sauv.	+	+	+	-	+	-	-	-
Chrysophyta								
Chrysococcus cordiformis Naum.	+	+	-	-	+	-	-	-
Dinobryon borgei Lemm.	-	-	+	-	-	-	-	-
D. cylindricum Imh. var. *cylindricum*	-	-	-	-	+	-	-	-
Pyrrophyta								
Cryptomonas marssonii Skuja	-	+	-	-	-	-	-	-
C. ovata Ehr.	-	+	-	-	-	-	-	-
Cryptomonas sp.	-	-	+	-	-	-	-	-
Chroomonas sp.	-	+	-	-	-	-	-	-
Peridinium goslaviense Wolosz.	-	-	-	-	-	+	-	-
P. inconspicuum Lemm.	-	-	-	-	-	+	-	-
Glenodinium sp.	-	-	-	-	-	-	-	+
Bacillariophyta								
Tabellaria fenestrata (Lyngb.) Kutz.var.*fenestrata*	+	-	+	-	-	+	+	+
T.fenestrata var. *intermedia Grun.*	+	-	-	-	-	-	-	-
Aulacosira italica (Ehr.) Kutz. Sim. var. *italica*	+	-	+	-	-	-	-	-
A. italica subsp. *subarctica O. Mull. Sim.*	-	-	+	+	-	-	-	-
A. islandica subsp. *helvetica O. Mull. Sim.*	-	-	-	+	+	+	+	+
A. distans (Ehr.) *Kutz. var. alpigena Grun. Sim.*	+	-	-	+	-	-	+	-
A. varians Ag. var. varians	-	-	+	-	-	+	-	-
Comphonema intricatum Kutz.	+	-	-	-	-	-	-	-
Ceratoneis arcus (Ehr.) Kutz. var. *arcus*	+	-	-	-	-	-	-	-
Cyclotella comta (Ehr.) Kutz.	+	-	-	-	-	-	-	-
C. meneghiniana Kutz.	+	-	-	-	-	-	-	-
Cyclotella sp.	-	-	+	-	-	-	-	-
Asterionella formossa Hass. var. *formosa*	-	-	+	-	-	-	-	-
Synedra ulna (Nitzsch.) Ehr. var. *ulna*	-	-	+	-	-	-	-	-
Diatoma vulgare Bory var. *vulgare*	-	-	+	-	-	-	-	-
D. elongatum (Lyngb.) Ag. var. *elongatum*	-	-	+	-	-	-	-	-
Nitzshia sp.	-	-	+	-	-	+	-	-
Navicula sp.	-	-	-	-	-	+	-	-
Pinnularia sp.	-	+	-	-	-	-	-	-
Cymbella sp.	-	-	+	-	-	-	-	-
Euglenophyta								
Trachelomonas oblonga Lemm.	-	-	-	-	-	+	-	-
Euglena acus Ehr. var. *acus*	-	+	-	-	-	-	-	-

Chlorophyta								
Phacotus angustus Pasch.	+	-	-	-	-	-	-	-
Clamydomonas monadina Stein	-	+	+	-	-	-	-	-
Clamydomonas sp.	+	-	-	-	-	+	+	-
Monoraphidium dybowski (Wolos.) Hind.	-	+	-	-	-	-	-	-
M.mirabile (West) (Nyg.)	-	-	-	-	-	+	-	-
Monoraphidium sp.	-	-	+	-	-	-	-	-

* - Lakes: 1 - Ristonlampi, 2 - Elimysjärvi, 3 - Nikolampi, 4 - Nimetön 1, 5 - Nimetön 2, 6 - Nimetön 3, 7 - Pitkäjärvi, 8 - Kiitehenjärvi.

The cellnumbers of winter phytoplankton in the lakes studied varied from 4 to 66 000 cells/l and their biomass was 0.01-0.2 g/m^3 (Table 1). The highest biomass was observed in Nimetön 3, and the highest cell numbers in Elimysjärvi. Diatoms as well as green and golden algae species were most numerous in late July (Table 2 and 4). The diatom *Asterionella formosa* and the chrysomonad *Dinobryon divergens* accounted for 45 and 25 % of the total amount of phytoplankton. The cell number of plankton algae in the lake was 235 cells/l and their biomass was 0.2 g/m3 (Table 1). Diatoms and chrysomonads account for 50 % of the cell numbers and biomass.

Table 4. List of the observed of phytoplankton species in Särkilampi in summer 1993

Chrysophyta

Dinobryon divergens Imh. var. *divergens*
D. cylindricum Imh. var. *cylindricum*
D. bavaricum Imh. var. *bavaricum*
Chrysococcus rufescens Klebs. var. *rufescens*
C. punctiformis Pasch.
C. cordiformis Naum.
Mallomonas allorgei (Defl.)
Stenokalyix densata Schmid.

Bacillariophyta

Asterionella formosa Hass. var. *formosa*
Aulacosira distans (Ehr.) Kutz. var. *alpigena* Grun.
A. italica subsp. *subartica* O. Mull
Tabellaria fenestrata (Lyngb.) Kutz. var. *fenestrata*
T. fenestrata var. *intermedia* Grun.
T. flocculosa (Roth.) Kutz.
Frustulia rhomboides (Ehr.) D.T. var. *rhomboides*
Cyclotella bodanica Eulenst.
Stauroneis anceps Ehr. f. *anceps*
Eunotia sp.
Navicula sp.

Xantophyta

Centritractus brunneus Fott.

Pyrrophyta

Peridinium cinctum (O.F.M.) Ehr.
Glenodinium sp.

Euglenophyta

Trachelomonas hispida (Perty) Stein. emend. Delf.

Chlorophyta

Koliella longiseta (Vischer.) Hind.
Planctococcus sphaerocystiformis Korsch.
Cosmarium margaritatum (Lundell) Roy & Bisset
C. imperessulum Elbving.
Oedogonim sp.
Chlamydomonas sp.

Cyanophyta

Anabaena sp.

In autumn, phytoplankton species composition was studied in Sininenlampi, Fenozero, Mustakivilampi and in the lake near the airfield. In all, 54 species dominated by diatoms as well as chrysomonads and green algae were found (Table 2 and 5). Diatom species were most numerous in Fenozero and chrysomonad in Mustakivilampi and in the lake near the airfield. The species from all systematic groups (Table 5) contributed to algal flora diversity in Sininenlampi, where the chrysomonad *Dinobryon cylindricum* and the green alga *Coenocystis planctonica* accounted for 30-35 % of the total number of algae. In Fenozero, the diatom *Aulacosira islandica* accounted for 34 % of the total number of phytoplankton, and the green alga *Dictyosphaerium pulchellum* contributed 29 % to the total number of algae. In the lake near the airfield, chrysomonads (species of the genus *Dinobryon*) make up 99,6 % of all phytoplankton (70 % *D. cylindricum* and 28 % *D. pediforme*). In Mustakivilampi, diatoms (41 %) and chrysomonads (41 %) are most abundant and account for 51 and 19 % of phytoplankton biomass, whereas green algae contributed about 30 % to total algae biomass. The diatom *Aulacosira distans* and the cryptophytic chrysomonads *Chrysococcus cordiformis* were numberous in this lake.

Table 5. List of the observed phytoplankton species in some small lakes in autum 1993
(+ denotes for species observed and - for species not observed)

Species	Lake*			
	1	2	3	4
1	2	3	4	5
Bacillariophyta				
Aulacosira islandica subsp. *helvetica* (O.Mull.) Sim.	+	+	+	+
A. italica subsp. *subarctica* (O.Mull.) Sim.	+	+	-	-
A. distans (Ehr.) Kutz.var *alpigena* Grun. Sim.	-	-	-	+
Tabellaria fenestrata (Lyngb.) var. *fenestrata*	+	+	+	-
T. fenestrata var. *intermedia* Grun.	-	+	-	-
T. flocculosa (Roth.) Kutz.	-	-	+	+
Frustulia rhomboides (Ehr.) D.T. var *rhomboides*	-	+	-	-
Diatoma elongatum (Lyngb.) Ag. var *elongatum*	+	-	-	-
D. elongatum var. *actinastroides*	-	+	-	-
Nitzschia linearis W. Sm. var. *linearis*	-	+	-	-
Nitzschia sp	+	-	-	-
Actinella punctata Lewis.	-	+	-	-
Pinnularia major (Kutz.) Cl. var. major	-	+	-	-
Pinnularia sp.	-	+	-	-
Eunotia sp.	-	+	-	-
Achnanthes sp.	-	+	-	-
Navicula sp.	-	+	+	-
Cymbella sp.	-	+	-	-
Cyclotella sp.	-	-	-	+
Fragilaria sp.	-	-	-	+
Chrysophyta				
Dinobryon acuminatum Ruttn.	+	-	+	-
D. divergens Imh. var *divergens*	+	-	+	+
D. divergens var. *angulatum* (Seligo) Brunnth.	-	-	+	-
D. bavaricum Imh. var. *bavaricum*	+	+	+	+
D. pediforme (Lemm.) Steinecke	+	+	+	-
D.cylindricum Imh. var. *cylindricum*	+	+	+	-
D. cylindricum var. *palustre* Lemm.	+	+	+	+
D. elegans Korsch.	-	-	+	-
Chrysococcus rufescens Klebs. var. *rufescens*	-	-	-	+
C. cordiformis Naum.	-	-	-	+
C. punctiformis Pasch.	-	-	-	+
Stenokalyx densata Schmid.	-	-	-	+
Mallomonas sp.	-	-	-	+
Pseudokephyrion entzii (Conrad.) Schmid.	-	-	-	+
Kephyrion doliolum Conr.	-	-	-	+
K. cupuliforme Conr.	-	-	-	+
Cyanophyta				
Cyanarcus hamiformis Pasch.	-	-	-	+
Pyrrophyta				
Glenodinium sp.	+	-	+	-
Peridinium sp.	+	-	-	-
P. inconspicuum Lemm.	-	-	+	-
Chlorophyta				
Glenodinium sp.	+	-	+	-
Peridinium sp.	+	-	-	-
P. inconspicuum Lemm.	-	-	+	-

Chlorophyta				
Coenocystis planctonica Korschik.var. *planctonica*	+	-	-	-
Oocystis elliptica West.	+	-	-	-
O. lacustris Chod.	+	+	-	+
Chlamydomonas monadina Stein.	+	-	+	-
Chlamydomonas sp.	-	-	-	+
Dictyosphaerium pulchellum Wood. var. *pulchellum*	+	+	-	-
Planctococcus sphaerocystiformis Korschik.	-	-	-	+
Crucigenia quadrata Morren	-	-	-	+
C. tetrapedia (Kirchn.) W. et W. var. *tetrapedia*	-	-	-	+
Sphaerocystis polycocca Korschik.	-	-	-	+
Monoraphidium komarkova Nygaard.	-	+	-	+
Cosmarium sp.	-	+	-	-
Oedogonium sp.	+	-	-	-
Mougeotia sp.	+	-	-	-

* Lakes: 1 - Sininenlampi, 2 - Fenozero, 3 - lake near the airfield, 4 - Mustakivilampi.

Table 6. Ecological and geographical characteristics of algae in the lakes studied (according to Hustedt 1939, Proshkima-Lavrenko 1953, Sladecek 1973).

Characteristics	Number of species
Geographical distribution:	
cosmopolitic	40
boreal	3
northern-alpine	6
Characteristic of habitat:	
planktonic	54
benthos	3
litoral	4
periphytic	1
Indicator of halobic zone:	
oligohalob:	
halofob	4
indifferent	42
halophil	4
pH indicator:	
acidophil	5
indifferent	16
alkaliphil	2
Indicator of saprobic zone:	
xeno oligosaprobic (x 0)	3
oligosaprobic (0)	6
oligo B mososaprobic (0 B)	14
B mososaprobic (B)	14
a saprobic (a)	1

In autumn, the abundance and biomass of phytoplankton was minimum in Mustakivilampi (97 000 cells/l and 0.07 g/m^3) and maximum in the lake near the airfield (5.600 000 cells/l and 2.9 g/m^3) (Table 5). Most of the taxa found are widespread in continental waters. Biogeographically, plankton algae was dominated by cosmopolitan forms, northern alpine and boreal species being scarce. Benthic diatoms were occasionally observed being resuspended by hydrodynamic processes. Regarding water salinity, most of the species were dominated by indifferent types. Acidophilic organisms were present. Species indicative of saprobic water accounted for 36 % of all algae. They are dominated by oligo-b-and b-mesosaprobes represented by diatoms, euglenoidea and green algae (Table 6).

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Bacterial communities and primary production of some aquatic environments of the Kostomuksha Nature Reserve

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Abstract

The data presented in this article contains the information about bacterial communities (total number, the heterotrophic bacteriums, CO_2 -dark assimilation, organic matter destruction) and primary production in two water bodies (Lake Kiitehenjärvi and Lake Haukijärvi). The two water bodies are situated near Kostomuksha ore-dressing mill and are under the influence of its air-emissions. The possible effects of acidification are discussed.

Key words: bacterioplankton, production, destruction, pollution, acidification, CO_2 dark and light fixation

Introduction

The construction and function of the largest ore-dressing mill in Karelia (Kostomuksha) is a new source of pollution for water ecosystems in that region.This fact caused the need of constant monitoring of the ecological condition in the area.

The first hydrochemical and hydrobiological investigations of the water bodies in Kostomuksha region were conducted in the begining of the 1970s (Freindling & Harkevich 1974, Sokolova et al. 1977). Later on the same observations were done during different periods (Harkevich 1985 Feoktistov & Salo 1990, Feoktistov et al. 1992).

Microbiological observations had been conducted in an unsufficient extent earlier. In the 1970s they included quantitative characteristics of total number of bacteria and heterotrophic organisms taken from water bodies of the River Kivijoki basin (Filimonova 1986). In the 1980s the goal of the investigations was to study the influence of waste waters of the mill on the lake-river system of the River Kenti (Feoktistov et al. 1992). The observations were made in 1991-1993 with the aim to obtain data about the primary production and about the state of bacterial communities in two water bodies situated in the Kostomuksha Nature Reserve. Lake Kiitehenjärvi and Lake Haukijärvi were chosen as the control ones for the future monitoring of possible influence of the emissions from the ore-dressing mill on their ecosystems. 90 % of these emissions is SO_2 which may result in acidification of the lakes.

Methods

Primary production was determined by the flask method in radiocarbon modification (Steemann-Nielsen 1952). Water samples were taken from different levels in the water layer equal to 3 transparancies. Samples were exposed to Na_2CO_3 (1-3 μg/ml) under the natural light and in darkness during one day. After that samples were fixed with formalin. Then 50 ml of each sample were filtered (pore diameter of 0.7 - 0.8 μm). Filters with samples were assessed using the Beta-2 meter. Primary production was calculated by Steemann-Nielsen formula taking into account CO_2 dark fixation by phytoplankton.

Intensivity of CO_2 dark assimilation was determined by water surface, near the bottom and in the zone of temperature leap in situ by Romanenko method (1974). Organic matter destruction was evaluated by the flask method in oxygen modification. Samples were incubated in situ during one day (Winberg 1960). Total number of heterotrophic bacteria was calculated by the method of Kuznetsov & Dubinina (1989).

Results and discussion

Lake Kiitehenjärvi and Lake Haukijärvi are not directly influenced by the local industry, but as they are situated close to the ore-dressing mill, they are subjected to the emissions. The two water bodies differ from each other by size and hydrological characteristics.

Lake Kiitehenjärvi is a large water body (105.5 km^2, water volume 782.5 x 10^3 m^3, average depth 7.9 m) with a shattered shore-line. The lake water is characterized by high transperancy, low mineralization (24 mg/l), low colour (18-35 by cobalt scale). Hydrological and hydrochemical data of Lake Kiitehenjärvi are published partly (Freindling & Harkevits 1974).

Lake Kiitehenjärvi is poor in organic matter of dominantly allochtonous nature. Its amount produced by autochthonous processes (photosynthesis of phytoplankton) is not great either, even during the period of maximum water temperatures. At the pelagic sites, maximum photosynthesis values ranged from 24.0 to 62.3 μg C/l day and the daily production under one m^2 is about 0.1 g C. As the water is very clear, the bulk of organic matter is produced in the 3-4-meter-deep surface layer. In the largest bays such as Babya Guba Bay and Kamalahti, the rate of photosynthesis in the surface layer is 2-2.5 times higher, but organic matter production under 1 m^2 is comparable to that at the pelagic sites. The results obtained in both cases (July 1991) are within the range, typical for oligotrophic lakes.

Total organic matter destruction is as low as 0.05-0,1 mg C/l/day (Table 1). Over 0.3 g C was destroyed under 1 m^2 in 24 hours, which is much higher than primary production. Bacteria account for 70-80 % of the above amount. Destruction is typically higher than production in oligotrophic water bodies. According to most researchers, this phenomenon is due to a significant role of allochtonous organic matter in the energy pattern of such ecosystems (Winberg 1960, Bouillon 1983, Romanenko 1985). This interpretation is supported by the data obtained in the lake bays, where the effects of allochtonous organic matter, especially that of terrigenous origin, is much stronger than at pelagic sites.

Table 1. Characteristic bacterioplankton of Lake Kiitehenjärvi (1991).

Zone of the lake	Depth m	Dark assimilation CO_2 mg C/l/day	Production of the bacteria CO_2 mg C/l/day	Destruction of the o.m. mg C/l/day
Pelagic	0.50	0.63	10.50	0.07
zone	21.00	0.17	2.80	0.06
Kamalahti	0.50	0.61	10.2	0.06
Bay	5.00	0.87	14.7	0.12
North Babya Bay	0.5	1.61	26.8	-
South Babya Bay	0.5	0.59	9.7	0.06

Bacterial plankton is present in small quantities. Its total amount is 0.3-1.0 x 10^6/ml. Saprophytic flora count ranges from 3 to 670 col/ml and that of oligotrophic bacteria from 0 to 200 col/ml. The heterotrophic component accounts for only 0.001-0.06 % of bacterial coenoses, indirectly indicating that the water is relatively clean and there is no marked anthropogenic effect. The low variability of structural indices, especially total count, in both time and space is characteristic of the bacterial plankton. Thus, the maximum-minimum ratio in different sesons is 1.0-1.5. On the contrary, the saprophytic microflora is highly variable, indicating that the ecosystem is heterogeneous (Table 2).

Table 2. Total counts of bacteria 1 (=1 x 10^6/ml) and saprophytic microflora 2 (=colonies/ml) in Lake Kiitehenjärvi (1992).

Lake zone	Winter		Spring		Summer		Autumn	
	1	2	1	2	1	2	1	2
Pelagic zone	0.41	258	0.55	111	0.69	101	0.8	99
Kamalahti Bay	0.65	43	0.76	68	0.84	173	0.82	68
Babya Bay	0.38	110	0.58	176	0.75	41	0.81	175

Depth distribution is typical of oligotrophic water bodies in which maximum density is observed in the warmest trophogenic layer. Density decreases with depth and slightly increases again in a bottom layer. Such distribution in the deep water layer is characteristic of both structural (total count and the amount of heterotrophic bacteria) and functional (dark CO_2 assimilation and bacterial production) parameters. Thus, CO_2 assimilation by the bacterial community is 2-3 times higher near the water surface than at depth and is higher in the shallow parts of the bays. In this respect, the outer part of the Babya Guba Bay is notable as it approaches the lower level (2.53 mkg C/l/day) of mesotrophic ecosystems. The low biosynthetic activity of bacterial plankton results in its small productive capacity which varies from 2.8 to 42.1 μg C/(l/day) and follows structural distribution. However, bacterial production under 1 m^3 is comparable to phytoplankton production.

The comparative analysis of the structural characteristics of the bacteria communities made in the early 1970s (Filimonova 1986) and 1990s revealed no significant changes in the saprophytic component. Total count changes are due to annual fluctuations and depend primarily on hydrometheorological condition because those years (1971-1972 and 1991-1992) greatly differed in temperature, water regime and solar radiation. A slight tendency for increased bacterial content is apparent in the northen bays such as Babya Guba and Kamalahti, were human activities may have an effect on the microbiological processes (Table 3). The bacterial communities of Lake Kiitehenjärvi are thus formed under natural nutrient cycle conditions. The effects of the allochotonous organic matter are observed in the upper part of the bays. The northern part of the lake is of oligotrophic type and the bay of mesotrophic type.

Table 3. Mean total counts of bacteria and saprophytic microflora in Lake Kiitehenjärvi

Years	1971-1972	1991-1992
Total counts of bacteria, x 10^6/ml	0.25	0.60
Saprophytic bacteria colonies/ml	51	65

Lake Haukijärvi is situated near Lake Kiitehenjärvi. It is is small and shallow (average depth 3.5), morphometrically simple and has a weak water exchange and a high water colour index. Background observation began in 1993 and continued twice a month during the growth season (June-September).

The study period differed from other years in relatively low air temperatures, abundant precipitation and small amount of solar radiation affecting the water surface. Maximum photosynthesis ranged from 11.3 to 164.3, the average value being 60 μg C/l/day for the whole period. The average seasonal value for the entire water column was 26-60 μg C/(l/day) (Table 4).

Table 4. Photosynthetic rate in Lake Haukijärvi (1993).

Date of sampling	Trans-parency, m	Photosynthetic rate, min-max mg C/l/day	Average photosynthetic rate, min-max mg C/l/day
10.06	1.1	4.3-66.3	15.4-29.3
17.06	1.1	5.5-164.3	29.8-64.5
7.07	1.0	3.8-56.1	14.8-22.4
20.07	1.4	3.2-37.1	11.6-14.3
10.08	1.1	10.2-58.8	5.8-29.4
1.09	1.1	10.5-26.1	2.5-16.8
16.09	1.0	3.1-11.3	3.6-5.3

Water transparency being 1-1.4 m, photosynthesis proceeded almost down to the bottom. The maximum photosynthesis was restricted at a depth of 1.0-2.0 m. The maximum-minimum photosynthesis range was 2.5-29.8 in the study period but gradually decreased in the autumn.

Daily production/ 1 m² varied from 12.0 to 106.0 mg C and averaged 48.1 mg C/ (m²/day) for the season. The total amount of carbon synthesized/ 1 m² during the season (180 days) was about 8 g (Table 5). Two peaks in seasonal dynamics; a spring-summer peak (mid-June) and a latter summer peak (mid-August), alternating with a pronounced summer (mid-July) depression in production processes were observed. The spring-summer period accounted for 50% of the seasonal primary production. Productive processes (photosynthesis) are fairly low in Lake Haukijärvi. However, it is humified and therefore processes of bacterial CO_2-fixation may be important for production of organic substances.

Table 5. Primary production in Lake Haukijärvi (mg C/m²/day)

Date of observation							For the season (180 days)
10.06	17.06	7.07	20.07	10.08	1.09	16.09	
49.1	105.9	41.5	24.3	61.3	42.9	12.0	8100

The data obtained for Lake Kiitehenjärvi and Haukijärvi reveal the primary links of the food chain. These links in aquatic ecosystems are the most vulnerable for acidification. The early investigations of water bodies in South Karelia demonstrated that acidification first influence the processes of light and dark CO_2-fixation and thus that of biosynthesis of phyto- and bacterioplankton (Timakova & Tekanova 1995; Shirenko 1995).

The ratio of different forms of carbon dioxide compounds changes in acid environment, and at pH 5,5 it completely lacks hydrocarbonic ions. There are different opinions about the way of utilizing different forms of carbon by phytoplankton during photosynthesis (Steeman-Nielsen 1963, Watt & Paasche 1963, Paasche 1964; Williams & Turpin 1967; Liehr et al. 1988). Some of the investigators consider that hydrocarbon ions play a very important role in photosynthesis. The lack of hydrocarbons due to acidification influences CO_2-assimilation by phytoplankton and decreases biomass production. Decreased photosynthetic processes may be due to the shortage of CO_2 in water (Stokes 1986), but this is not always supported by data from some aquatic environments.

Oligohumous ecosystems (e.g. Lake Kiitehenjärvi) are more sensitive to acidification. Decreased total productivity of such ecosystems under acidification will be evident much earlier. In humified lakes (water colour 130) large amounts of humous organic substances contribute to the development of heterotrophic (bacterial) links. Converting poorly assimilated dissolved organic substances of humus into their biomass, micro-organisms make them available for the next trophic links, thus including them in biotic cycle. That is the reason of exhaustion of trophic conditions being less evident in humified lakes compared to oligohumous ones. Very often they have similar pH-values, but higher productivity of bacterio- and zooplankton.

These processes can develop very quickly in the lakes of the Kostomuksha Nature Reserve in the close proximity to the ore-dressing mill. The effect of acidification can be more evident in isolated, shallow bays with their poor water exchange conditions.

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Birds of Kostomuksha

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Abstract

The history of ornithological investigations of Kostomuksha region is described and a table of birds on the basis of observations in 1972-75 and 1987-95 is given. For each species its status, distribution and nesting density (pairs/km^2) is shown. 171 species of birds were observed in total, 124 of them nesting: 137(104) in the Kostomuksha Nature Reserve; 158(115) in the Green Zone around the town and 78(35) in Kostomuksha town. The bird communities of the reserve are typical of central parts of the watershed between the White Sea and Baltic Sea.

Key words: Bird species, bird communities, species distribution, density, Kostomuksha region

Introduction

The Kostomuksha Nature Reserve is located in the centre of the White Sea-Baltic Sea watershed and is considered as a reference area of primaeval northern taiga landscapes. The effect of human activities on its ecosystems has been insignificant in the past. Within the radius of 30 km around the old village of Kostomuksha there were no more than ten small settlements. The main means of livelihood of the local population were agriculture, fishing, hunting, selective forest cutting and small-scale iron processing. Such forms of wildlife management transformed the landscapes insignificantly. Moreover, their effect extended over a distance of no more than 10-12 km from the settlements.

The ecological situation has dramatically changed since the construction of the ore-dressing mill and the city of Kostomuksha. Technogenic and damaged lands such as the industrial zone, quarry, waste dumps, communication networks, power transmission lines, highways, railways, heat power plant lines etc. cover large areas. The mill gave rise to a city with a population of 35,000 with country houses and holiday resorts around it. In this connection a recreation impact on the taiga ecosystems became stronger. Also intensive commercial use of forest areas began. Clearcuttings are conducted in the north-western, northern and south-eastern parts of the region. At the same time, due to the establishment of the reserve and the green belt around the city as well as the absence of fellings along the forest border zone, primaeval taiga has been preserved over a vast territory. Practically continuous stands begin north of the state border at Kiitehenjärvi-Niemijärvi and extend eastwards as far as Kostomuksha, Lake Vongozero, the River Luva, Lake Luvajärvi and Lake Maksimjärvi. In the south, it ends again at the state border in the upper reaches of the Iso-Palonen lake-river system.

In the early 1970s the Kostomuksha area was poorly studied from the ornithological point of view, publications by the Finnish authors (Lehtonen 1943; Lampio 1945) being the only source of information on bird fauna. The tables of the birds of the region, made up by the above mentioned authors is based on the observations made in the neighbourhood of the settlements Vuokkiniemi, Vuonninen, Lomozero, Luusalmi, Ohtanjärvi, Kananainen, Sofporog and Kiestinki which lie north of the study area. The data obtained in a short excursion done on June 11-19, 1944 near Kontokki and the Kamalahti bay of Lake Kiitehenjärvi (Lampio 1945) are an exception.

The first thorough zoological research in the Kostomuksha region was conducted in 1972-1975 in connection with the development of the Kostomuksha iron ore deposit (Danilov et al. 1972). Most of bird fauna studies were done in 1975 within the period March 23th - April 15th and May 16th July 25th in the Luvajärvi zone. That season was extraordinary, with warm and early spring and a hot summer with lots of southern bird species. The results of the research provided a basis for a complete table (table 2) of birds of the region (182 species, 117 of them nesting) published with regard for the data available in the literature (Danilov et al. 1977) and archives.

After the reserve was established, the study of regional bird fauna became more active. Since 1987 ornithofaunistical research in the reserve and neighbouring territories has been conducted by the expeditions of the Chair of Biogeography, Moscow State University (E. A. Danilenko 1987-1990), and the Laboratory for Protection of Forest Ecosystems of the Forest Research Institute, Karelian Research Centre, Russian Acad.Sci. (Sazonov S.V. 1987-1994), as well as the All-Russia Research Institute of Nature (L. V. Kuleshova 1988-1989, 1992). The observations carried out by the researchers of the Kostomuksha Nature Reserve, publications and manuscripts and the results of the above mentioned expeditions, were presented in the Nature Annals and a table of the birds of the region was compiled (table 2). The table of 1988 included 189 species, 118 of them in the reserve territory (Adrianova et al. 1990).

In addition, in 1988-1990, a cycle of quantitative censuses of bird populations in the Friendship Park nature reserve (Finnish side) was performed. The results of the censuses were published by Rajasärkkä & Virolainen (1990). Besides the 5 districts of Friendship Park (165 km), the counts were done in 1984-1990 in 15 other routes in Kuhmo (a total of 260 km of transects).

Since the publication of the last table of the birds of the reserve and adjoining territories many new species have been discovered and the character of the distribution of others has been studied in more details. Moreover, the necessity appears to outline more exactly the territory, on which the data on bird fauna are to be extrapolated. The main criteria for outlining the territory of the research were the landscape and its natural properties. An integral local territory, limited by the sources of the river Livo, the lake-river system Koivas-Kento, lakes Vongozero and Luvajärvi, the Maksimjärvi and Iso-Palonen lake basins, was chosen. The fact that the soil quality is higher and the nature is richer in the vicinity of lakes Kiitehenjärvi, Kontokki and Kostamus compared to the northern territories (Lomozero, Luusalmi, Vuokkiniemi, Vuonninen) was taken into consideration: Bird fauna of the above areas has pronounced southern features (Lampio 1945) compared with other study areas.

A revised table of birds of the Kostomuksha nature reserve and adjacent territories is compiled with regard for the above considerations about the size of the territory to which it is applied. N.V. Lapshin and V. G. Annenkov of the Laboratory of Zoology, Institute of Biology, Karelian Research Centre, participated in the bird fauna studies of 1973-1975. Information on the bird fauna of the territory was given by S. A. Pozdnyakov, B. N. Kashevarov, D. P. Zakharov and V. O. Nikitin. We express our gratitude to all of them.

Materials and methods

The study area, according to Volkov et al. (1995) was divided into two main types of landscape and 4 types of terrain. The accounting of the summer density of birds was done on 514 km of transects in 3 main types of terrain. The standard methods of accounting was used (Shchegolev 1977) with modifications (Sazonov 1989). The registration of birds was executed on marked landscape profiles and constant transects by mapping nests and individual territories inside some strips (25+25, 50+50, 100+100 and >100+>100 m) The density was defined according to number of birds in main stripes. The accuracy of accounting was controlled additionally on 50 ha plot by methods of Naumov (1963) and Berthold (1976).

Species review

For convenience of the exposition the majority of the references to the above mentioned publications and interrogation data are omitted. The species that have been reliably proved to nest in the territory are numbered, others are given without numbers. The species included into the Red Data Books of Russia, Karelia, the Murmansk region and Finland are marked with figures 1, 2 ,3 and 4.

1. Red-throated diver[4] - *Gavia stellata* (Pontopp.). A very rare probably nesting species of the region. In 1950 it was found to be a very common nesting species at the western extremity of Lake Nyuk (Gibet 1953). A sharp decline in its number took place everywhere in Karelia, the Kola Peninsula and Finland in the last 15-30 years. In August 1989 a single bird was recorded on Lake Särkijärvi. On June 13th 1993 a couple was registered on Lake Kiitehenjärvi in the Mokrovaara area (both encounters were in the reserve territory); on June 2nd 1994 a couple was observed on Lake Okatijärvi in the direct vicinity of the reserve.
2. Black-throated diver[4] - *G.arctica* (L.). A common nesting species. 8 couples were registered in the vicinity of Lake Luvajärvi in the area of 25 km² in 1975. In the reserve they concentrate on Lake Kiitehenjärvi (6-8 couples in the northern part of the lake). In 1990-1993, 1 to 4 couples were encountered round Lake Kiitehenjärvi over an area of 500 ha. It nests in the Kostomuksha green belt. In 1987-1989 hatches were recorded on Lake Suojärvi (the upper reaches of the Koivas-Kento system) and on Lake Luvajärvi.
3. Red-necked grebe - *Podiceps griseigena* (Bodd.). A very rare nesting species. Recorded on July 29th 1975 on Lake Luvajärvi. Presumably registered on July 5th 1990 on Lake Kiitehenjärvi. An adult and juveniles were encountered, according to interrogation data, in the creek of the River Kivijoki in the reserve in summer 1990.

Grey heron - *Ardea cinerea* L. Considered a visitor of the reserve, according to Adrianova et al. (1990).

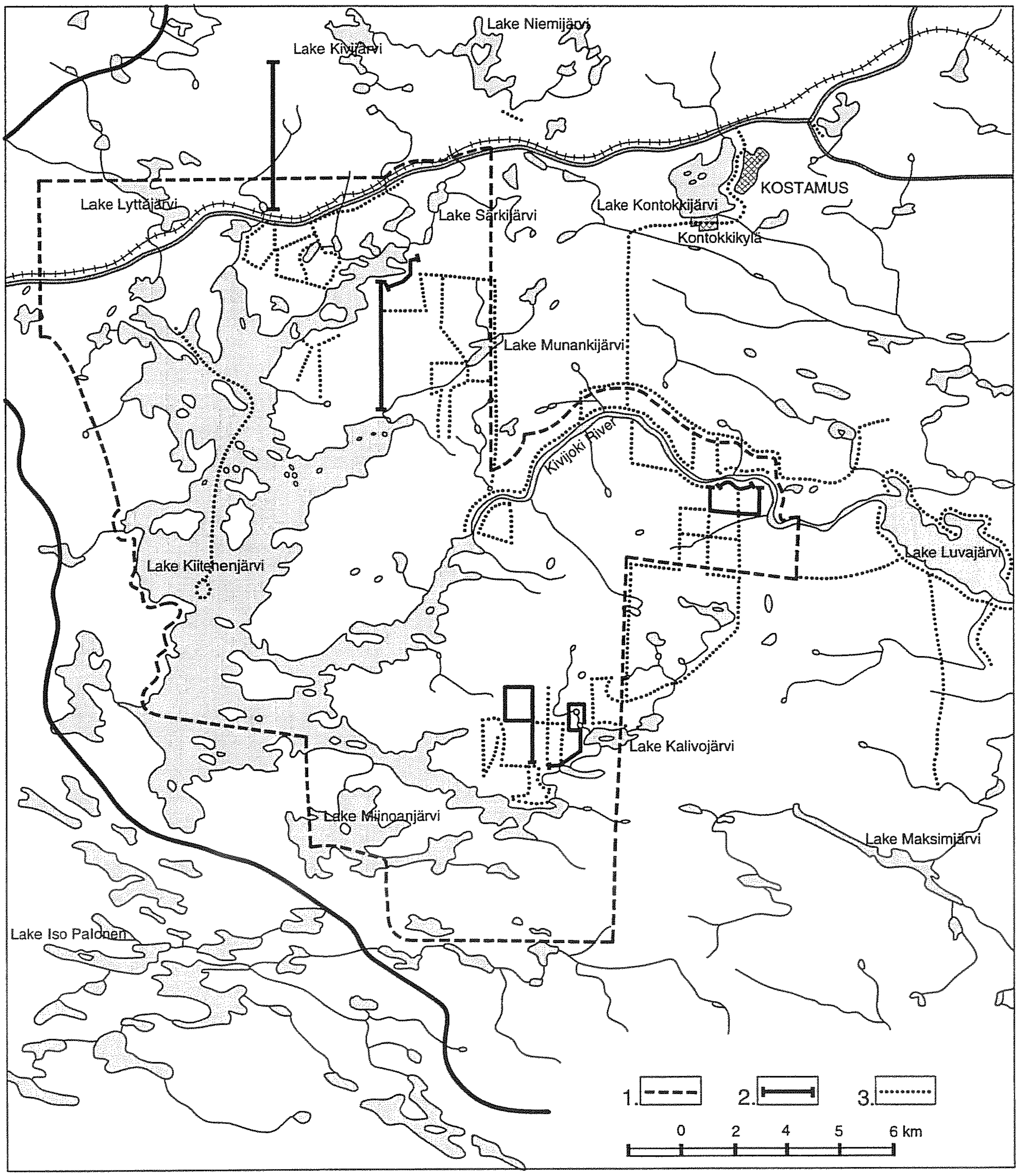

Fig. 1. The map of observation localities. 1 - boundaries of the Kostomuksha Nature Reserve, 2 - the landscape profiles and constant transects; 3 – the special zoological transects.

4. Whooper swan[2,3] - *Cygnus cygnus* (L.). A common nesting and hibernating species of the territory. There are about 10 permanent nesting grounds of the swans in the reserve: Lake Kiitehenjärvi 5 couples, Lake Miinoanjärvi 2, lakes Munankijärvi, Kalivo and Koidojarvi 1 couple on each. In addition to the nesting couples, the migrating ones stay in the reserve; the total number of swans is subject to strong variation. In localities around Kalivo it fluctuates in different years from 1 to 5 couples.

In 1975 in the vicinity of Luvajärvi in the area of 30 km^2 6 swan couples (2.0 couples per 1000 ha) were registered, two of them nesting. A couple began nesting in 1974 at the Kontokki stream 8 km south of the village of Kontokki. At present, all these nest-grounds are abandoned. A swan couple is known to have nested on a mire north of Vongozero within the city green belt (1986-1988, 1990), and another couple probably nested in the lower River Kivijoki(1991). Hibernating Whooper swan individuals and couples were recorded in the seasons of 1972-1973 and 1974-1975 (upper River Livo, the vicinity of Lake Luvajärvi), as well as in 1991-1992 (2 couples on Lake Miinoanjärvi).

Bewicks swan[1,2,4] - *C.bewickii* Yarr. A very rare passing species. On May 29 1994 a flock of 8 individuals was observed on passage in the reserve above the northern coast of Lake Kalivo.

Greylag goose[2,3] - *Anser anser* L. Recorded as a rare nesting species of the Lake Nuokkijärvi area in 1950-1952 (Gibet, 1953). It is included in table 2, probably as a passing species of the reserve, but the fact is hardly reliable. In the last 15-20 years the species was never encountered in the north taiga subzone of Karelia. It should probably be considered an extinct species in the region.

White-fronted goose - *Anser albifrons* (Scop.). A rare passing species. In the second half of May, 1975 several flocks were recorded on passage in the vicinity of Lake Luvajärvi. On May 25th 1994 two individuals were observed in the water area on the west shore of Lake Kalivo. It obviously migrates together with bean goose *A.fabalis* via the reserve in late September - early October. Some flocks of white-fronted geese can be encountered among bean geese at grazing grounds for instance in the Kalivo area.

5. Bean goose - *A.fabalis* A common nesting and passing species of the study area. High nesting density was recorded in 1988 (2 nests and 2 broods were found). According to the observations in the neighbourhood of Kalivo, the number of nesting couples changed from 1 to 3 making up an average of 1.4 couples per 1000 ha. On Lake Luvajärvi the nesting density in 1975 was estimated at 3 couples per 25 km^2 (1.2 couples per 1000 ha). Since mid-June, when hatching and moult started, a very secretive behaviour is characteristic of the geese. Small groups of moulting birds are scattered about the reserve. A high concentration of moulting geese is annually reported from the Lake Maksimjärvi area. In the 1950-1960s, bean goose were hunted. In the first days of August moulting geese were chased with dogs along streams to open mires and forest lakes so that poorly flying adults and juveniles were shot there.

Since the middle of August the migrations of unseparated goose broods and groups of 5-7 to 10 individuals are observed. In autumn, the stay of some passing flocks of bean geese near Kalivo are registered.

Brent goose[2,3] - *Branta bernicla* (L.). A very rare migrant species. A flock of about 100 individuals was seen to pass by Kamalahti on June 14th in 1992 and two more passing flocks were observed on the next day. Brent goose is considered as a rare species of the reserve according to table 2. Several stops of migrating Brent goose flocks are known at the east shore of Lake Nuokkijärvi in mid-October in 1988.

Barnacle goose[1,2,3] - *B. leucopsis* (Bechst.).
A very rare passing species. Three flocks were seen to be flying North-east (one flock consisted of 9 birds) on May 30th in 1994 at some localities north of Lake Kalivo.
6. Mallard - *Anas platyrhynchos* L. A common nesting species. Concentrates for nesting in water and mire areas rich in food, like the lake-river systems Munankijärvi and Kalivo, the lower River Kivijoki and Lake Luvajärvi. At some localities around Kalivo its density varies from 3 to 5, making an average of 2.7 couples per 1000 ha. In the vicinity of Lake Luvajärvi 4 mallard hatches (1.6 couples per 1000 ha) were found in 1975. Cases of hibernating individuals were registered in the seasons of 1972-1973 and 1973-1974.
7. Teal - *A.crecca* L. A common nesting species. The distribution is analogous to the previous species. In the Kalivo area there are 1-5 couples (average 2.3 couples per 1000 ha). The population density on Lake Luvajärvi was 1.2 couples per 1000 ha in 1975.
Gadwall - *A.strepera* L. A visit to the reserve was recorded in 1987 (Adrianova et al. 1990), but the fact should be supported by additional observations.
8. Wigeon - *A.penelope* L. A common nesting species. Its distribution is similar to that of other river ducks. In the Kalivo area there are annually 1-3 nesting couples. A high nesting density was recorded in 1975 on Lake Luvajärvi: 5 broods or 2.0 couples per 1000 ha.
Pintail - *A.acuta* L. is considered a rare passing species for the reserve and adjoining areas (table 2). The nesting grounds in North Karelia are situated in the most productive areas - shallow lakes and aapa mires. Such wetlands are scarce in the vicinity of Kostomuksha. Reproduction is not ruled out, but is to be supported by reliable facts.
Garganey - *A.querquedula* L. Visits were registered in 1950-1952 at the western extremity of Lake Nuokkijärvi (Gibet 1953) as well as in 1987 in the reserve (table 2).
Shoveler - *A.clypeata* L. A visitor, on May 11th in 1943 a male was registered on Lake Lomozero, Koivas-Kento system (Lampio 1945). On May 30th in 1993 an individual at a pool near Lake Kalivo in the reserve.
9. Tufted duck - *Aythya fuligula* (L.). A very rare passing and nesting species of the region. The only encounter of a hatch was reported from the reserve on July 19th in 1987.
Scaup[4] - *A.marila* (L.). A rare passing species. Flocks migrating as transit were observed in late May-early June 1975 on Lake Luvajärvi. Some specimens probably stop on passage. For instance, a couple was registered on May 16th in 1943 on Lake Lomozero (Lampio 1945).
Velvet scoter[4] - *Melanitta fusca* (L.). A rare passing species. Like other sea ducks, flies chiefly as transit in late May-early June (Lake Luvajärvi, 1975). In autumn, the stay of some individuals is recorded, for example, on October 11th in 1975 at the western part of Lake Kiimasjärvi.
Common scoter[4] - *M.nigra* (L.). A very rare passing species. A stay of a common scoter flock of 23 specimens was recorded on June 11th-12th 1944 on Lake Kontokki (Lampio, 1945). Several common scoter males stopped on passage in late May-early June in 1975 on Lake Luvajärvi.
Long-tailed duck - *Clangula hyemalis* (L.). The most common migratory sea duck species of the region. In the autumn of 1975 in the western part of the Lake Kiimasjärvi was encountered since October 11th (small flocks up to 10 individuals). The peak in their passage is in the middle of the month (stops of flocks up to several hundreds of specimens). Within the same period the species is to be encountered in the reserve (Lake Kiitehenjärvi).

10. Goldeneye - *Bucephala clangula* (L.). A common, most numerous duck species evenly distributed over the territory. Hatches are encountered at all types of water bodies, including the smallest lakes among mires. In the Kalivo area 3-6 couples nest annually, the average density is 2.7 couples per 1000 ha. The species nests in the immediate vicinity of the city. In the first post-war decades a goldeneye hunt existed among the local population. The nest boxes preserved since then were found in 1975 on the River Luva. In the season of 1972-1973 a wintering goldeneye individual was registered.
11. Smew[4] - *Mergus albellus* (L.). A very rare passing species. It was found in the territory of the reserve and in the city green belt. It was met twice in the Kalivo lake-river system; on June 5th in 1991 two juveniles, on May 28th and 30th 1993 a male at small lakes and streams north of the lake. A smew female was registered on June 7th in 1991 at a small forest lake among white-moss coniferous forest not far from the northern boundary of the reserve. In some years probably nests in the reserve. The closest sites of permanent nesting are in the Paanajärvi basin and on the White Sea coast north of Pongoma.
12. Red-breasted merganser -*M.serrator* L. A rare passing and nesting species of the region. The only hatch was encountered on Lake Luvajärvi on July 28th in 1975. It is nesting near Lake Kiitehenjärvi, where an individual was encountered on July 5th in 1990.
13. Goosander - *M.merganser* L. A common nesting species. The highest density is characteristic of the upper River Kivijoki, where three hatches were encountered over a distance of 14 km in July 1987. The average density is 1.1 couples per 1000 ha.
Honey buzzard - *Pernis apivorus* (L.). A very rare possibly nesting species. Habitats coincide with forest landscapes transformed by man (forests in burnt areas, agricultural lands, cuttings, etc.). In 1975 it was registered on Lake Luvajärvi, on August 5th in 1992 was encountered at Vuokkiniemi. Far more common in the Finnish part of Friendship Park. In the summer censuses by Rajäsärkkä and Virolainen (1990) a single bird was registered in Ulvinsalo (40 km south of the reserve) and one more in Iso-Palonen (adjoins the southern boundary of the Kostomuksha Reserve). Two other encounters of honey buzzard are known from Lososuo and Murhijärvi, located 10 km north and north-west of the Kostomuksha Reserve. In some years the species possibly nests in the southernmost parts of the study area, for example in the upper Iso-Palonen lake-river system.
14. Golden eagle[1,2,3,4] - *Aquila chrysaëtos* (L.). A very rare nesting species of the region. A nesting site of a golden eagle couple adjoins directly the south-eastern boundary of the reserve. Most often occurs between Lakes Luvajärvi and Okatijärvi, less often at Kalivo (1987-1990). In early July 1990 a single bird (of the same couple) was met at the southern boundary of the reserve in the upper reaches of the Iso-Palonen system.
Hen harrier - *Circus cyaneus* (L.). A very rare, probably nesting species. The only encounter of a male was recorded on June 15th in 1992 on the side of the highway and railway among the northern compartments of the reserve. Reported earlier from the reserve (table 2). Rare in the adjoining Finnish territory as well. In the period of counts (1984-1990) was met only once.
15. White-tailed eagle[1,2,3,4] - *Haliaeectus albicilla* (L.). A very rare nesting species. According to the interrogations, a white-tailed eagle couple is supposed to nest in the central part of Lake Kiitehenjärvi and at some localities south and south-east of Lake Miinoanjärvi (probably the couple nesting near the reserve). It was registered twice in the western part of Lake Luvajärvi (June 6th 1975 and May 25th 1991).
Black kite - *Milvus korschun* (Gm.). A very rare species. In 1943-1944 it was quite common in the Upper Kuito area (Lehtonen 1948). In 1975, two permanent habitats of black kite were known in the Luvajärvi area: at the western extremity and in the middle of the south lake shore. According to table 2, the species was registe-

red in the reserve as well (1987-1988). In the summer of 1988 and 1989 black kite was met twice in the city green belt near Lake Luvajärvi and in the outskirts of Kostomuksha. Available evidence is too insufficient for any conclusions about the possible reproduction of the species in the study area.

16. Buzzard - *Buteo buteo* (L.). A comparatively rare nesting species. In the summer 1975 five couples nested in the forest area of 20-25 km^2 near Lake Luvajärvi, the density was 2.0-2.5 couples per 1000 ha, which is a maximum index for the region. In the plain primaeval taiga their number is markedly lower, in the Kalivo area 1-2 couples nested in 14 km^2 (nesting was not annual), the average density was 0.36 couples per 1000 ha. Buzzard is also rare in the adjoining Finnish territory (0.3 - 3.0 couples per 1000 ha in different plots).

17. Rough-legged buzzard - *B.lagopus* (Pontopp.). A rare passing and nesting species. Nesting was registered at 3 localities : the eastern extremity of the Kamalahti Bay (1988-1990), the white-moss coniferous forests in the middle of the River Kivijoki (1989) and the Kalivo area (1990-1991). The average density was 0.3 couples per 1000 ha at Kalivo.

18. Goshawk - *Accipiter gentilis* (L.). A rare nesting species. In the Luvajärvi area 2 couples nested in 1975, density being about 1 couple per 1000 ha. In 1987-1993, two couples were registered in the Kostomuksha green belt. In the reserve it is met less often, only 2-3 permanent habitats were discovered: near Lake Munankijärvi, in the Ehrimenvaara area and in the white-moss coniferous forests along the River Kivijoki. In some years it probably hibernates. One individual was encountered on March 9th in 1973 in the village of Kontokki.

19. Sparrow hawk - *A.nisus* (L.). A common nesting species. At some localities around Kalivo 1-3 couples nest annually, the average density being 1 couple per 1000 ha. The maximum occurrence of the species here was recorded in 1990 (3 couples, the density of 2 couples per 1000 ha), in the year of high spruce seed yield and abundance of nesting granivorous passerine birds (Passeriformes). It is regularly registered in the city green belt, including the direct vicinity of the city.

20. Osprey[1,2,3,4] - *Pandion haliaëtus* (L.). A rare nesting species. In 1975, 3 couples nested in the neighbourhood of Lake Luvajärvi in the area of 30-40 km^2 (as far as the Luva river source), the density was 0.7-1.0 couples per 1000 ha. In the 1990s, osprey was not registered there. In the reserve area 4 couples were found, 3 of which were met on Lake Kiitehenjärvi. Another couple lives in the Kalivo area. In 1993-1994 an occupied nest was revealed in a pine tree near the mire edge 2 km from the boundary of the reserve.

21. Kestrel[2,3,4] - *Falco tinnunculus* (L.). At present a very rare migratory species. Its distribution is connected with agricultural landscape. In June 1944, it was common in the Kostomuksha area. Two nests were discovered on the Kontokki lake shore. (Lampio 1945). Further north at Lomozero, Vuokkiniemi and Vuonninen nests were scarce (Lehtonen 1943; Lampio 1945). In the last 20 years flying individuals were seen only twice: in August 1992 in the fields at Vuokkiniemi and on May 31st in 1994 near Lake Kalivo. It occurs more often in the adjacent Finnish territory. In June a single bird was met in Juortanansalo (1990), another bird in Lososuo (1989) and one near Kuhmo (1984-1990).

22. Merlin[2,3,4] - *F.columbarius* (L.). A rare nesting species. In 1975 on an island in Lake Luvajärvi a nest was found. On July 14th there were three ca.2-week-old hatchlings. In the reserve they are met near lakes and mire areas (Mustakivilampi, Jokijärvi, Kalivo), in white-moss pine forests on the southern bank of the River Kivijoki (burnt area).

23. Hobby[3,4] - *F.subbuteo* (L.). A very rare nesting species. In 1975 2 hobby couples nested near Lake Luvajärvi in the area of 40 km^2. In the period of 3-8 of August in 1989 a couple was constantly seen near the village of Zarechny. In the autumn of

1992, an individual was encountered on Lake Särkijärvi. In 1994, a hobby couple occupied an old raven (*Corvus corax*) nest situated in the burnt area on the southern bank of the River Kivijoki.
24. Peregrine[1,2,3,4] - *F.peregrinus* Tunst. A very rare nesting species of the region. Since 1988 a local peregrine couple has been registered in the north-eastern quarter of the reserve and the adjacent quarters of the city green belt. A single peregrine was encountered in search flight on the west shore of Lake Kalivo on May 27th in 1990. The distance between these finds is 23 km. The latter probably applies to the couple found near the reserve with its nesting site in the Maksimjärvi lake area.
25. Willow grouse - *Lagopus lagopus* (L.). It is common outside breeding period. The number, according to the data of winter route count is 2.4 specimens per 1000 ha (Adrianova et al. 1990). In summer it is registered more rarely, chiefly because of the difficulty for detection in the periods of hatching clutches and conducting hatchlings (June-August). In all the time of summer censuses (more than 500 km of transects) no local couples were encountered. A hatch was observed only once (August 5th in 1990). In autumn months willow grouse is met near the city on the Kontokki lake shore.
26. Black grouse - *Lyrurus tetrix* (L.) Comparatively common in the reserve and adjacent territories. According to route count data, its abundance ratio is 0.3 birds per 1000 ha (Adrianova et al. 1990). A total of less than 25 males per 20 km were reported in 1991-1992. In 1987-1991 the population density increased considerably. By 1991 a permanent mating place with about 20 males had formed. This fact can be related to the appearance of dense deciduous undergrowth on the northern side of the highway (since 1983) and vast areas of new cuttings near the reserve, along the road to Niemijärvi (since 1985). The abundance of the species is observed to increase gradually near Kalivo from 7-10 males in 1990-1991 to 15-17 males in 1993. The density in the Kalivo area is 7.2 couples per 1000 ha.
27. Capercaillie - *Tetrao urogallus* L. Common in the study area. According to the results of censuses in the Kalivo area the medium nesting density is 11 couples per 1000 ha. According to WRC its number is 4.0 specimens per 1000 ha (Adrianova et al. 1990). In 1993, an appreciable reduction in population density was recorded, only 4 capercaillies were encountered in the 70 km long transects (May 25 - June 14). The summer counts of 1988 showed the number of capercaillie to be 28.8 birds per 1000 ha (Adrianova et al. 1990). The reduction in the species number can be preliminarily assessed as 3-4 - fold. In the out-of-nest period capercaillies appear now and then in the immediate vicinity of Kostomuksha, including the city boundaries.
28. Hazel grouse - *Tetrastes bonasia* (L.). A common species. The number in the reserve in the summer period was 32.2 individuals per 1000 ha. According to the data of winter route counts it was 8.7 ind. per 1000 ha (Adrianova et al. 1990). The medium nesting density in the Kalivo area was 17 couples per 1000 ha. In 1990, a case of reproduction in an isolated forest area at the northern city outskirts was registered: a nest with a clutch was found at a distance of less than 1 km from the city.
29. Crane[2,3] - *Grus grus* (L.). A rare species in the study area. Nesting is probable. In the mires of the reserve 7 crane couples were registered. Crane is encountered in the city green belt, primarily near lakes Luvajärvi and Suojärvi.
30. Golden plover - *Pluvalis apricaria* (L.). A rare migrating and possibly nesting species. In some years it has been quite common. For instance, in 1975 golden plovers stayed in the meadows on the Luvajärvi lake shore all summer long: in May flocks of 7- 15 individuals were seen and in June-July, individual couples and single birds were reported. This year they nested on the nearest mires. In the reserve it has not been found by now, probably because of the lack of suitable stations (rich transitional mires, aapa - mire areas). In the adjacent Finnish territory it was common in the June counts of 1989-1990 and was met in 7 of the 20 plots studied.

Nesting golden plovers were observed close to the Kostomuksha Reserve: Elimyssalo (13 km South-west, 6 couples), Lososuo and Murhijärvi (10 km north-west, 2-3 couples in each territory). This fact should be obviously related to the abundance of mires.
31. Little ringed plover - *Charadrius dubius* Scop. A very rare migrating and nesting species. In late May 1975, it was encountered on Lake Luvajärvi, and on July 9th in 1987 an adult leading aside its hatch was observed at the bank of the tailingspile of the ore-dressing mill. According to table 2, it was registered as a nesting species in the reserve as well.
32. Lapwing - *Vanellus vanellus* (L.). A rare migrating and nesting species. In 1975, 3 lapwing couples nested on Lake Luvajärvi in coastal meadows (2) and on a lakeside mire (1). Nesting was also recorded near Lake Kiimasjärvi and in the neighbourhood of the Lietmajärvi railway station. In the summer 1988 a single lapwing was repeatedly registered on the mire along the Särkijärvi lake shore within the reserve, but the nesting of the species was not proved. It is far more common in Finland, where it typically nests on mires. It was found in 1989-1990 in 7 of 20 studied plots, including the ones situated in the vicinity of the Kostomuksha Reserve: Iso-Palonen and Lososuo (1 nesting couple in each territory).
33. Green sandpiper - *Tringa ochropus* L. A common nesting species. Inhabits various stream-side forests and beaver dams. According to 1990-1992 censuses, its nesting density was 0.3-0.9 couples/km^2, the average being 0.65 couples/km^2. In 1993 6 couples nested in the Kalivo area as compared to 2-4 couples in the previous years. In the Lutta district its density is 2.6 couples/km^2. It is common in the city green belt, including the immediate neighbourhood of Kostomuksha. Some cases of nesting were recorded in the outskirts of the city (the stream source from Lake Kontokki).
34. Wood sandpiper - *T.glareola* L. A common nesting species. It nests in mires often near water bodies. The density in the different parts of the reserve is 0.5 -1.0 couples/km^2. The average is 0.8 couples/km^2. Now and then it nests in the outskirts of Kostomuksha, in the sparse waterlogged forest along the riverbed.
35. Greenshank - *T.nebularia* L. A common nesting species. Encountered in mires with small lakes, along the waterlogged banks of lake-river systems. The density in some areas of the reserve is 0.0-1.5 couples/km^2 (average 0.67 couples/km^2).
Redshank - *T.totanus* L. A single visit was reported in 1975 from Lake Luvajärvi, an individual and two specimens were encountered on May in the riverside meadows.
36. Spotted redshank - *T.erythropus* (Pall.). A rare migrating and probably nesting species. Like the majority of other tundra Charadriiformes, it inhabits primarily grassy aapa mires with small lakes in hollows. Because of the absence of such stations at the localities studied, nesting spotted redshank has not been found yet. The only encounter of a migrating individual was registered on June 12th in 1975 at the coastal meadow of Lake Luvajärvi. According to table 2, it was also registered in the reserve. It was encountered during the June censuses in the adjacent territory of Finland: Lososuo (10 km north-west) and Tulisuo (20 km west of the reserve), where in 1989-1990 about 6 nesting spotted redshank couples were seen
37. Common sandpiper - *Actitis hypoleucos* (L.). A common nesting species of the region. High numbers were noted in 1975 and in 1987. In 1987 nesting in a new sandy cutting with pine cultures near a small stream was observed. In the reserve the highest density of sandpiper is reported from the Kivijoki river valley. In 1987 12 common sandpiper couples nested in a 14 km long river section (local density - 4.3 couples/km^2). Its number in the plain taiga is markedly lower and variable. For instance, in the Kalivo lake-river system it varied from 1 to 7 couples. The average density in 1990-1993 was 0.4 couples/km^2.

Terek sandpiper[4] - *Xenus cinereus* (Güld.). The first visit of an individual was registered on July 4th in 1975 near Lake Luvajärvi. In the reserve, a terek sandpiper was encountered on July 5th in 1990 on an islet in Babya Guba, Lake Kiitehenjärvi.
38. Ruff - *Philomachus pugnax* (L.). A rare migrating and probably nesting species of the region. In 1975 it was common in the meadows and overgrowing arable land near Lake Luvajärvi at a time of spring migration (16-28 May) and in the period of summer travels (since July 26). A ruff couple was constantly noticed since May 29th in the lakeside meadow, where they probably nested. In the reserve ruff can be found in mires lying south-west of Munankijärvi or in agricultural lands near large lakes (Babya Guba area). It is quite common in the June counts of 1989-1990 in Finland. Ruff was recorded in 4 of the 20 plots studied, including Lososuo, where about 7 ruff couples nested.
Little stint - *Calidris minutus* (Leisl.). A very rare passing species. Several encounters of individuals are known in the Luvajärvi lake area in late May 1975.
Temminck's stint[4] - *C.temminckii* (Leisl.). Very rare. Registered during spring migration together with the previous species near Lake Luvajärvi in 1975.
Dunlin[4] - *C.alpina* (L.). A rare species, encountered in the season of summer migrations. In the period from 23rd to 27th of July in 1975 several specimens were observed in the riverside meadows at Luvajärvi. Migrating species may be encountered at similar stations in the reserve.
Jack snipe[4] - *Lymnocryptes minimus* (Brunn.). Included in the table of the birds of the region after being detected on Lososuo, 10 km North-west of Lake Lyttä. In June 1989, three Jack snipe couples were registered there. In addition, the species was encountered in 1989-1990 in other two areas 20 and 40 km west of the reserve (1 couple in each territory). In the future it is likely to be found in the reserve, at least in migration seasons.
39. Snipe - *Gallinago gallinago* (L.). A common species, nesting on mires and near water bodies (streams, river branches and smll lakes). Its density in the different parts of the reserve is 0.6-1.0 couples/km^2 (average 0.83 couples/km^2). A very late encounter of a snipe (or of the previous species) in the outskirts of Kostomuksha is of interest: an individual was recorded on December 7th in 1987 near the ore-dressing mill.
40. Woodcock - *Scolopax rusticola* L. A rare migrating and irregularly nesting species. In 1975 it was common in the vicinity of Lake Luvajärvi, where a nest with a clutch was found (another nest was discovered near the village of Kiimasjärvi). On the Luvajärvi lake shore 11 males in display flight were recorded on June 12th in 1975. In 1987-1993 no more than 5 encounters were registered. In summer 1991 some individuals were observed on June 9th at Kalivo and June 7th in 1993 on the Kamalahti Bay shore.
41. Curlew - *Numenius arquata* (L.). A rare migrating and nesting species of the region. In 1975 about 3 couples nested near the lake on meadows and nearby mires in the neighbourhood of the village of Luvajärvi. At the same locality from June 18, onwards summer migrants were recorded in flocks of 10-15 birds each. In 1990 individuals were encountered on passage in May in the overgrown meadows of the Lake Kontokki shore and on the mires near Lake Kalivo. On May in 1994, several birds migrating in transit were registered in the Kalivo area. In some years it is possible to find curlew nesting within the reserve, primarily in large mires near Munankijoki. In the adjoining Finnish territory the species is more common, in the June counts of 1989-1990 it was observed in 5 of the 20 studied districts, including Elimyssalo, Lososuo and Murhijärvi near the reserve.
42. Whimbrel - *N.phaeopus* (L.). A rare migrating and nesting species of the region. In the pre-nesting period of 1990 it was recorded on the Kontokki lake shore (May 21st 2 birds) and on the mires near Lake Kalivo (May 23rd 1 bird). In mid-June 1994 a single bird was encountered on the mire on the southern bank of the River Kivi-

joki. During summer migrations whimbrel was registered in the vicinity of Luvajärvi beginning from July 26th in 1975. Like the previous species, it may nest in the reserve in some years. In the adjacent Finnish territory in the June censuses of 1989-1990 it was discovered in 9 of the 20 plots studied, including the sites bordering the reserve such as Iso-Palonen, Juortanansalo, Lososuo and Murhijärvi .

Black-tailed godwit - *Limosa limosa* L. A very rare migrating species. In 1975 it was registered twice on Lake Luvajärvi: on May 17th a flock of 10 specimens, and on July 29th a single bird were recorded. In 1993 on June 14th a low-flying back-tailed godwit was seen above the large sedge fen 3.5 km from the northern boundary of the reserve

Bar-tailed godwit[4] - *L.lapponica* (L.). A very rare migrating species. In 1975 several individuals were recorded near Luvajärvi in the period of post-nesting migrations.

43. Common gull - *Larus canus* L. A common aestivating species, rarely nesting. In May 1975, migrating flocks of 20-30 specimens were recorded on Lake Luvajärvi. In June-July, vagrant individuals and groups of 5-6 birds were encountered, their nesting not being registered. 1987-1993 observations have shown that common gull is a scarce aestivating species. Several hatches, which began to fly, were registered in early August 1992 on Lake Kontokki. In 1990-1994, 3 nesting couples were recorded in the northern part of Lake Kiitehenjärvi and a couple in the extreme south-eastern bay of Lake Kiitehenjärvi. A single bird was seen in the mire area on the northern bank of the River Kivijoki.

44. Herring gull - *L.argentatus* Pontopp. A rare aestivating, presumably nesting species. Migrating birds are noticed in summer on Lake Luvajärvi and at the outskirts of Kostomuksha. A couple was registered on July 5th, in 1990 in the northern part of Lake Kiitehenjärvi.

45. Lesser black-backed gull[4] - *L.fuscus* L. A rare aestivating and nesting species. In the reserve, it is the most common gull (*Larus spp.*). The migrating birds are observed on Lakes Luvajärvi and Kontokki. In 1990-1992, 7 nesting couples were registered in the northern part of Lake Kiitehenjärvi (the birds of the local group often appear in the Kamalahti Bay), one in the eastern, one in the extreme south-eastern bay of Lake Kiitehenjärvi. Until 1987, a lesser black-backed gull couple nested on a rocky islet on Lake Särkijärvi and disappeared after the construction of a beaver dam and a rise in the lake water level. The total of 15 lesser black-backed gull couples are assumed to nest on Lake Kiitehenjärvi within the reserve.

46. Black-headed gull - *L.ridibundus* L. A common but not numerous aestivating and nesting species in the vicinity of Kostomuksha. It has not been found in the reserve. In May-June 1975 migrating black-headed gulls were constantly recorded on Lake Luvajärvi. In the summer of 1988, a small nest colony, abandoned because of human disturbance, was found in one of the islands of Lake Luvajärvi. In 1987-1993 the species was constantly met in the city and on the small lakes. Some nest colonies of the species were probably situated at the lakes lying south-east of Kostomuksha. In early August 1992, migrating hatches consisting of adults and juveniles were observed.

47. Common tern - *Sterna hirundo* L. A rarely nesting species of the region. In 1975, about 10 couples nested on Lake Luvajärvi. On July 5th in 1990 20 common tern couples nesting in 3 colonies on rocky shoals of the northern part of Lake Kiitehenjärvi were met; probably there are nesting grounds of the species on the islands situated to the south. The species is sometimes registered at the lakes of the reserve that lie east of Lake Kiitehenjärvi (Särkijärvi, Kalivo).

Arctic tern - *S.paradisaea* Pontopp. It may well be found in the study area as a rare migrating species (since mid-May). Nesting is known at some large lakes of Karelia such as Topozero and Paanajärvi.

48. Rock dove - *Columba livia* L. A common nesting and hibernating species in Kostomuksha. Outside the city it is encountered in large settlements (Vuokkiniemi, Lietmajärvi and Tiiksa). In July-August 1987-1990, in the Kostomuksha trading centre there were from 80 to 160 individuals (a total of 70 rock dove couples nest in the city).
49. Woodpigeon - *C.palumbus* L. A rare nesting species of the region. High density was recorded in 1975. In the western part of Luvajärvi, 5-6 woodpigeon couples nested in an area of 1000 ha. Only 3 encounters are known in the reserve; in white-moss pine forests growing along the River Kivijoki (June 30th in 1990, 1 bird), at the edge of the hayfield in the eastern part of Miinoanjärvi (June 16th in 1992, 2 specimens), on the Kiitehenjärvi lake shore near Tetriniemi (July 5th in 1990, 5 birds).
50. Cuckoo - *Cuculus canorus* L. A common nesting species evenly distributed over the territory of the region. A high nesting density was recorded in 1992 in the Kamalahti area (4.9 couples/km²) and in the vicinity of Kalivo (2.1 couples/km²). The average density in 3 sections of the reserve was 3.0 couples/km².
Eagle owl[2,3] - *Bubo bubo* (L.). In 1941-1942, it was registered at the northernmost localities of the region: on September 21st in 1941 a couple in the vicinity of Lake Kento, on July 16th in 1942 an individual at the River Malaya Kurzhma (Lehtonen 1943; Lampio 1945). According to interrogations, the owls resembling eagle owl were observed twice in 1990 and in 1992 at Luusalmi and Ponkalahti, but the possibility, that in both cases great grey owl (Strix nebulosa) was registered, cannot be ruled out. In the adjacent Finnish territory in June censuses 1984-1990 the species was not found.
Snowy owl[2,3,4] - *Nyctea scandiaca* (L.). A very rare migrating species. In early March 1987 an individual was staying in the outskirts of Kostomuksha near the settlement of Kontokki for several days (Adrianova et al. 1990).
51. Hawk owl - *Surnia ulula* (L.). In the years of mass of mouse rodents, hawk owl is common in the region. Earlier such invasions were registered in north Karelia near Vuokkiniemi 1941-1942 (Lehtonen, 1943) and the western part of the Paanajärvi lake basin (1941-1944) (Waaramäki 1945). In other years hawk owl has been rare. Its highest density in the reserve was registered in 1988, in the year of the abundance of forest lemming (*Myopus schisticolor*), when 1-2 couples nested in the Kalivo area and one at the Kamalahti Bay shore. In 1989-1994 it was encountered only once in the reserve, on May 29th in 1990 on Lake Kalivo. In the city green belt nesting hawk owl was recorded in 1975 near Luvajärvi. In addition, two birds were seen in early spring in the forests south of Lake Koivas (March 2nd in 1989). According to the results of the June censuses of 1988-1990 in the adjacent Finnish territory, in 1990 2 hawk owls were recorded.
52. Pygmy owl[4] - *Glaucidum passerinum* (L.). A rare nesting and irregularly hibernating species of the region. In December 1941 an individual was recorded in the vicinity of Kostamus (Lampio 1945). In the extreme north-eastern corner of the reserve a pygmy owl was registered on August 6th in 1989. It is also known in the adjacent Finnish territory. Pygmy owl was also found at the state border, including some localities near the reserve (June 1989-1990 Murhijärvi and Elimyssalo).
53. Great grey owl[2,3] - *Strix nebulosa* Forst. In the years of abundant mouse rodents it commonly nests and hibernates whereas in other years it becomes rare. In the autumn-winter-spring season of 1942-1943 it was very common at Vuokkiniemi (Lehtonen 1943). In the year 1988, abundant in lemmings, in the localities around Lake Kalivo 3 great grey owl couples nested in an area of about 1000 ha: 2 nests were 400 m apart and a hatch 1.5 km from them. In the period 1990-1992, great grey owl was registered there only once. In 1993, when the record number (since 1987) of voles (*Clethrionomys glareolus, Microtus agrestris*, etc.) was noted, 3 couples of great grey owls lived in the Kalivo area again. In addition to Kalivo, 1-2 local couples were met in 1993 in the northern part of the reserve. In the city green belt

the species has not been found up to now. Based on the data of the June censuses of 1988-1990 in the adjacent Finnish territory 2 out of 3 registrations of great grey owl refer to 1990.
54. Ural owl[3] - *S.uralensis* Pall. A rare nesting and hibernating species of the region. Only once it was registered in the reserve: on May 26th in 1993 an individual was encountered near Lake Kalivo. In the count period of 1988-1990, 4 registrations are known from the adjacent Finnish territories.
55. Short-eared owl - *Asio flammeus* (Pontopp.). A rare irregularly nesting species of the region. In May-June 1975, hunting individuals of the only couple were constantly encountered on the coastal meadows near the village of Luvajärvi. According to table 2, it exists in the reserve. In the adjoining Finish territory it is also rare (3 encounters in 1988-1990 censes), characteristic chiefly of agricultural landscapes (the neighbourhood of Kuhmo).
56. Tengmalm's owl - *Aegolius funereus* (L.). A rare nesting and irregularly hibernating species. In 1942-1943, it was common and hibernated in the Vuokkiniemi area (Lehtonen 1943). On April 9, 1975 at Luvajärvi the first passing individual was recorded. It was found in the reserve on June 14th in 1993 in the forests growing along the northern boundary (the Lyttä district). According to the results of the 1988-1990 censuses in the adjoining Finnish territory the species was registered only once.
57. Nightjar[4] - *Caprimulgus europaeus* L. A flight of a male exhibiting mating behaviour was registered on July 26th in 1975 on the meadows at the western extremity of Lake Luvajärvi.
58. Swift - *Apus apus* L. A rare nesting species. Its habitats coincide with the shores of large lakes, river valleys and the margins of mires. Its density in the different parts of the reserve is 0.3-0.5 couples/km^2 (average 0.3 couples/km^2).
Grey-headed woodpecker[4] - *Picus canus* Gm. A very rare species of the region. Found in the period of post-nesting migrations at Vuokkiniemi, where 3 encounters were registered in November-December 1943 (Lampio 1943). According to table 2, it exists in the reserve, but the reliability of the registration of the species should be verified and proved. In North Karelia the species was found only once in the past three decades during autumn migrations. Nesting was not observed.
59. Black woodpecker - *Dryocopus martius* (L.). A rare nesting and hibernating species. The distribution in the territory of the region is uniform. In some years up to 3-4 black woodpecker couples nested in the Kalivo district in an area of 14 000 ha. The density in different parts of the reserve is 0.1-0.2 couples/km^2, the average being 0.17 couples/km^2.
60. Great spotted woodpecker - *Dendrocopos major* L. A common resident species evenly distributed over the study area. According to the data obtained in 1990-1993, its density in the Kalivo lake area is 2.6-4.5 couples/km^2, the average in 3 plots of the reserve being 3.2 couples/km^2.
Lesser spotted woodpecker[4] - *D.minor* L. A very rare vagrant species. In 1942-1944 lesser spotted woodpecker was seldom found at Vuokkiniemi. Nesting was probable (Lehtonen 1943; Lampio 1945). According to table 2, it exists in the reserve presumably as a vagrant species. In the last decades no encounters or cases of nesting were registered in north Karelia.
61. Three-toed woodpecker - *Picoides tridactylus* (L). A common resident species evenly distributed over the study area. Its density in the Kalivo district in different years was 1.3-2.7 couples/km^2, the average in the reserve being 2.3 couples/km^2.
62. Wryneck - *Jynx torquilla* L. A very rare irregularly nesting species. In 1975 a couple was registered in a cutting area near the village of Luvajärvi. In 1991 a displaying male was recorded in the sparsely stocked white-moss forest with abun-

dant pine upgrowth on the northern bank of the River Kivijoki near the reserve boundary. The species is more common in the adjacent Finnish territory.Seven registrations of the species are known during the 1984-1990 censuses.
63. Skylark - *Alauda arvensis* L. A rare species nesting in agricultural lands and occasionally on mires. In 1975 it was commonly found on the shore and in island meadows of Lake Luvajärvi (about 15 couples). At present it is very rare in the vicinity of Kostomuksha. This is due to the withdrawal of the bulk of meadow areas from agricultural rotation and their use for industrial, housing or recreational purposes. In 1990, a nesting couple was met on a meadow on the Kontokki lake shore within the city boundaries. The species is occasionally found to be nesting within the reserve, primarily in the agricultural lands of the Kiitehenjärvi lake shore (Babya Guba area).
Shore lark[4] - *Eremophila alpestris* (L.). A very rare migrant species. The only early shore lark flock was seen on passage on April 17th in 1975 near Lake Luvajärvi. The number of the species in passage routes and at nesting sites within Fennoscandia (mountain and tundra regions) has dramatically reduced in the last 20-30 years.
64. Sand martin - *Riparia riparia* (L.). A rare nesting species of the region. In 1975, two sand martin colonies were found in the vicinity of Lake Luvajärvi (a total of about 30 tunnels in sand precipices). In 1990-1994, it was regularly recorded in some inland waters of the reserve such as Lakes Kiitehenjärvi and Kalivo). In 1992 no colonies were found while examining the new sand pits along the boundary fence. The species probably nests in the Babya Guba area on the Kiitehenjärvi lake shore.
65. Swallow - *Hirundo rustica* L. Commonly seen near the villages of the region. Nests in Kontokki settlement. Individual couples nest in Kostomuksha. In 1975 about 15 couples were found in the village of Luvajärvi. It is presently seen to be nesting in country houses along the north shore of Lake Luvajärvi. Within the reserve couples and groups of 3-5 couples inhabit some buildings and facilities. The majority of swallows nest along the boundary fence (about 15 couples in 1992-1993). According to assessments the reserve has a total of 25 swallow couples.
66. House martin - *Delichon urbica* (L.). Commonly seen in villages. In 1975 7 house martin nests were found in the village of Luvajärvi. In 1992-1993, about 30 couples nested in the village of Kontokki, and 2 house martin couples in Kostomuksha. In the reserve the bird nests on the buildings and structures along the boundary fence, where in 1992 18 house martin couples were found. In the reserve the species is represented by 20-25 couples.
67. Siberian jay - *Perisoreus infaustus* (L.). Common in the study area. Its distribution is connected with paludified forests and the margins of marshlands. In 1990-1993 its average density in the reserve was 1.5 couples/km². In 1994 a noticeable increase in its abundance was registered.
68. Jay - *Garrulus glandarius* (L.). A very rare irregularly nesting and hibernating species of the region. On July 14th in 1987 it was encountered in the city green belt at the edge of a medium-age pine forest near an overgrown cutting area along the Kostamus Lake shore.
69. Magpie - *Pica pica* (L.). A rare resident species. Nests in the neighbourhood of Luvajärvi and near Kostomuksha about 0.5 km from the city. In 1992 the species was found in the reserve in the eastern part of Miinoanjärvi; where 2-3 magpie couples nest at the edges of agricultural lands. An individual, obviously vagrant, was observed on July 13th in 1993 in the Mokrovaara area on the Kiitehenjärvi lake shore.
70. Raven - *Corvus corax* L. A fairly common species. Its density at 3 localities of the study area is 0.3 couples/km² on the average.

71. Hooded crow - *C.cornix* L. A comparatively rare nesting and hibernating species of the region. More characteristic of the Kostomuksha area and the western part of Lake Luvajärvi. About 8 nesting couples were found in the reserve. The habitats of hooded crow are connected exclusively with the Kiitehenjärvi lake shore and dense forests and bushes along the roads.
Rook - *C.frugilegus* L. A very rare passing species. Several individuals were registered on the Kontokki lake shore in April 1975.
Jackdaw - *C.monedula* L. A very rare transit migrant. A group of passing jackdaws was seen on the Kontokki lake shore in April 1975.
Nutcracker - *Nucifraga caryocatactes* (L.). A very rare visitor species. A single bird was encountered in pine stand with spruce undergrowth along the road to Niemijärvi about 12 km from Kostomuksha on May 20th in 1990. In the years of mass autumn invasion, Siberian sub-species may be encountered in the reserve.
72. Great tit - *Parus major* L. A rare nesting and hibernating species of the region. More characteristic of the immediate vicinity of Kostomuksha. In the reserve the nesting grounds are connected with the forests and bushes along the roads (local density 2.0-2.5 couples/km^2). Its abundance varies in different years: in the River Kivijoki - Lake Kalivo section, 6 couples were encountered in 1991. In other years 2-3 great tit couples were counted every year. The total density in the reserve is no more than 0.1 couples/km^2 in the plain taiga.
73. Coal tit - *Parus ater* L. A very rare species. Nesting is probable. In mid-June 1992 two singing males were met in ripe spruce forests near the Munankijoki river estuary and Lake Kalivo. In late May 1994 a singing male was seen again in the Kalivo district in a pine-spruce forest growing along the mire margin.
74. Willow tit - *P.montanus* Bald. A common resident species, the most numerous of tits. Evenly distributed over the study area. In 1990-1993, its average density in the different parts of the reserve was 5.3 couples/km^2.
75. Siberian tit - *P.cinctus* Bodd. A rare resident species. Nesting sites coincide with ripe white-moss, *Vaccinium myrtillus* and Dutch myrth-*Sphagnum* pine forests. According to the 1990-1993 censuses there were 0.4 couples/km^2. In 1994 a noticeable density increase in abundance was reported.
76. Crested tit - *P.cristatus* L. A common resident species evenly distributed over the study area. In 1987-1989 a gradual increase in crested tit number was observed. In 1990-1993 its density in the different parts of the reserve was 3.8-6.2 couples/km^2 (average 4.6 couples/km^2). In 1994 another sharp decline in abundance was recorded.
77. Treecreeper - *Certhia familiaris* L. A common resident species of the region. Like in crested tit the number of treecreeper increased in 1990 after a depression period in the early 1980s. The species prefers spruce stands, and occasionally it inhabits monodominant *Vaccinium vitis-idaea*, white-moss and *Vaccinium myrtillus* pine forests. The hatches met and the nests found suggest the existence of two reproduction cycles in the reserve. According to the 1990-1993 counts its average density was 3.9 couples/km^2. In 1994, in the Kalivo area and near the River Kivijoki a sharp decrease in abundance was registered.
78. Long-tailed tit - *Aegithalos caudatus* (L.). A very rare nesting and irregularly hibernating species. In North Karelia, it is observed in years of mass invasions. In 1975 the species was comparatively common in the vicinity of Luvajärvi (about 6 couples in different forest types). A nest and several long-tailed tit hatches were found there as well. According to table 2, the tit is obviously a vagrant species in the reserve.
Dipper[3] - *Cinclus cinclus* (L.). A rare passing and hibernating species. In February-April 1974-1975, the species was registered more than once by the rivers with rapids near lakes Kontokki and Luvajärvi. The nearest permanent nesting sites are in the Paanajärvi basin and, probably, in the upper River Voinitsa.

79. Wren - *Troglodytes troglodytes* (L.). A rare nesting species of the region. The number of wren was constantly increased in the 1987-1994 after a period of depression that had affected the whole territory of Karelia in the early 1980s. In early August 1989 an unseparated hatch was registered in the reserve. One to two singing males were recorded annually in 1991-1993 and four in 1994. All birds were seen in riverbank spruce forests. The average density, estimated from the 1990-1993 censuses, was 0.3 couples/km^2.
80. Spotted flycatcher - *Muscicapa striata* (Pall.). A common nesting species evenly distributed over the study area (avoids close stands). Its abundance is subject to periodical fluctuations. Its average density in 3 districts of the reserve is 8.9 couples/km^2.
81. Pied flycatcher - *Ficedula hypoleuca* (Pall.). A common, but not abundant nesting species. Prefers inland waters and near-water plantations with a high percentage of deciduous species. Its average density in the different parts of the reserve is 1.8 couples/km^2.
Red-breasted flycatcher[4] - *F.parva* Bechst. A visiting species. Singing males were registered on June 8th in 1991 in the spruce forest growing on the bank of the River Kivijoki and on June 3rd in 1994 in a riverside spruce forest in the city green belt.
82. Whinchat - *Saxicola rubetra* (L.). A rare nesting species of the region. An increase in its number was recorded in 1975 in the vicinity of Luvajärvi, where about 12 whinchat couples nested in coastal meadows and on barren arable land. In 1987 the species was also fairly common in the city green belt. Four couples were found in new cutting areas near Kostomuksha. In the reserve whinchat is encountered in some mires. In 1990 two couples nested in overgrown meadows near Ehrimänvaara. According to the 1990-1993 censuses its average density in the different parts of the reserve was 0.2 couples/km^2.
Stonechat - *S.torquata* (L.). A visiting species. A singing male was seen on June 9th in 1975 near the old village of Luvajärvi.
83. Wheatear - *Oenanthe oenanthe* (L.). A rare nesting species. A comparatively high number was registered in 1975 in the vicinity of Luvajärvi and in 1987 in the outskirts of Kostomuksha. In the latter case the birds were seen nesting on agricultural lands and in new cutting areas with rock exposures. In the reserve the species was encountered twice (1990 and 1994) on the shore of a south-eastern bay in Lake Kiitehenjärvi occupied by a transitional mire with some rocky islets and a narrow sandy beach.
84. Redstart - *Phoenicurus phoenicurus* (L.). A common nesting species evenly distributed in the region. Prefers pine forests and mire margins. Its density in the different parts of the reserve is 7.7-8.7 couples/km^2 (average 8.2 couples /km^2). The hatches encountered and the nests found suggest bicycled reproduction of a part of the population.
85. Robin - *Erithacus rubecula* (L.). A common, but not numerous nesting species. In 1990-1993, it was more abundant than in 1987-1989. Prefers plantations with a high percentage of spruce, as well as stream-side, river-side, lake-side water and near-water stations. According to the censuses of 1990-1993, its density in the different parts of the reserve was 1.0-7.5 couples/km^2, the average density being 3.6 couples/km^2.
Bluethroat - *Cyanosylvia suecica* (L.). A very rare passing species. In late May-early June 1975 bluethroat was recorded twice in the vicinity of Luvajärvi. In the reserve it was registered on May 22nd and 24th in 1990. In the latter case a single bird was seen in a pine stand with dense dwarf birch cover on a transitional mire. The nearest sites of permanent nesting are in the basin of Paanajärvi, where bluethroat nests in the subalpine zone of sparse birch forests in uplands.

Red-flanked bluetail - *Tarsiger cyanurus* (Pall.). A visiting species. A singing male was registered once on June 26th in 1990 in the Kalivo area in an overmature rocky pine forest with a young spruce undergrowth.
86. Mistle thrush - *Turdus viscivorus* L. A common, but not abundant nesting species. Nesting sites are found in mature pine forests and along mire margins. Its density in the different parts of the reserve is 1.5-1.9 couples/km^2 (average 1.8 couples/km^2).
87. Song thrush - *T.philomelos* Brehm. A common nesting species inhabiting different biotopes. Its average density in 3 districts of the reserve is 4.2 couples/km^2.
88. Redwing - *T.iliaceus* L. A rare nesting species. The highest local density was registered in young deciduous stands on the northern side of the highway and railway (3.2 couples/km^2). In the plain taiga, its density is much lower.
89. Fieldfare - *T.pilaris* L. A rare nesting species. In the city green belt fieldfare nests in coppices at the edges of agricultural lands. Fieldfare colonies number no more than 10 couples. In the reserve the species is met at the edges of overgrowing meadows, in young deciduous stands along the northern sides of the highway and railway and occasionally in pine islands among mires. Its average density in 3 districts of the reserve is 0.2 couples/km^2.
Blackbird - *T.merula* L. A visitor. In 1975 a male was registered more than once in March in the village of Kontokki. It was seen again on June 18th in the old village of Luvajärvi. According to table 2, it is considered to exist in the reserve obviously as a visitor.
90. Willow warbler - *Phylloscopus trochilus* (L.). A common nesting species. Being a species of secondary plantations and waered habitats (like redwing and fieldfare, a species of alpine sparse forests), distributed unevenly in the reserve. Willow warbler's nesting sites coincide with the edges of mires, sparse tree stands growing along the banks of streams and rivers and lake shores as well as secondary stations. Its local density in optimum biotopes young deciduous stands along the roads is 44 couples/km^2. In plain taiga, its density in 3 localities is 9.5-20.4 couples/km^2, the average density being 14.8 couples/km^2.
91. Chiffchaff - *Ph.collybita* (Vieill.) A common, but not abundant nesting species. Prefers spruce stands, primarily high-quality plantations. Its density in 3 plots of the reserve is 0.2-3.8 couples/km^2, average density being 1.5 couples/km^2.
92. Wood warbler - *Ph.sibilatrix* (Bechst.). A rare nesting species. Unevenly distributed over the study area. Inhabits high-quality coniferous-deciduous plantations. Its local density in the Ehrimänvaara area (ripening pine forests with a high percentage of birch and birch-pine young stands) is 6 couples/km^2. Its density in the plain taiga districts of the reserve is 0.2-1.3 couples/km^2, the average density being 0.5 couples/km^2. In some years the species nests in the immediate vicinity of Kostomuksha, especially in the pine-and-birch stands of medium age growing between the city and the Kontokki lake shore.
Arctic warbler - *Ph.borealis* (Blas.). A very rare species. Regularly visits North Karelia, where it occasionally makes isolated reproduction sites. In 1975, four singing males were seen in the vicinity of Luvajärvi. They stayed in permanent areas for a month since June 15th. Judging by the birds behaviour, arctic warbler could be nesting in the Kostomuksha area in that season. In the period June 18th to 24th in 1990, 4 singing males were also registered in the village of Tiiksa. The species inhabits various plantations, including young coniferous and deciduous stands with residual stand patches (mature and maturing birch, spruce and pine stands). When the territory of the reserve and the city green belt was studied in 1990 (June 25-July 5), the species was not found. In the future arctic warbler is likely to stay in the reserve, at least as a passing species.

Greenish warbler - *Ph.trochiloides* (Sundev.). A visiting bird. A singing male was registered more than once in the same forest plot (ripe huckleberry pine forests altered by moist huckleberry spruce forests) near the Kamalahti Bay of Lake Kiitehenjärvi between June 12 and 14, 1992. Occasional nesting is quite probable, but it should be supported by additional evidence.

93. Icterine warbler - *Hippolais icterina* (Vieill.). A very rare irregularly nesting species of the region. A singing male with some indications of breeding behaviour was encountered for the first time on July 2nd in 1990 in a pine-birch stand with abundant willow and alder undergrowth on the bank of the Kontokki stream source. In the same place a displaying icterine warbler male was registered in June 1992. Its stay in the reserve is problematic, though possible for the cultivated well-drained habitats with highly productive soils adjoining water bodies.

Blyth's reed warbler - *Acrocephalus dumetorum* (Blyth). A visiting bird. Singing males were seen in agricultural lands on June 15th in 1992 in Ehrimänvaara area.

94. Sedge warbler - *A.schoenobaenus* (L.). A rare nesting species of the region. Nesting density was high in 1975 near Lake Luvajärvi, where 8 sedge warbler couples were registered on coastal and island meadows. In the next years met only twice: on July 2nd in 1990 on a meadow on the Kontokki lake shore and on June 15th in 1992 on an overgrowing meadow in the Ehrimänvaara area.

Grasshopper warbler - *Locustella naevia* (Bodd.). A visiting species. A singing grasshopper warbler was registered on June 15th in 1992 on the meadows of Ehrimänvaara within the reserve.

95. Garden warbler - *Sylvia borin* (Bodd.). A rare nesting species. The highest population density is restricted to agricultural landscapes such as coppices at the edges of agricultural lands and lake shore meadows with osiers. Garden warbler penetrates into the reserve through ecological corridors from the damaged habitats such as young deciduous stands growing along the roads (local density 7.5 couples/km^2) and overgrowing meadows in Ehrimänvaara (up to 3-4 couples in some years). Isolated couples inhabit parts of the River Kivijoki with pronounced water meadows. The species is observed to be nesting in transformed lands (forests and bushes along the roads, engineering constrictions, etc.). Its average density in 3 districts of the reserve is 0.5 couples/km^2.

96. Blackcap - *S.atricapilla* (L.). A very rare probably nesting species. In 1975 it was registered in the vicinity of Luvajärvi. A singing male was encountered in the reserve in a stream-side herb-rich paludified spruce forest near Lake Munankijärvi on July 19th in 1987.

97. Whitethroat - *S.communis* Lath. A very rare nesting species. In June 1975 about 3 couples were seen on the meadows near Lake Luvajärvi. In July 1988 a couple displaying alarm over the hatch was observed. A male singing in the nesting ground was registered on June in 1992 on the northern side of the highway near the Kamalahti Bay of Lake Kiitehenjärvi. Recorded in the reserve also according observations of 1987-1988.

98. Lesser whitethroat - *S.curruca* (L.). A rare nesting species. Prefers secondary habitats: coppices at the edge of agricultural lands, young coniferous-deciduous stands, the sides of roads, etc., where density locally reaches 2.6 couples/km^2. It is very rare in or is completely absent from the plain taiga. Its average density in 3 districts of the reserve is 0.3 couples/km^2.

99. Goldcrest - *Regulus regulus* (L.). A common nesting and hibernating species. During the nesting season prefers forest plots with a high percentage of spruce and avoids pine stands. In the course of study its population density was low (a small increase in abundance was observed in 1989). In the early 1980s, a depression

began over the whole goldcrest area in North Karelia. Its average density within the reserve is 3.5 couples/km^2. The analysis of hatch distribution suggests the existence of two reproduction cycles, at least among a part of the population.

100. Dunnock - *Prunella modularis* (L.). A rare nesting species. Most commonly inhabits stream side and riverside biotopes with a high proportion of spruce as well as overgrowing stubbles with juniper undergrowth at the edges (Ehrimänvaara, Mokrovaara). Its average density is 0.7 couples/km^2.

101. White wagtail - *Motacilla alba* L. A common, but not abundant nesting species. Met in all large lake-river systems. Nests in the settlements of the region. An increase in the number was observed in 1975 (Luvajärvi) and in 1987 (reserve and green belt). In 1987, nesting in new cutting areas near Kostomuksha was registered. Its average density estimated in the reserve is 0.7 couples/km^2. The nests and hatches found suggest bicycled reproduction . The percentage of couples with two hatches noticeably increases in the years with favourable climatic conditions (early spring, warm summer).

102. Yellow wagtail - *M.flava* L. A common nesting species. Inhabits mires and paludified meadows (Luvajärvi). Encountered on meadows along the River Kivijoki. In the years of high abundance (1975,1987) nested in dryland meadows along the shores of water bodies and in new cutting areas with mires formed in relief depressions. Based on results of 1990-1993 quantitative counts a very low nesting density of the species was generally recorded in the mires studied. This is due to the prevalence of poor transitional associations in the mire structure. Its average density in 3 districts of the reserve is 1.9 couples/km^2.

103. Tree pipit - *Anthus trivialis* (L.). A common nesting species. Confined to swampland margins. Its average density in the different parts of the reserve 8.6 couples/km^2.

104. Meadow pipit - *A.pratensis* (L.). A common, but not abundant nesting species. Encountered in mires. In the years of high abundance nesting on near-water meadows and overgrowing arable land (Luvajärvi) and in new cutting areas with small mires in depressions. In the mires studied in 1990-1993 a very low nesting density was recorded. An average for 3 localities of the reserve is 1.0 couples/km^2.

Red-throatad pipit - *A.cervinus* (Pall.) A very rare passer. Migrating individuals were registered in May 1975 at Luvajärvi.

Rock pipit - *A.spinoletta* (L.). A visiting species. A singing male was seen to stay on May 29th in 1994 in the Kalivo area on pine-forested island surrounded by mires and two lakes. The nearest nesting grounds were found in 1993 in the Kuzova archipelago in the White Sea between Kem and the Solovetsk Islands.

105. Waxwing - *Bombycilla garrulus* (L.). A common, but not abundant nesting and irregularly hibernating species of the region. In the Kalivo area in 5 years of observations its abundance varied considerably in different years. The species was registered in 1990 and 1993 (6 and 1 couples), in other years it was absent. The waxwing population was more stable in the white moss pine forests along the River Kivijoki, where the species was observed annually (1-3 couples in permanent route), except 1994. Inhabits high-stem mature pine forests, usually in the vicinity of water bodies. Its average density in 3 districts of the reserve is 1.0 couples/km^2. In 1994, the study of the reserve and the city green belt revealed no presence of waxwing that could be related to the complete absence of cowberry crop (also for the first time) in the previous autumn.

106. Great grey strike - *Lanius excubitor* (L.). A very rare irregularly nesting species. In North Karelia normally nests at localities of mass mouse rodent reproduction. The species was comparatively common at Voinitsa and Lomozero in the summer-autumn of 1942 and in the spring of 1943 (Lehtonen 1943; Lampio 1945). In July 1975, a single bird was registered at Luvajärvi. In the territory of the reserve, abun-

dant in lemmings, 2 couples were recorded in 1988 on the southern side of the highway on the shore of the Kamalahti Bay of Lake Kiitehenjärvi and at the boundary fence built near the mire south of the Kivijoki river source. In 1992, it was met again on a highway near the Kamalahti Bay shore (comparatively high density of voles, peak abundance being observed in 1993).

107. Red-backed shrike - *L.collurio* L. A very rare nesting species. In 1975, about 3 couples nested in agricultural landscape in the vicinity of Luvajärvi. In early July 1987, the species was recorded at the edge of a forested transitional mire near the settlement of Ledmozero. Penetrates into the reserve like many other species of south origin, through ecological corridors from disturbed habitats. In 1990, two red-backed shrikes were found to be nesting on the southern side of the highway and railway between Mustakivilampi and Lake Lyttä. A singing, obviously migrating male was observed near Lake Kalivo, in the plot of a rich transitional mire with crooked pine forest by the brook bank on June in 1994.

108. Starling - *Sturnus vulgaris* L. A rare formerly nesting species of agricultural lands. Its nesting was recorded for the first time in June 1944 in the vicinity of Vuokkiniemi (Lampio 1945). In 1975, about 10-12 starling couples nested at the western extremity of Luvajärvi. Three nests were found in nesting boxes and three in tree cavities 3-4 km from settlements. In June (13th to 20th) the juveniles left their nests. After that a united flock of starlings (about 80-100 birds) was migrating about for a month. The latest encounter of the species this year was registered in October (village of Kiimasjärvi). In the mid-1980s a sudden decrease in its abundance was observed in Karelia. Nowadays it has ceased to nest at most of its North Karelian localities. The last nesting in the region was recorded in 1990 (settlement Tiiksa). In this connection starling should be considered an extinct species of the study region.

109. Yellow hammer - *Emberiza citrinella* L. A common nesting species of agricultural landscape and suburban areas. In 1975 about 3 couples nested in the vicinity of Luvajärvi. In 1990-1993, 6-8 to 10-11 yellow hammer couples were reported from the outskirts of Kostomuksha (an increase in abundance compared to 1987-1989). The only site of its permanent nesting in the reserve is found on overgrowing meadows in the Ehrimänvaara area (1988-1990). In addition, a couple was found near the boundary fence in the south-eastern bay of Lake Kiitehenjärvi in 1992.

110. Rustic bunting - *E.rustica* Pall. A common nesting species. Prefers waterlogged forests with sparse stands as well as stands growing along mire margins. As paludified forests and mires are widespread in the study region, the species is evenly distributed and shows a relatively high nesting density. The nests and hatches found suggest bicycled reproduction. Its density in 3 plots of the reserve is 7.2-12.5 couples/km^2, average density being 10.3 couples/km^2.

111. Little bunting - *E.pusilla* Pall. A very rare, presumably nesting species. In late May - early June 1975, a singing male was observed in the vicinity of Luvajärvi in the permanent nesting ground in a pine-birch stand along a paludified brook bank. In late June an alarmed individual was recorded at the same place. In the adjacent Finnish territory, in the June censuses of 1990, 4 singing little bunting males were registered, including one in Iso-Palonen directly adjoining the southern part of the reserve and 3 in Tulisuo, 20 km west of the state border.

112. Yellow-breasted bunting - *E.aureola* Pall. A very rare nesting species of the region. In 1975 on the coastal and island meadows near Lake Luvajärvi 15-17 couples nested. They formed several semicolonies. While studying a short strip of the Luvajärvi lake shore near an old village, 3 nesting couples were found on July 21st in 1988. In the future, yellow-breasted bunting is likely to be discovered, at least as a passer, in the reserve.

Ortolan bunting - *E.hortulana* L. A visiting species. A short stay of a singing male was registered on May 31st in 1975 in the old village of Luvajärvi. Also rare in the adjacent Finnish territory, as indicated by the 1984-1990 counts. In the Kuhmo area only one encounter was recorded. According to the 1942-1944 observations it was a rarely nesting bird characteristic of agricultural landscape in the region. Seen in isolated groups up to 5 couples, for instance in the vicinity of Vuonninen (Lehtonen 1943; Lampio 1945). Presently considered an extinct species in the study region.

113. Reed bunting - *E.schoeniclus* L. A common, but not abundant nesting species. A high number was recorded in 1975 in the vicinity of Luvajärvi, where 19 reed bunting couples nested in coastal meadows and treeless islands covered by osiers (density about 10 couples/km²). In the same year, bicycled reproduction was traced. Within the reserve, the species inhabits the shores and banks of large lake-river systems (Lake Kiitehenjärvi, River Kivijoki, Lake Kalivo). It is met in rich transitional mire margins, as well as along the roads with fragments of waterlogged stations in relief depressions (local density up to 3 couples/km²). The average density in the reserve estimated for the entire landscape area, including forests and mires, is 0.6 couples/km².

Lapland bunting - *Calcarius lapponicus* (L.). A very rare passing species. Two birds were seen only once on April 25th in 1990 on a meadow near Lake Kontokki.

Snow bunting - *Plectrophenax nivalis* (L.). A common, but not abundant migrating species. In 1975 in the vicinity of Luvajärvi its arrival and passage were observed in late March and the first ten days of April. In other years, spring migration was reported at later dates (first half of April, 1973). According to table 2 it is also met within the reserve.

114. House sparrow - *Passer domesticus* (L.). Commonly resides in the villages of the region. The house sparrow population in Kostomuksha is small (about 20 couples). It is due to the prevalence of multistoreyed houses in residential areas. The nesting population consists of no less than 30-40 couples, including the village of Kontokki and new cottages. The species was first met in the reserve in 1992 while studying the boundary fence. Two to three couples nest in dwelling houses in the eastern part of lake Miinoanjärvi. A male was encountered on June 19th in some abandoned houses in the Mokrovaara area.

Tree sparrow - *P.montanus* (L.). A visiting species. In the period of pre-nesting migrations single birds were registered in March-April 1973 and 1975 at Kontokki and Luvajärvi. The nearest nesting ground of tree sparrow was recorded in Kalevala.

115. Chaffinch - *Fringilla coelebs* L. A common abundant nesting species. Evenly distributed over the study area, though in the years of decreased abundance, the species preferred waterlogged and near-water biotopes with high soil productivity and high-quality plantations (Kivijoki river valley). Its density in 3 plots of the reserve is 11.3-27.0 couples/km², average density being 17.9 couples/km². Usually breeds in Kostomuksha primarily because patches of pine and pine-birch stands are preserved in the city (up to 20 couples in some years).

116. Brambling - *F.montifringilla* L. An abundant nesting species. Inhabits various biotopes definitely avoiding only dense stands (fully stocked spruce stands and pine stands with spruce undergrowth young deciduous and coniferous-deciduous stands at pole stage). The highest nesting density of 34.6 couples/km² was recorded in strongly waterlogged areas dominated by pine stands. In the year of a high pine seed yield (1990) a maximum abundance index of 41.7 couples/km² was registered in the Kalivo area at a strongly waterlogged locality with wide-spread (in addition to pine stands) spruce and pine stands with spruce undergrowth. Its density in 3 districts of the reserve is 25.8-34.6 couples/km², average density being 31.1 couples/km².

117. Redpoll - *Acanthis flammea* (L.). A common nesting and wintering species. Its variable abundance is characteristic. Mass redpoll reproduction was registered at Luvajärvi in 1975 after a few years (1972-1974) with hot and dry summers and a good seed yield. The birds nested in individual couples and groups of 2-3 couples commonly seen along mires and in curved stands between mires as well as in coppices at the edges of agricultural lands or almost treeless lake islands. A total of about 30 redpoll couples were met. More than 20 nests were found with clutches in mid-May - late June near Lake Luvajärvi. In 1987-1991 redpoll was observed as a non-abundant species. In 1992 and 1993, the first indications of nesting were revealed. In mid-June, 7 and 5 redpoll couples were met at typical reproductive stations (mire edges). The average density estimated from of the 1990-1993 censes, was 3.2 couples/km^2. In the season of 1994, with a high pine seed yield and a good birch seed yield in the previous autumn, redpoll was most abundant. At a strongly waterlogged locality near Lake Kalivo in late May-early June no less than 30 redpoll couples, scattered over the nesting grounds (local density in some areas is 15-20 couples/km^2) were encountered. In other parts of the reserve such as white-moss pine stands on the bank of the River Kivijoki, isolated couples were met in the first half of June 1994.
Linnet - *Cannabina cannabina* (L.). A visiting species. Single birds were encountered in April-June 1975 at Kontokki and Luvajärvi.
118. Siskin - *Spinus spinus* (L.). A common nesting species evenly distributed over the study area. Its abundance at some localities is highly variable. In 1990, the year of a high pine seed yield, its density in the Kalivo area was 31 couples/km^2 and next year only 4 couples/km^2. In the season of 1990, very early nesting and bicycled reproduction were recorded. Its density in 3 districts of the reserve was 10.6-16.4 couples/km^2, average density being 13.2 couples/km^2.
Goldfinch - *Carduelis carduelis* (L.). Visits of individuals were recorded in April-May 1975 in the vicinity of Luvajärvi.
119. Greenfinch - *Chloris chloris* (L.). A very rare, irregularly nesting species. In April 1975, it was encountered on passage in the village of Kontokki. In 1990, 2-3 greenfinch couples nesting in the pine stands preserved in the housing estates of Kostomuksha and at the edges of suburban forests were registered.
120. Two-barred crossbill - *Loxia leucoptera* Gm. A rare nesting and hibernating species. In the years of high pine seed yield (1973-1974 and 1989-1990) the species became comparatively common, staying in the region as early as the first ten days of August (1989); in other years it has been met less often. Its average density, estimated from the 1990-1993 censuses, was 0.4 couples/km^2.
121. Crossbill - *L.curvirostra* L. A common resident species. Abundance varies in different years, depending on spruce seed yield. The species was especially abundant in 1973-1974 and in 1989-1990. At the end of the first ten days of August 1989 in connection with a very high spruce seed yield, crossbills were highly active: males sang, occupied nesting grounds and got anxious when people approached them. Autumn reproduction, like the one observed in 1989 in the mid-taiga subzone of Karelia, is quite probable. In the spring-summer of 1990, the nesting density of crossbill was 9 couples/km^2 near Lake Kalivo. Next year, it decreased to 0.6 couples/km^2. The average density within the reserve was 2.4 couples/km^2, as indicated by the 1990-1993 counts.

122. Parrot crossbill - *L.pityopsittacus* Borkh. A common resident species. Population density varies from year to year, but less markedly than that of other crossbill species. Small increases in abundance were recorded in 1990, 1992 and 1994. The density in 3 districts of the reserve is 1.5-3.8 couples/km^2, average density being 2.3 couples/km^2.
123. Scarlet rosefinch - *Carpodacus erythrinus* (Pall.). A rare nesting species of the region. In the territory of the reserve it breeds in some areas with agricultural landscape (Ehrimänvaara 3-4 couples, Mokrovaara 1-2 couples), as well as along the boundary fence and roads (local density is 2 couples/km^2). The average density in 3 localities of the reserve is 0.5 couples/km^2.
Pine grosbeak - *Pinicola enucleator* (L.). A rare passing and irregularly wintering species. In spring, it migrates most actively in March - the first ten days of April, and in autumn after October 20th.
124. Bullfinch - *Pyrrhula pyrrhula* (L.). A common resident species evenly distributed over the study area. Its density in 3 districts of the reserve is 1.9-5.7 couples/km^2, average density being 3.5 couples/km^2.

A total of 171 bird species, 124 of them nesting, were registered in the study region based on the results of 1973-1994 studies and published data. 137 species, 104 of them presumably nesting, were recorded in the territory of the Kostomuksha Nature Reserve. Of the 104 bird species nesting in the reserve, 35 form part of Arctic and taiga-Siberian ornithocomplexes and only 23 represent the bird fauna of European broad-leaved forests (Table 2). Thus, the percentage of northern species is 33.7%, and that of typical southern species is 22.1% of the total species diversity of the nesting fauna. The other 46 species are widespread. Moreover, some of them can be characterised as forms with pronounced northern or southern relations. Red-necked grebe, bean goose, hen harrier, osprey, peregrine, lesser black-backed gull, great grey shrike (a total of 7 species) are birds of dominantly northern distribution. Some of them are represented in the taiga zone either by northern subspecies or specific geographic populations. Jay, great tit and wren are among the species of southern origin, their optimum areas being in coniferous broad-leaved forests.

Table 1. Genetic structure of nesting bird fauna in the Kostomuksha area*

Characteristics	Reserve	City green belt	City	Total in the region
Total species number	137	158	78	171
Nesting species	104	115	35	122
including:				
species of Arctic and taiga-siberian ornithocomplexes	35	38	7	40
%	33.7	33.0	20.0	32.8
Species of European broad-leaved forests and Mediterranean ornithocomplex	23	26	14	28
%	22.1	22.6	40.0	23.0

*– Distribution of bird species by fauna-genetic complexes is given accoding to Stegman (1938) and Brunov (1980).

The discovery in the reserve in the breeding period of a number of Arctic and north-taiga species such as red-throated diver, red-necked grebe, rough-legged buzzard, smew, terek sandpiper, red-breasted flycatcher, greenish warbler, red-flanked bluetail is of a great zoogeographical interest. Black kite, nutcracker, arctic warbler, Blyth's reed warbler and little bunting were met in the adjacent territory. Nesting yellow-breasted bunting, icterine warbler and greenfinch were found.

13 bird species, included into the Red Data Books of Russia and Karelia, were registered in the reserve, among them osprey (4 couples), white-tailed eagle (1-2), peregrine (1-4), golden eagle (1 couple), whooper swan (10 couples), crane (7 couples), great grey owl and merlin, breed in the reserve. Extremely specific are the fauna and bird population of Lake Kiitehenjärvi. The overwhelming majority of the white-tailed eagle and whooper swan nesting grounds are connected with its shores and water areas. In the islands and rocky shoals the colonies of lesser black-backed gull (about 15 couples) and common tern (over 20 couples) are located, and nesting black-throated diver is common (6-8 couples in the northern part of the lake).

Conclusion

The conclusion can thus be drawn that the ornithofauna of the reserve is quite representative. The species diversity of the bird fauna of the north-taiga subzone in Karelia is relatively complete. The bird communities of the reserve can also be considered typical of primaeval plain landscapes in the centre of the White Sea-Baltic Sea watershed.

Table 2

List of bird species of the Kostomuksha Nature Reserve and adjacent areas. Symbols: n - breeding; t - migrating; h - wintering species; e - met occasionally.

Species		reserve	green zone	town
1.	Gavia stellata	n t	n t	-
2.	G. arctica	n t	n t	t
3.	Podiceps griseigena	n t	n t	-
4.	Ardea cinerea	t	-	-
5.	Cygnus cygnus	n t h	n t h	-
6.	C. bewickii	t	-	-
7.	Anser fabalis	n t	n t	-
8.	A. albifrons	t	t	-
9.	Branta bernicla	t	t	-
10.	B. leucopsis	t	-	-
11.	Anas platyrhyncha	n t	n t h	n t
12.	A. crecca	n t	n t	n t
13.	A. penelope	n t	n t	-
14.	A. acuta	t	t	-
15.	A. querquedula	e	-	-
16.	A. clypeata	e	-	-
17.	Aythia fuligula	n t	n t	t
18.	A. marila	t	t	-
19.	Melanitta fusca	t	t	-
20.	M. nigra	t	t	-
21.	Clangula hyemalis	t	t	-
22.	Bucephala clangula	n t	n t h	n t
23.	Mergus albellus	t	t	-
24.	M. serrator	n t	n t	-
25.	M. merganser	n t	n t	-
26.	Pernis apivorus	-	n t	-
27.	Aquila chrysaetos	n t	n t	-
28.	Circus cyaneus	n t	-	-
29.	Haliaeetus albicilla	n t	n t	-
30.	Milvus korshun	t	n t	-
31.	Buteo buteo	n t	n t	-
32.	B. lagopus	n t	t	-
33.	Accipiter gentilis	n t	n t h	t h
34.	A. nisus	n t	n t	t
35.	Pandion haliaetus	n t	n t	-
36.	Falco tinnunculus	t	t	t
37.	F. columbarius	n t	n t	-
38.	F. subbuteo	n t	n t	t
39.	F. peregrinus	n t	n t	-
40.	Lagopus lagopus	n h	n h	e
41.	Lyrurus tetrix	n h	n h	-
42.	Tetrao urogallus	n h	n h	e
43.	Tetrastes bonasia	n h	n h	e
44.	Grus grus	n t	n t	-
45.	Pluvialis apricaria	-	n t	-
46.	Charadrius dubius	n t	n t	-

47.	Vanellus vanellus	t	n t	-
48.	Tringa ochropus	n t	n t	n t
49.	T.glareola	n t	n t	n t
50.	T.nebularia	n t	n t	t
51.	T. totanus	-	e	-
52.	T. erythropus	t	t	-
53.	Actitis hypoleucos	n t	n t	n t
54.	Xenus cinereus	e	e	-
55.	Philomachus pugnax	-	n t	-
56.	Calidris minutus	-	t	-
57.	C. temminckii	-	t	-
58.	C. alpina	-	t	-
59.	Lymnocryptes minima	-	t	-
60.	Gallinago gallinago	n t	n t	t
61.	Scolopax rusticola	t	n t	-
62.	Numenius arquata	t	n t	t
63.	N. phaeopus	t	n t	t
64.	Limosa limosa	e	e	-
65.	L. lapponica	-	t	-
66.	Larus canus	n t	n t	t
67.	L. argentatus	t	t	t
68.	L. fuscus	n t	t	t
69.	L. ridibundus	-	n t	t
70.	Sterna hirundo	n t	n t	t
71.	Columba livia	-	-	n h
72.	C. palumbus	n t	n t	-
73.	Cucculus canorus	n t	n t	-
74.	Nyctea scandiaca	-	t	-
75.	Surnia ulula	n t h	n t h	-
76.	Glaucidium passerinum	n t h	n t h	-
77.	Strix nebulosa	n t h	-	-
78.	S. uralensis	n t (h?)	n t h	-
79.	Asio flammeus	n t	n t	-
80.	Aegoleus funereus	n t h	n t h	-
81.	Caprimulgus europaeus	-	e	-
82.	Apus apus	n t	n t	t
83.	Dryocopus martius	n t h	n t h	-
84.	Dendrocopus major	n t h	n t h	t h
85.	Picoides tridactylus	n t h	n t h	-
86.	Jynx torquilla	n t	n t	-
87.	Alauda arvensis	-	n t	n t
88.	Eremophila alpestris	-	t	-
89.	Riparia riparia	t	n t	t
90.	Hirundo rustica	n t	n t	n t
91.	Delichon urbica	n t	n t	n t
92.	Perisoreus infaustus	n t h	n t h	n t h
93.	Garrulus glandarius	n t	n t (h?)	-
94.	Pica pica	n t	n t h	n t h
95.	Corvus corax	n t h	n t h	t h
96.	C. cornix	n t	n t h	n t h
97.	C. frugilegus	-	e	-
98.	C. monedula	-	t	-
99.	Nucifraga caryocatactes	-	t	-
100.	Parus major	n t	n t h	n t h

101. P. ater	n t (h?)	-	-
102. P. montanus	n t h	n t h	t h
103. P. cinctus	n t h	n t h	-
104. P.cristatus	n t h	n t h	-
105. Certhia familiaris	n t h	n t h	-
106. Aegithalos caudatus	t	n t (h?)	-
107. Cinclus cinclus	t h	t h	-
108. Troglodytes troglodytes	n t	n t	-
109. Muscicapa striata	n t	n t	n t
110. Ficedula hypoleuca	n t	n t	t
111. F. parva	n t	t	-
112. Saxicola rubetra	n t	n t	(n?) t
113. S. torquata	-	e	-
114. Oenanthe oenanthe	n t	n t	n t
115. Phoenicurus phoenicurus	n t	n t	n t
116. Erithacus rubecula	n t	n t	t
117. Cyanosylvia svecica	t	t	-
118. Tarsiger cyanurus	e	-	-
119. Turdus viscivorus	n t	n t	-
120. T. philomelos	n t	n t	t
121. T. iliacus	n t	n t	n t
122. T. pilaris	n t	n t	n t
123. T. merula	e	-	-
124. Phylloscopus trochilus	n t	n t	n t
125. Ph. collybita	n t	n t	n t
126. Ph. sibilatrix	n t	n t	n t
127. Ph. borealis	-	n t	-
128. Ph. trochiloides	t	-	-
129. Hippolais icterina	-	n t	n t
130. Acrocephalus dumetorum	e	e	-
131. A. schoenobaenus	n t	n t	n t
132. Locustella naevia	e	-	-
133. Sylvia borin	n t	n t	n t
134. S. atricapilla	n t	n t	n t
135. S. communis	n t	n t	-
136. S. curruca	n t	n t	n t
137. Regulus regulus	n t h	n t h	t
138. Prunella modularis	n t	n t	-
139. Motacilla alba	n t	n t	n t
140. M. flava	n t	n t	t
141. Anthus trivialis	n t	n t	(n?) t
142. A. pratensis	n t	n t	t
143. A. cervinus	-	t	-
144. A. spinoletta	e	-	-
145. Bombycilla garrulus	n t	n t	t
146. Lanius excubitor	n t	n t	-
147. L. collurio	n t	n t	-
148. Sturnus vulgaris	-	n t	-
149. Emberiza citrinella	n t	n t (h?)	n t (h?)
150. E. rustica	n t	n t	n t
151. E. pusilla	(n?) t	-	
152. E. aureola	-	n t	-
153. E. hortulana	-	(n?) t	-
154. E. shoeniclus	n t	n t	n t

155.	Calcarius lapponicus	-	t	t
156.	Plectrophenax nivalis	t	t	t
157.	Passer domesticus	n t	n t	n t h
158.	Pass. montanus	-	t	-
159.	Fringilla coelebs	n t	n t	n t
160.	F. montifringilla	n t	n t	n t
161.	Acanthis flammea	n t h	n t h	t
162.	Cannabina cannabina	-	e	-
163.	Spinus spinus	n t	n t	n t
164.	Carduelis carduelis	-	e	-
165.	Chloris chloris	-	t	n t
166.	Loxia leucoptera	n t h	n t h	-
167.	L. curvirostra	n t h	n t h	n t h
168.	L. pityopsittacus	n t h	n t h	t
169.	Carpodacus erythrinus	n t	n t	n t
170.	Pyrrhula pyrrhula	n t h	n t h	t h
171.	Pinicola enucleator	t	t	t

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Tetraonidae of the Kostomuksha Nature Reserve

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Abstract

The number and distribution of four grouse species (capercaillie, black grouse, willow grouse and hazel grouse) were studied in the years years 1987-1993 in the Kostomuksha Nature Reserve. During the studies the most abundant species in the reserve were capercaillie and hazel grouse. Differences in their diet in autumn are compared with species from southern Karelia.

Key words: Grouse species, seasonal occurrence, habitats, feeding, Karelia, Russia

Introduction

The study of birds, including grouse species (Tetraonidae), began in the Kostomuksha Nature Reserve immediately after its founding. Until now there has been no publications of this region which would fully cover the biology and ecology of this family, whose representatives are of great ecological and economic value. Data on the species composition of birds, including grouse, were published in the 1970s by Karelian scientists (Danilov et al. 1974 1977). They quantitatively characterized the grouse population which had markedly changed in the past twenty years, as was noted in a review paper on the fauna of the reserve (Adrianova et al. 1990).

Study area

The Kostomuksha Nature Reserve is a mosaic system of insular woodlands separated by mires and lakes. Forests dominate the vegetation. Pine stands cover 245 559 ha (69.5% of land area), whereas spruce stands occupy 4700 ha (13.5%) and mires 5497 ha (15.7%). Other plant associations account for 1.3%.

Material and methods

The basis for the present paper was provided by the materials collected by the staff of the Guard and Science Sections of the Nature Reserve in the field studies during 1987-1993. Counts were made every month between November and March on permanenet routes using standard winter counting methods (Kuzyakin 1979). The routes were circular and about 8-12 km long. The observations lasted for two days and all encounters with grouse birds were registered. The biotope, the distance between the bird and the observer and the angle between the route as well as the direction to the bird were recorded. The researchers walked over 200 km a year. In addition, 1578 record cards which indicate the number of Tetraonidae encountered in various biotopes, were processed. Feeding was studied by examining the gizzards of the grouses shot in the neighbourhood during several hunting seasons. Altogether over 70 gizzards were examined.

Results

Five gallinaceous species, one species of the family Phasianidae (gray partridge) and four species of the family Tetraonidae (capercaillie, black grouse, hazel grouse and willow grouse), have been registered in this region during the 20th century. Gray partridge has not been observed since the founding of the reserve as there are no agricultural lands in the area nowadays. In the previous literature (Merikallio 1958) this species was characterized as a rare one. Thus, as partridge is not important for the taiga coenoses of the reserve it is not discussed in this article.

Hazel grouse is the most abundant bird in the reserve, and capercaillie is the second in order (Table 1). During the 7-year observation period the number of grouses varied a lot. The abundance peak of hazel grouse and capercaillie, which inhabit coniferous forests, was observed in 1989 and that of black grouse and willow grouse in 1993 (Table 1). Obviously, the abundance dynamics of Tetraonidae is largely dependent on the use of various habitats by the species. Three out of four Tetraonidae species, especially capercaillie and hazel grouse, became much less abundant which might be due to the unusual high air temperatures in the winter of 1989-90 (Annals of Nature 1991). In February, the average daily temperature was -1.2 °C, the snow was melting vigorously, and it often rained. By the end of February shrubs came into sight, and circular thawed patches were formed around the trees. It was much colder in March when the average daily temperature was -4.5 °C and the minimum temperature decreased to -9.8 °C. Such weather persisted in early March and a frozen snow-crust was formed. This crust could harm the grouse which stays overnight under the snow. A few dead birds, found after the snow had melted, indicate that such weather probably caused the mass death of the birds. Black grouse and willow grouse are not abundant. Their number varies greatly from year to year (Table 1), as indicated by their high coefficient of variation calculated for Poisson distribution (Ivanter & Korosov 1992).

Hazel grouse *(Bonasa bonasia L.)*, the most abundant Tetraonidae species of the reserve, inhabits pine and spruce forests (Table 2). However, it is inferred from the spruce-pine-forested area ratio, that hazel grouse prefers the former biotope and seldom stays on mires and in cutting areas although some birds were seen along their margins. The abundance peak of hazel grouse was reported in 1989 (Table 1). Our itinerary was the shortest that year, but the Table 1. shows the real abundance of the species because these data are supported by visual observations and oral evidence for adjacent areas received from the hunters. The first clutches appear in early June, and the first hatched broods are observerd between 26 June and 3 July.

Table 1. Numbers (ind./km) of Tetraonidae in the Kostomuksha Nature Reserve. (The total length (km) of annual itineraries is given in parentheses.)

Species	1987 (252,1 km)	1988 (227,9)	1989 (125,0)	1990 (263,3)	1991 (455,8)	1992 (303,2)	1993 (262,0)	Average long- term density	CV %
1. Capercaillie	3,1	4,0	45,2	5,7	5,7	3,8	5,8	10,7	6,5
2. Hazel grouse	2,3	8,7	61,3	7,0	10,3	7,0	12,8	15,6	4,6
3. Black grouse	0,6	0	2,5	0,5	0,1	0,7	5,2	1,4	52,6
4. Willow grouse	3,5	2,4	0	2,9	0,1	0	8,4	2,5	47,6

Table 2. Occurrence of Tetraonidae in various habitats.

		Hazel grouse				Capercaillie		
		Season				Season		
Biotope	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Pine forest	64,7	42,9	43,7	38,9	72,1	60,4	62,0	68,1
Spruce forest	35,3	45,7	46,0	49,2	9,3	12,6	16,9	19,0
Cutting area	0	2,9	5,6	0	0	13,2	4,4	3,2
Mire	0	8,5	4,8	11,9	18,6	13,8	16,7	9,7
		Black grouse				Willow grouse		
		Season				Season		
Biotope	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Pine forest	12,1	39,8	38,1	27,1	0	18,7	0	33,3
Spruce forest	36,4	9,7	23,8	5,1	1,7	1,3	0	33,3
Cuting area	18,2	9,7	28,6	16,1	36,7	43,8	0	0
Mire	33,3	40,8	9,5	51,7	61,7	25,0	100	33,3

Capercaillie (*Tetrao urogallus L.)*, represented by the Karelian subspecies *Tetrao urogallus karelicus* Lonn. (Anon. 1987), is the biggest bird of the family in the reserve. The abundance peak of this species, like that of hazel grouse, was recorded in 1989 and supported by indirect evidence. In the fall of 1989, groups of 5-7 males were often seen. In all seasons capercaillie was most commonly encountered in pine stands (Table 2). It was also seen in other biotopes, but, considering the insular pattern of woodlands and their habit to fly over larger open areas than hazel grouses, it should be noted that this species avoids only large dense spruce forests. The first traces of its wings on the snow were seen on 10 March, but mating began in mid-April and continued until mid-May. Some males mated until the end of May. In one case, a male was observed to utter its mating-call in the presence of two females on 14 June. Egg-laying was reported earliest between 20 and 27 May, and the first broods were seen on 24 June. In the sex structure of capercaillie males predominated over females, but in 1988 and 1989 females slightly dominated over males, and sometimes the sex ratio was 1:1 (Table 3).

Table 3. Sex structure of capercaillie

Year	Females	Males	Young birds	Sex not determined
1987	50	85	10	3
1988	84	70	94	31
1989	44	41	90	23
1990	56	104	68	5
1991	45	73	38	4

Black grouse (*Tetrao tetrix L.)* is common, but not abundant. Its abundance peak was observed in 1993. It is more evenly distributed than other Tetraonidae (Table 2) with a slight preference of mires. Males began mating in the first ten days of May and continued until early June. In the initial period males were often observed to be mating on ice-covered lakes. Black grouses were sometimes seen to mate in early fall. Incubating females were first encountered between 27 May and 3 June. Out of four nests found, one was revealed in a marsh tea pine forest, another one in a blueberry spruce forest and two in a blueberry pine forest. Hatched broods were first met from 28 June to 1 July.

Willow grouse *(Lagopus lagopus L.),* represented by the subspecies *L. l. pallasi* Port., typical of the taiga subzone, is not abundant either. In connection with some biological characteristics of this species it was mainly registered in autumn and in winter. Its abundance peak was observed in 1993. In the reserve willow grouse typically inhabits open biotopes such as mires and cutting areas extending along country roads (Table 2).

It has been found by analysing the gizzard contents that the food spectra of grouse species are similar in the autumn (Table 4). Both capercaillie and hazel grouse eat various berries, primarily lingonberries *(Vaccinium vitis-idae)* and blueberries *(Vaccinium myrtillus)* when grass and shrubs are not yet completely covered with snow. In fall, cranberries *(Vaccinium oxycoccos)* are not essential for either the hazel grouse or capercaillie that inhabit the reserve, but in South Karelia cranberries and lingonberries are their main food (Annenkov 1981).

Table 4. Occurrence of various food types in the rations of hazel grouse and capercaillie, %

Food type	Hazel grouse	Capercaillie
Vegetative parts of plants:		
Pine (needles and twigs)	-	60,7
Spruce (twigs)	-	3,6
Juniper (branches)	-	17,9
Willow (buds, twigs)	24,4	-
Alder (buds)	22,0	-
Blueberry (shoots)	31,7	67,9
Crowberry (shoots)	-	25,0
Heather (shoots)	-	10,7
Lingonberry (leaves)	4,9	67,9
Butterbur (leaves)	-	3,6
Seeds and berries:		
Birch (aments)	46,3	-
Blueberries	73,2	35,7
Lingonberries	80,5	50,0
Cranberries	2,4	7,1
Crowberry	9,8	28,6
Cowwheat	65,9	3,6
Sedge	7,3	17,9
Reedgrass	9,8	-
Invertebrates	24,4	7,1

In early autumn blueberries, lingonberries and cowwheat *(Melampyrum sp.)* seeds are the main constituents of hazel grouse's diet. As winter approaches, the role of blueberries and cowwheat becomes less important, whereas coarser food such as the vegetative parts of trees and bushes as well as reedgrass *(Calamagrostis sp.)* seeds and blueberry twigs, not eaten in early autumn, form part of its ration. It should be noted that the above changes in hazel grouse's ration are not related to the inaccessibility of berries and other early autumn food types caused by snow, because berries and the vegetative parts of willow *(Salix caprea)*, alder *(Alnus incana)* and blueberry were found in large quantities in most of the hazel grouses shot in late fall. Until mid-September and even later young hazel grouses eat invertebrates in high quantities.

Transition to pine needles in capercaillie's ration is not due to the unavailability of other food items either. The gizzards of some individuals were filled with needles and those of others contained blueberry twigs and leaves as well as lingonberries. In late autumn, a capercaillie whose struma was filled with needles and blueberry twigs, was shot. The ration of a capercaillie caught in late October was also very interesting. Its struma was mainly filled with heather *(Calluna vulgaris)*, but butterbur *(Andromeda polifolia)* leaves and lingonberries were also present in large quantities. Besides, its struma contained two pine twigs with dry needles.

The rations of black grouse and willow grouse are similar to that of hazel grouse, as indicated by the analysis of the struma of each species. Black grouse's ration is dominated by birch *(Betula sp.)* buds, lingonberries, bog bilberries *(Vaccinium uliginosum)* and cowwheat seed capsules, whereas willow grouse prefers blueberry twigs.

Conclusions

The most abundant Tetraonidae of the Kostomuksha Nature Reserve are hazel grouse and wood grouse whose average number during the study period was 7.7 and 4.7 ind./1000 ha, respectively. Black grouse and willow grouse are less common (0.7 and 1.5 ind./1000 ha). In the past 20 years the number of willow grouse decreased so markedly that it can no longer be considered a major species. (Danilov et al. 1974). The abundance peak of capercaillie and hazel grouse, observed in 1989, was followed by a decline presumably caused by winter weather. The diet of North Karelian Tetraonidae is similar to that of South Karelian species (Annenkov 1981), but there are some differences, e.g. the almost complete absence of cranberries. Transition to winter food is not directly related to the unavailability of autumn food types caused by a thick snow cover.

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Notes on the mammal fauna of the Kostomuksha Nature Reserve

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Abstract

The mammal fauna of the Kostomuksha Nature Reserve is structurally typical of northern boreal forests. It is characterized by relatively poor species composition and low abundance. The penetration of southern forest fauna and subarctic animals in the Kostomuksha area seems to result from changes caused by human activities. In the mammalfauna inventory, which began in 1985, 40 mammal species were registered.

Key words: Mammal species, predators, species density, human impact, Kostomuksha Nature Reserve

Introduction

The mammal fauna of the Kostomuksha area has been studied by the Karelian Research Centre in 1971-74 (Danilov et al. 1974; Danilov et al. 1977; Ivanter et al. 1974) before the beginning of the industrial development in Kostomuksha in 1976. Observations were later made occasionally when organizing the nature reserve. The Kostomuksha area is one of the few territories in Northern Europe where large virgin forests, with characteristic typological conditions and fauna, grow near urbanized and industrially developed areas. Some present-day characteristics of the study area can be used to assess the changes in mammal fauna at the early stages of industrial development in natural northern taiga ecosystems.

Material and methods

The materials provided by the mammal fauna inventory, which began in the Kostomuksha Nature Reserve in 1985, are briefly reviewed in the present paper. The data was collected by winter tracking and by trapping small mammals. Information received from hunters of the Kostomuksha region was also used. There has not been any detailed studies of small mammals in the adjacent areas of the nature reserve during the period of our researches.

Results

According to the data available in the literature (Danilov 1975; Danilov & Tumanov 1970 and 1976; Isakov 1939; Marvin 1948 and 1959; Siivonen 1979) and the information received from the staff of the reserve in 1986-1993, 40 mammal species occur in the nature reserve and its environs (Table 1).

Table 1. Occurrence of mammal species in The Kostamuksha Nature Reserve in 1986–1993. Symbols: ? = probably occurs; + = species registered for certain; – =species not registered for certain.

No	Species	Occurrence in the Kostomuksha area, based on literature	Our data	
			In the Reserve	In the adjacent area
1.	Common hedgehog (*Erinaceus europeus)*	-	+	+
2.	Common shrew (*Sorex araneus*)	+	+	+
3.	Masked shrew (*Sorex caecutiens*)	+	+	-
4.	Lesser shrew (*Sorex minutus*)	+	+	-
5.	Pygmy shrew (*Sorex minutissimus*)	+	+	-
6.	Graves shrew (*Sorex isodon*)	-	+	-
7.	Water shrew (*Neomys fodiens*)	+	+	-
8.	Northern bat (*Eptesicus nilssoni*)	+	+	+
9.	Mountain hare (*Lepus timidus*)	+	+	+
10.	Flying squirrel (*Pteromys volans*)	+	+	-
11.	Red squirrel (*Sciurus vulgaris*)	+	+	+
12.	Canadian beaver (*Castor canadensis)*	+	+	+
13.	House mouse (*Mus musculus*)	-	-	+
14.	Norway rat (*Rattus norvegicus)*	-	+	+
15.	Muskrat (*Ondatra zibethica*)	+	+	+
16.	Water vole (*Arvicola terrestris*)	+	?	?
17.	Field vole (*Microtus agrestis*)	+	+	-
18.	Root vole (*M. oeconomus*)	-	?	-
19.	Bank vole (*Clethrionomys glareolus*)	+	+	+
20.	Northern redbacked vole (*C. rutilus*)	+	+	-
21.	Large-toothed redbacked vole (Grey-sided vole) (*C. rufocanus*)	-	+	-
22.	Wood lemming *(Myopus schisticolor)*	+	+	+
23.	Otter (*Lutra lutra*)	-	+	+
24.	Badger (*Meles meles*)	+	+	+
25.	Wolverine (*Gulo gulo*)	-	+	+
26.	Pine marten (*Martes martes*)	+	+	+
27.	Weasel (*Mustela nivalis*)	+	+	+
28.	Stoat (*Mustela erminea*)	+	+	+
29.	American mink (*Mustela vison*)	+	+	+
30.	European mink (*Mustela lutreola*)	+	-	-
31.	Polecat (*M. putorius*)	-	?	+
32.	Brown bear (*Ursus arctos*)	+	+	+
33.	Wolf (*Canis lupus)*	+	+	+
34.	Fox (*Vulpes vulpes*)	+	+	+
35.	Raccoon dog (*Nyctereutes procyonoides*)	?	+	+
36.	Lynx (*Felis lynx*)	+	+	+
37.	Wild boar (*Sus scrofa)*	-	-	+
38.	Reindeer (*Rangifer farandus fennicus)*	+	+	+
39.	Roe (*Capreolus capreolus*)	?	+	+
40.	Elk (Moose) (*Alces alces*)	+	+	+

Common shrew, which occurs in all the inland biotopes of the reserve, is the most abundant insectivorous mammal. Masked shrews are less numerous. They are typical of overmature spruce forests. Other Insectivora are less common. Lesser shrew is encountered in light mixed forests, on grasslands and along bog margins. Pygmy shrew inhabits green-moss and lichen pine stands. Graves shrew was regularly trapped north of the River Kivijoki, but only two individuals were caught in fall in 1993 and in spring in 1994 in a blueberry spruce stand, south of the river. One shrew was trapped in a lingonberry pine stand in the northern part of the reserve and another one in the city.

Water shrew is more evenly distributed over the reserve, but it is less common than Graves shrew. The abundance peak of this species was observed in 1993. Hedgehogs were occasionally reported from the Kostomuksha area in 1989-1990. A single individual was caught by a frontier guard on 21st September in 1990 near the southern boundary of the reserve 4 km from the nearest houses and 40 km from the city. It is not clear, however, why the hedgehog migrated so far north. The Northern Bat is scarce, but typical in the reserve. It is regularly met between late May and September.

In rodent fauna, bank vole is more abundant than other species and dominates among all small mammals. Like common shrew, this species is highly eurytopic. Its abundance is characterized by a four-year population cycle. Northern redbacked (Report of GF MGU 1989) and large-toothed redback voles are scarce and occur to the north of the River Kivijoki. Field vole prefers mires and haylands. In the latter habitat it often dominates over bank vole. Wood lemming is seldom encountered in the reserve. In years of decreased abundance it typically occurs in overmature coniferous stands, but in periods of mass production (1987-1989) it has been ubiquitous. Occasionally dead lemmings have been found at mink-inhabited sites near water bodies, in pike stomachs and in the city.

Canadian beaver is common (about 25 individuals). The highest density of this species is observed along the highways in the northern part of the reserve. The occurrence of water vole is deduced from its footprints found in Nilma Guba, Lake Kiitehenjärvi, but not a single individual has actually been seen. Muskrat is more abundant than the two previous semiaquatic rodent species, but here it is evenly distributed.

The occurrence of flying squirrel was detected from the feces found by an MGU expedition in the Middle River Kivijoki (Geographical dep. of MGU, 1989) and a single encounter was recorded in 1987. Red squirrel is less common in the study area than in other parts of Karelia. The sharp increase in its abundance in March 1989 resulted from its mass migration from adjacent areas which coincided with spruce cone maturation.

House mouse and Norway rat are typical synantropic mammals whose occurrence is restricted to residential areas. However, in 1991 a single Norway rat was seen in the Lower River Kivijoki.

The Kostomuksha area is inhabited by 17 predator species. Weasel, otter, fox and wolf are rare. Polecat is very rare in the Kostomuksha area. Two to three individuals are caught by hunters every year near lakes Luvajärvi and Nuokkijärvi (Adrianova et al. 1990) which lie to the north of its distribution area (Danilov & Tumanov 1976). The occurrence of badger, very seldom encountered in North Karelia, was reported (Danilov & Tumanov, 1970). In 1987, an uninhabited hole was revealed by a MGU expedition near the northern boundary of the reserve, and in 1993 a young female badger was encountered near Kontokki, 6 km from the eastern boundary. Raccoon dog, shot by hunters in the Kalevala area already in the late 1940s (Marvin 1948), was shot in 1992 near the southern boundary of the reserve.

Individual dogs and cats from adjacent settlements occasionally penetrate the study area. Reindeer and elk are not abundant, but fairly common. Some summer reindeer habitats were revealed. Until 1990, groups of five or more individuals were often met from March until December. In late September-October in 1987 and 1988, howling reindeers were seen near Lake Kalivo. However, individuals and groups of no more than three animals are more often met nowadays. The decline in the number of reindeers was presumably caused by the installation of a barbed wire fence along the state border which disturbed the natural migration of hoofed animals. Reindeers and young elks cannot overcome this barrier. In summer time they keep close to the fence, and in October they leave for Finland. Elk is less common than reindeer (Table 2.). Its typical habitats are cutting areas and grasslands formed in former residential areas where it stays in spring and autumn. In winter, elks usually migrate southwards.

In 1987-1988, bears were encountered in groups and individually near Kostomuksha and Kontokki. In 1990-1992, roes were seen to penetrate the reserve from Finland, where a stable roe population has existed since 1971 (Siivonen 1979) and thus it is obvious that the animals can easily migrate towards the reserve (Siivonen & Sulkava 1994).

The change of plant communities as a result of human influence has promoted penetration of some species, characteristic for southern and northern regions, to the nature reserve. Agriculture and regeneration of forests as a result of cuttings has created necessary conditions for the representatives of southern fauna such as badger, polecat, hedgehog and others. With the beginning of industrial development of the Kostomuksha region such species as Norway rat and house mouse were delivered here. It is necessary to note the high number of large-toothed red-backed vole in northern parts of nature reserve where human influence is strongest. Data received from the Lapland Nature Reserve (Kola peninsula) during 5 decades (Dr. G. Kataev, verbal notice) show that at present this species has become a dominant in the small mammal fauna. However, in the beginning of industrial development of this region, bank vole dominated here. The annual alternation of the number of voles and shrews is also obvious in regions which are disturbed by human activities and located in southern and northern Karelia (Ivanter 1975). Our data collected during an eight-year period show that such phenomenon was observed in parts of the nature reserve, where plant complexes such as meadows were maintained. During the whole period the bank vole was the most numerous in native forests.

Table 2. Density of some mammals in the Kostamuksha Nature Reserve in 1986–1993.

Species	PC	Density per 1000 ha 1986	1987	1988	1989	1990	1991	1992	1993	average long-time density per 1000 ha
		B = 194.2	B = 252.1	B = 227.9	B = 125.0	B = 263.3	B = 455.8	B = 303.2	B = 262.0	
1. Hare	1.3	23.30	26.06	23.3	9.8	21.3	11.4	7.07	7.3	16.6
2. Squirrel	4.3	5.63	9.09	12.2	24.8	30.8	23.8	17.72	3.4	15.93
3. Marten	0.53	0.57	1.27	0.3	0.24	0.86	0.48	0.7	0.9	0.67
4. Ermine	1.4	0.15	1.61	4.8	8.1	1.96	17.5	0.65	0.7	4.43
5. Least weasel	8.0	0.0	0.96	0.0	0.0	2.6	1.04	0.0	1.36	0.58
6. Wolverine	0.065	0.02	0.02	0.02	0.005	0.026	0.011	0.013	0.009	0.015
7. Lynx	+	0.09	0.02	0.08	0.27	0.2	0.08	0.005	0.02	0.12
8. Wolf	0.06	0.03	0.03	0.0	0.008	0.0	0.014	0.01	0.02	0.012
9. Fox	0.24	0.09	0.0	0.05	0.05	0.8	0.095	0.0	0.0	0.14
10. Elk	0.59	0.06	0.52	0.2	0.35	0.21	0.25	0.35	0.0	0.25
11. Reindeer	0.35	0.0	0.50	0.35	0.19	1.01	0.91	0.0	0.05	0.37

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Some aspects on the recent changes in the Kuhmo - Lake Kiitehenjärvi subpopulation of the wild forest reindeer (Rangifer tarandus fennicus Lönnb.).

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Abstract

The Kuhmo-Lake Kiitehenjärvi subpopulation of the wild forest reindeer has been investigated further after a couple of years´ pause since the end of 1980´s. It has been found out that the distribution area of the subpopulation now includes Kuhmo and partly the neighbouring communes as well. The whole distribution area is ca. 5000 km^2 in summer and ca 700 km^2 in winter, now situating further west than during the 80s. The subpopulation seems not to have been split into pieces, yet, though there are obvious signs for that on the southwestern part of the distribution range. The number of individuals was counted by using a helicopter in March 1993 767 heads in all, were detected which stands for the yearly increase of ca. 3 % since 1985 (621 inds.). The reproduction potential of the females equals to that of the 80s (> 90 % of adult females get calves) but the survival of the young individuals seems to be smaller now than in the middle of 80s, resulting that ca. 20 % less yearlings reach the age of adults. The main reasons for the observed deaths of individuals (ca. 2,6 and 4,6 % of the total number of the individuals in 1993 and 1994) are traffic (ca. 34 %) and the great carnivores (ca. 24 %), mainly the bear and the lynx. The reasons for the slow growth rate of the subpopulation are not known in detail, so far, as for instance the dispersion rate into the neighbouring reindeer husbandry area cannot be estimated. There is now a fence along the southern boundary of the reindeer husbandry area under construction to prevent the wild forest reindeer from migrating to that area and from mixing into the herds of the semi domesticated reindeer there.

Key words: Wild forest reindeer, Kuhmo-Lake Kiitehenjärvi subpopulation, Friendship Park

Introduction

Wild forest reindeer totally disappeared from Finland at the very beginning of the 20th century and then returned back in the 1950s. During the period of disappearance it survived in some areas of the Karelian Republic, most obviously in the surroundings of Reboly, Lendery and Peninge. The disappearence and the first return took place in Viiksimo, Eastern Kuhmo (Komulainen 1972, Siivonen 1972, Montonen 1974, Helle 1975, Sulkava 1979, Pulliainen et al. 1983, 1985 and Heikura et al. 1985). After its return to Finland the reindeer has slowly expanded its distribution area both during winter and summer.The distribution area now covers the whole municipality of Kuhmo.

The development of the subpopulation has been intensively followed mainly by the Fenno-Karelian research team for about 20 years since the 1970s. The results got during the research period have been reported in numerous connections (ao. Erkinaro et al. 1983, 1989, Heikura 1984, 1993, 1994; Heikura et al. 1983, 1985, 1989a; Lindgren et al. 1983, 1989; Pulliainen et al. 1981a,b, 1982, 1983, 1985, 1986, 1990 and Sulkava et al. 1983, 1989). Wild forest reindeer has also been connected into the establishment of the Friendship Park - being a generally speaking rare but a typical animal for that area - and thus included into the research program of the reserve.

In between 1990-1992 no intensive research work was done on the reindeer, though some more or less occasional observing was carried out. In the winter 1992-93 mainly climatical conditions (Pruitt 1985, Heikura et al. 1989b and Heikura 1993) caused the reindeer to appear in numerous herds and to move very fast westwards from its "traditional" wintering grounds around the Lake Lentua (Hänninen 1993). This in its turn caused additional pressure on the reindeer by the local inhabitants because of the fear of damages on agricultural lands along its moving routes and, becausethe reindeer appeared so numerously in new areas, as a potential game animal. On the other haud, there existed a need to protect the wild forest reindeer, due to the nearness of the reindeer husbandry area.

The basic knowledge, collected from the area and from Karelia (Danilov et al. 1983, 1986, Annenkov et al. 1989, Bljudnik et al. 1989, Danilov 1989, Pulliainen et al. 1983, 1990 and Pulliainen 1989) about the animal itself and its ecology in general existed and was available, but the up-to-date data for possible urgent administrative and practical decisions in this situation was lacking. To fill this gap, a continuation for the previous studies appeared to be necessary. Also, because of the fact that the subpopulation in question had its summer pastures on both the Finnish and Karelian territory and the strongly changed general situation in the Republic of Karelia, a part of the former USSR, was supposed to have some influence in the forest reindeer on the border zone of Finland and Karelia.

All this gave initiatives for starting again an intensive research period in the area of Kuhmo and its surroundings in Karelia. This work was started in February 1993 and is still continuing as a Fenno-Karelian program, which in practice is carried out by the Zoological Museum, University of Oulu and the Institute of Biology, Karelian Research Centre, RAS, Petrozavodsk.

The aim of this paper is to give some additional information about the wild forest reindeer today and to compare, in certain extent, that to the information got earlier (for further information about that see the publications mentioned above and listed at the end of this paper).

Materials and methods

The materials used here consist of the recordings made on field or of those made in the laboratory at the Zoological Museum of the University of Oulu (dead animals). The recordings made on field are besed on the direct sight observations, on the trackings performed by following the animals by a car, snow scooter, skis, boat or on foot, by radiotracking (28 individuals equipped with radiotransmitters in 1983-89 and 5 individuals since 1994 in Kuhmo) or by an aircraft or a helicopter (for counting the number of the individuals in the subpopulation). Radiotracking has been used especially for determining the time of migration, migration routes, summer and winter pastures and for detecting the accurate position of each individual. The batteries of the transmitters last ca. 3,5 years. This data is collected daily, year around, by specially trained field technicians.

The data collected in the laboratorywas receired got from the dead animals found in Kuhmo and transported to Oulu or from the heads or other remnants of those, in the cases it was not possible to get the whole animal into the laboratory. This part of the work was performed as a normal museum routine. The methods used in specific cases are discussed in the papers published previously (see the list of publications).

Results

Changes in the summer and winter ranges and the migrations between them

Up to about 1985 the main summer grounds were situated either on the Karelian territory, even rather far behind the Finnish-Karelian border, or along a rather narrow zone west of it in Finland reaching down to the southern/eastern parts of Kuhmo. The main wintering grounds were near the Lake Lentua (Fig. 1), but did not spread west of it. Since 1985 the summer grounds have enlargened mainly westwards but also northwards into the reindeer husbandry area in Finland. At the same time the Karelian part has become narrower. At the end of 80´s the migration routes turned more and more northwards along the border zone It has been estimated that about 1/3 of the individuals leaving their wintering grounds around Lake Lentua or west of it ended up in the southern parts of the reindeer husbandry area and none of them went across Lake Kiitehenjärvi in Karelia. The migration routes along the borderzone southwards still existed as before, but the radiotraced individuals did not get out of the range of the receiver any more, which means that also there the summer range of the reindeer had got narrower. The number of individuals migrating into this direction had also diminished. The summer range enlargened at the time reaching almost the entire municipality of Kuhmo, though so that the density of individuals being greatest in the traditional summer areas.

The spring migrations started, as a rule, at the middle or on the second half of April from the wintering grounds and lasted about three weeks depending on the length of the migration and surrounding circumstances. The autumn migration started soon after the rut, in October-November, ending at the shores of Lake Lentua at about the middle of December. Investigative wanderings have been observed, reaching even further than ca. 30 km (the most remote observations have been made by local inhabitants in Paltamo, Kontiomäki; Sotkamo, Maanselkä Kalliojärvi and Valtimo, Halmejärvi) from the main wintering grounds, during each winter. These have not, so far, resulted in forming of new satellites - new wintering areas separated from the main winter range-but all the individuals of the subpopulation appear as one relatively tight wintering herd. The size of the main wintering range is now ca. 700 km^2.

In the winter 1992-93 the autumn migration seemed to start - according to sporadical observations - normally, but it turned into rapid mass movement westwards over the Lake Lentua soon reaching the westernmost boundaries of Kuhmo and giving an impression of great numbers of reindeer moving around. The centre of the wintering area was in the western Kuhmo and the reindeer were moving there in rather small groups. During the helicopter counting in March 1993, 83 groups were met, sizing 9,3 individuals/group on an average (distribution of the groups according to the number of individuals in them was as follows: 1-5 inds. 42,2%, 6-10 27,7%, 11-15 9,6% 16-20 7,2%, 21-25 7,2%, 26-30 3,6% and 36-40 individuals 2,4%). The largest group met was composed of 38 individuals. Some of the groups were met also in the area south of lake Ontojärvi, southwestern Kuhmo, giving an impression of an enlargening winter range and even the splitting of it.

The spring migration started already in the last week of March continuing until the middle/second half of April, as before. The main summer grounds covered almost all the Kuhmo, southern parts of Suomussalmi and southeastern parts of Hyrynsalmi (see Fig.1). The greatest densities of individuals were met in the northern and eastern parts of the summer range, but the number of individuals in summer was increasing also in the western part of Kuhmo as well as locally in some of the southern areas. In the southeastern part, which was one of the main summer areas in 80´s,the number of individuals met was decreasing. The same trends were observed in 1994 as in 1993 conserning the timing of the migrations as well as the areal densities. The main summer grounds is nowadays ca. 5000 km^2 by its size.

The migration routes have principally kept their original structures also in 1993 and 1994, but new routes have been formed both southwards and northwards from the wintering area. Also changes the old routes have taken place. Especially those leading to southeastern directions have become weaker and are bending even more northwards and southwards along the borderzone than at the end of 80´s. This is due to the decreased number of individuals spending their summer in the southeastern parts of the range.

Some of the individuals did not change their summer and winter grounds at all or moved only for very short distances already in the middle of 80´s (on the isles of Lake Lentua and in some parts of the eastern shores of it) thus being residents. This has been observed also in 1993 and 1994 there and around Lake Kellojärvi. These individuals have previously been mainly calving females with yearlings, but in 1993 and 1994 also a relatively large amount (up to ca. 40 inds.) of adult males were observed, forming groups, acting the similar way in the forest area between Lake Ontojärvi and Lake Kellojärvi, ca. 20 km northwest of the centre of Kuhmo.

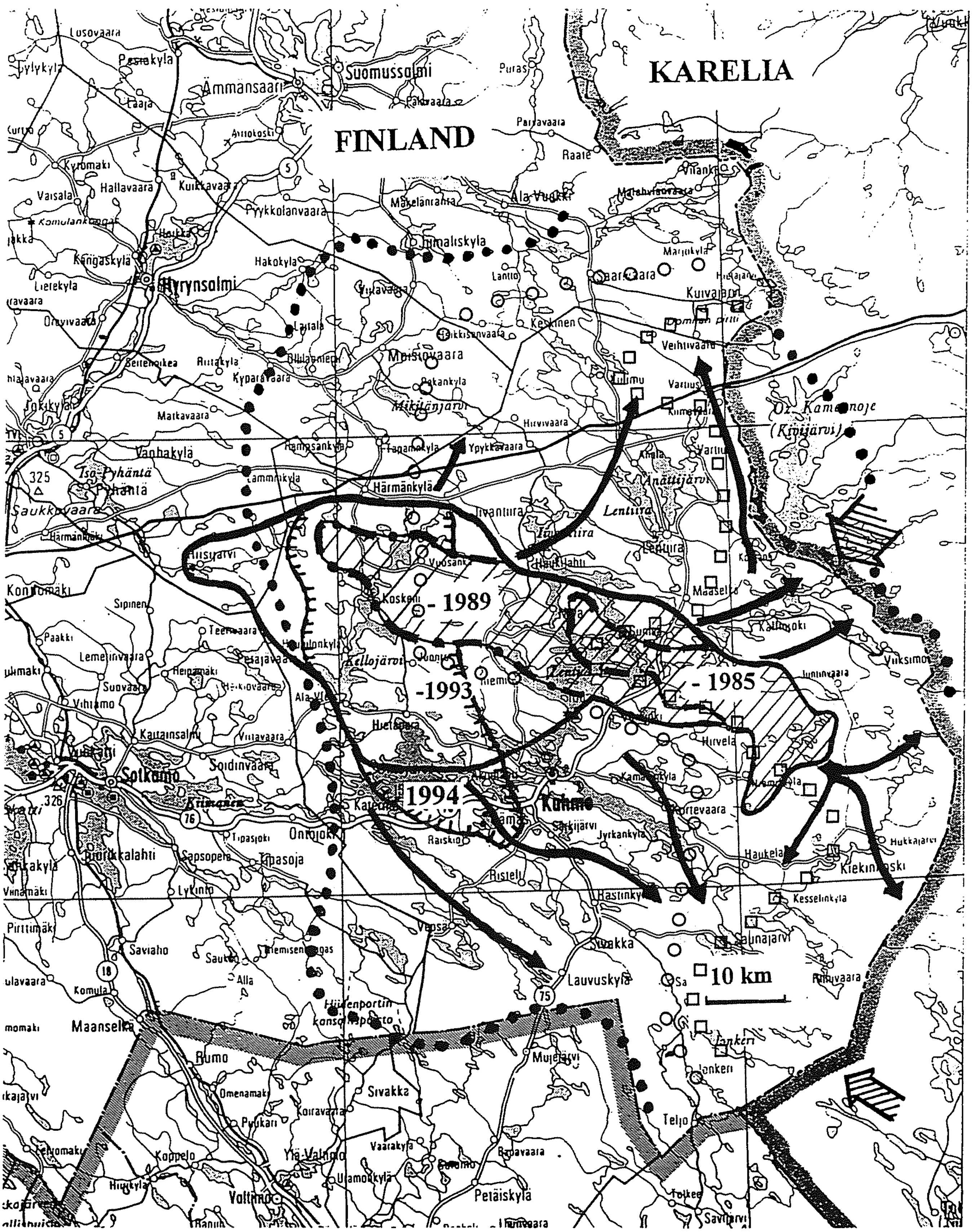


Fig. 1. The changes in the winter and summer grounds of the Kuhmo-Kiitehenjärvi subpopulation of the wild forest reindeer. The boundaries of summer grounds are shown by dotted lines (open squares: - 1985, open circles - 1989 and black dots - 1994). The black arrows show the recent run of the main migration routes and the hatched arrows the directions where the pionaar individuals arrived from.

The distribution of the observations of the wild forest reindeer onto different types of landscape

When observing the wild forest reindeer on field, also a habitat description of the place where the animals are met, is prepared. The material used here consists of those cases in which it has been possible to observe the animals without disturbing them. Examining the seasonal distributions of the observations (Fig. 2A, B and C) one can notice, that the pine forests are used all year round but especially in the winter. A decrease in the percentages of observations in pine forests along the research periods from 1985-87 to 1993-94 was detected trough. The watercourses and shores were mainly used during the winter period, as for resting sites and moving routes. The portion of those has also decreased a bit during recent years. This can be influenced by the allover change in the main landscape structure as well as by the phenomenon that the reindeer uses clear cuttings as substitutes for open lakes. The bogs and mires have mainly been used during the warmer period, mainly in the summer. They are offering suitable surroundings for females and their offspring in many respects, and for males they provide for excellent resources of food. The spruce forests are mainly used in the spring or early summer as calving sites, providing relatively cool and sheltered circumstances. They are also to some extent used in winter for grazing on the tree lichens, but this seems to be of minor importance in this area. As to calving sites, it has been observed that the wild forest reindeer can accept also other types of habitats than just spruce forest as for calving surroundings, most of them successfully (clear cuttings seem to be calving sites fatal to newborns). The use of the anthropogenic landscapes (agricultural lands, clear cuttings, sapling stands) has clearly increased (from ca.16 % in 1985-87 to ca. 29 % in 1993-94). This is due to the migration routes between the summer and winter areas nowadays being longer than before thus and the routes increasingly pass through both agricultural and actively reforestred lands. Also the summer and winter pastures are nowadays situated in those kinds of landscape because of the increased number of the individuals and of the increased degree in the economical use and handling of forested terrains.

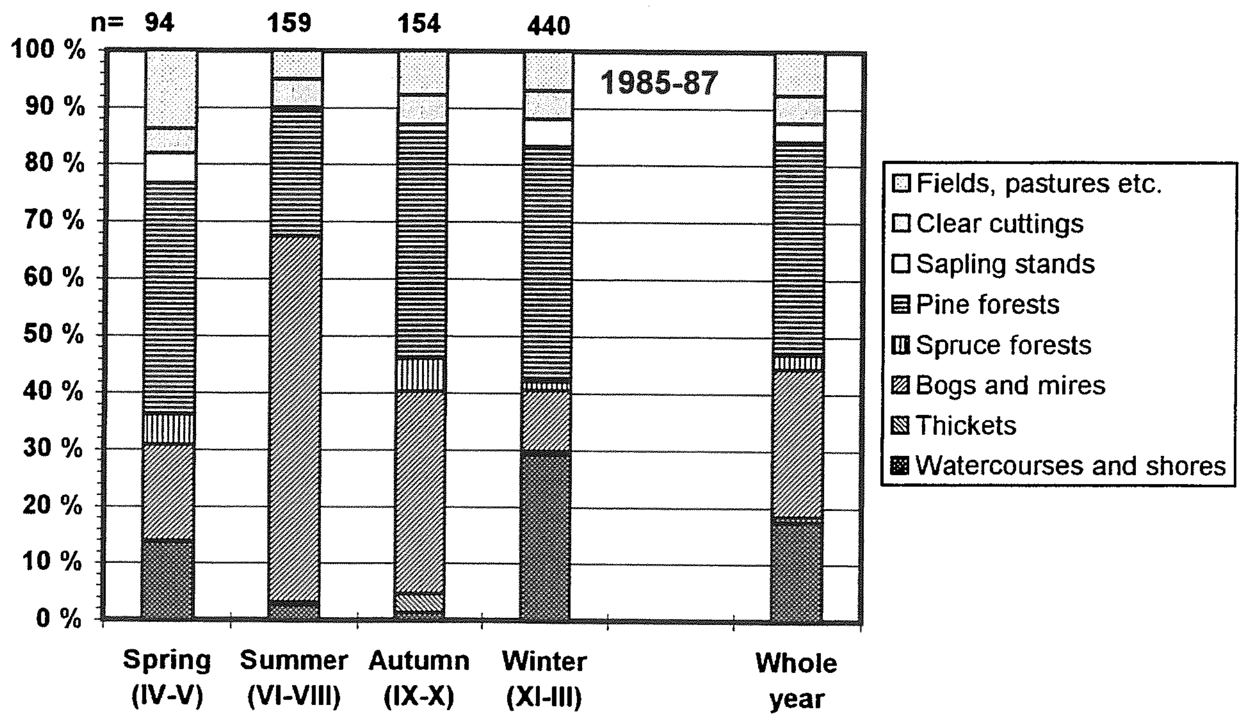
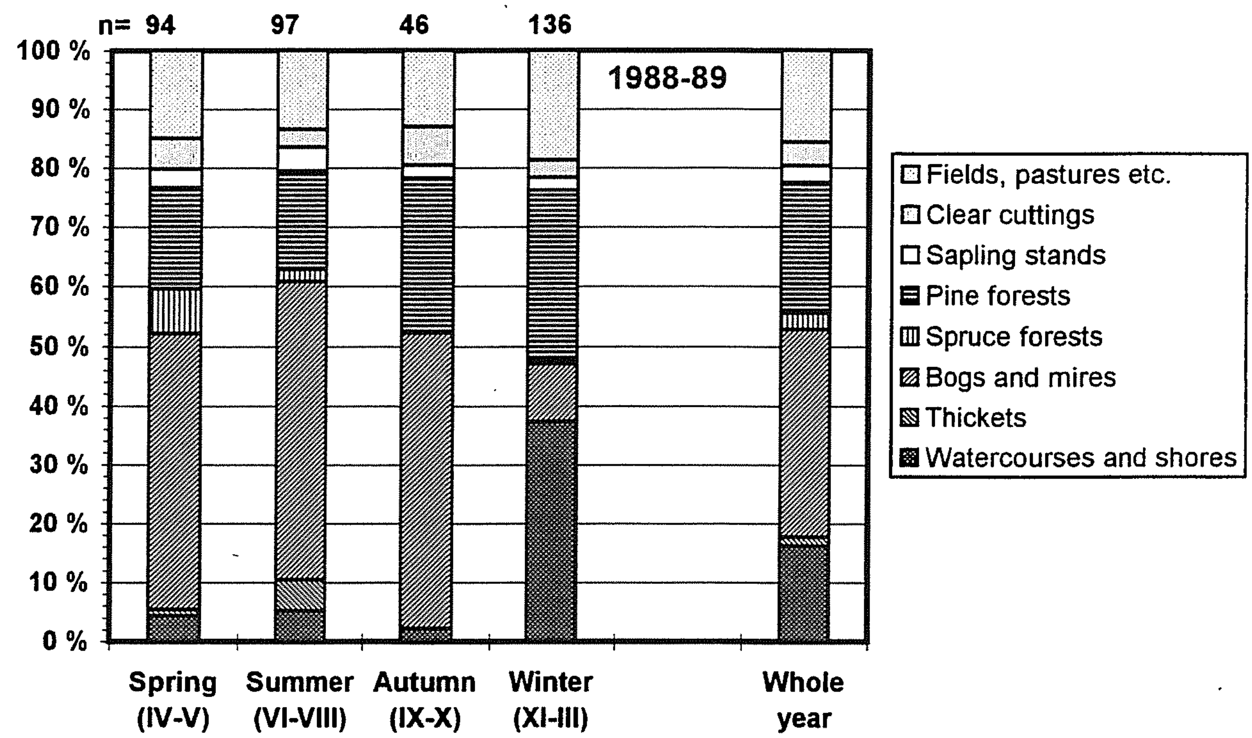
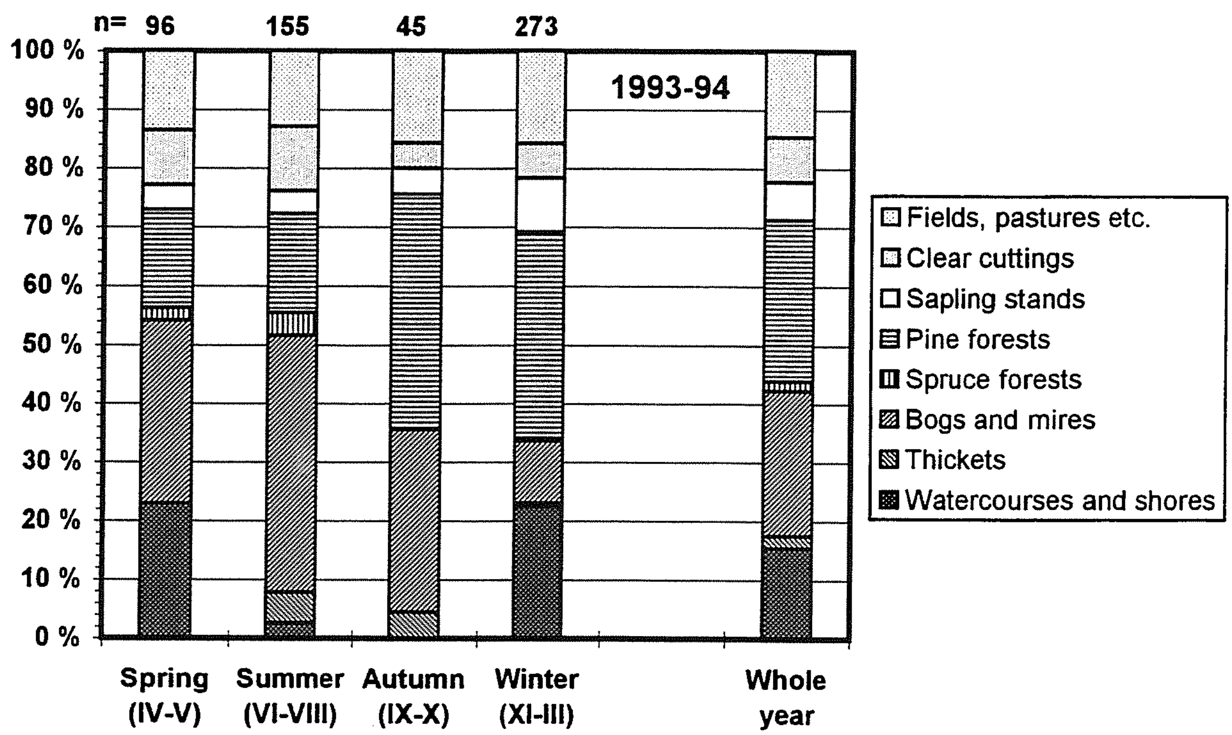


Fig. 2. (A, B, C). The seasonal distribution (in percentages) of the observations of the wild forest reindeer on different types of landscapes.


n= 94
97
46
136
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
1988-89
Spring (IV-V)
Summer (VI-VIII)
Autumn (IX-X)
Winter (XI-III)
Whole year
Fields, pastures etc.
Clear cuttings
Sapling stands
Pine forests
Spruce forests
Bogs and mires
Thickets
Watercourses and shores


n= 96
155
45
273
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
1993-94
Spring (IV-V)
Summer (VI-VIII)
Autumn (IX-X)
Winter (XI-III)
Whole year
Fields, pastures etc.
Clear cuttings
Sapling stands
Pine forests
Spruce forests
Bogs and mires
Thickets
Watercourses and shores

Changes in the number of the individuals in the subpopulation.

The number of the individuals in the subpopulation has been counted or estimated since 1971 yearly with the exception in 1986,1987 and 1990-92 (Fig. 3). The countings have been performed as ground estimations in 1971-74 and 1988-89. An airplane has been used in 1975-79 and a helicopter in 1981-1985 and 1993.

The number of the individuals has not increased uniformly along the whole observation period (since 1971). There has been a clear increase in the number between 1972 and 1974 after which no change has taken place within 5 years. There has been a rapid increase between 1978 and 1982 after which a decrease of ca. 200 individuals (1/3 of the whole subpopulation) has been met. Between 1983 and 1985 an increase of the same magnitude has occurred and the subpopulation size was the same as in 1982. After 1985 no accurate countings have been carried out until 1993, but the estimations from the years 1988 and 1989 can be thought to reflect relatively reliable figures because they were made by the experienced field technicians of the research team. In any case the increase in the number has been slower during the last ten years than during the ten previous ones. The helicopter counting in 1985 gave a number of 621 heads for the amount of reindeer in their wintering grounds. The recent counting in 1993 was carried out on 23-25 March and gave 767 heads as the result. When this result is compared to that in 1985, the average yearly increase in the subpopulation is only ca. 3%. This is less than 1/7 of the growth observed in a reintroduced herd of ca. 250 individuals in Central Finland (Kojola 1994).

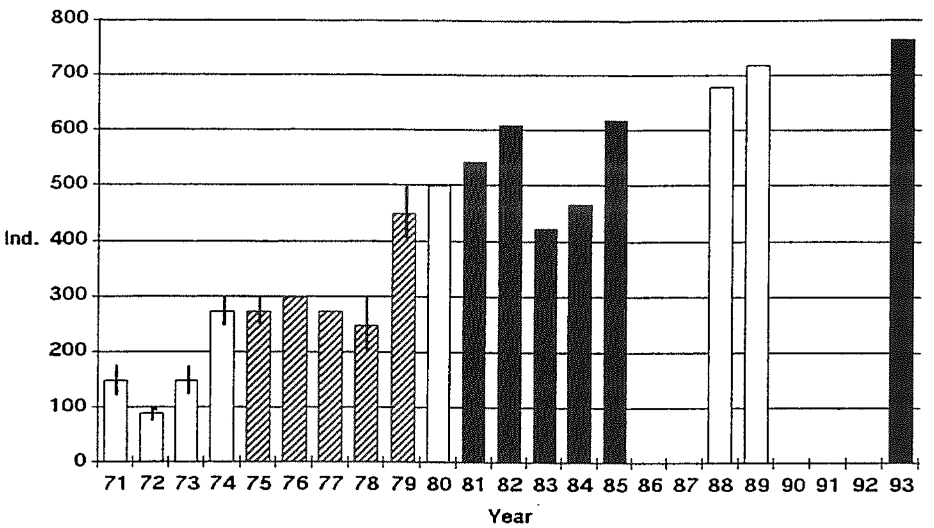


Fig. 3. The growth in the number of the wild forest reindeer in the Kuhmo-Kamennojeozero subpopulation counted in March by helicopter (blac), aircraft (hatched) or ground observations (white columns).

Population structure and the survival of calves

The population structure has been calculated as an annual average from those groups in which all the individuals have been recognizable by sex and age-class (males, females, calves and yearlings) (Table 1).

Table 1. The population structure of the wild forest reindeer in Kuhmo

Classes Years	Males %	Females %	Calves %	Yearlings %	Number of observations	Total amount of individuals observed
1985-87	26,2	32,1	23,2	18,3	644	3606
1988-89	22,9	42,2	20,9	14,0	373	2207
1993-94	27,1	36,8	20,9	15,2	543	3279

The percentage of males has been smaller during all the periods than that of females, most clearly so in 1988-89. The percentage of calves and yearlings has been highest during the period 1985-87 and during the two other periods about the same.

When the monthly population structure has been examined (Fig. 4) around a year (as the mean of the periods 1988-89 and 1993-94 combined) one can notice that the changes are reflecting the changes in the seasonal activities of the individuals. Most clearly that is observable during the calving period and short after that (from May to July). At the time the male portion of the population is most difficult to observe and the groups formed by females, calves and yearlings are most visible when grazing on open bogs. This is not the only reason for the changes in the percentages at that time, because the increase of newborn calves appears most clearly in June (somewhat already in May) and correspondingly those individuals having been calves during the previuos months turn into yearlings.

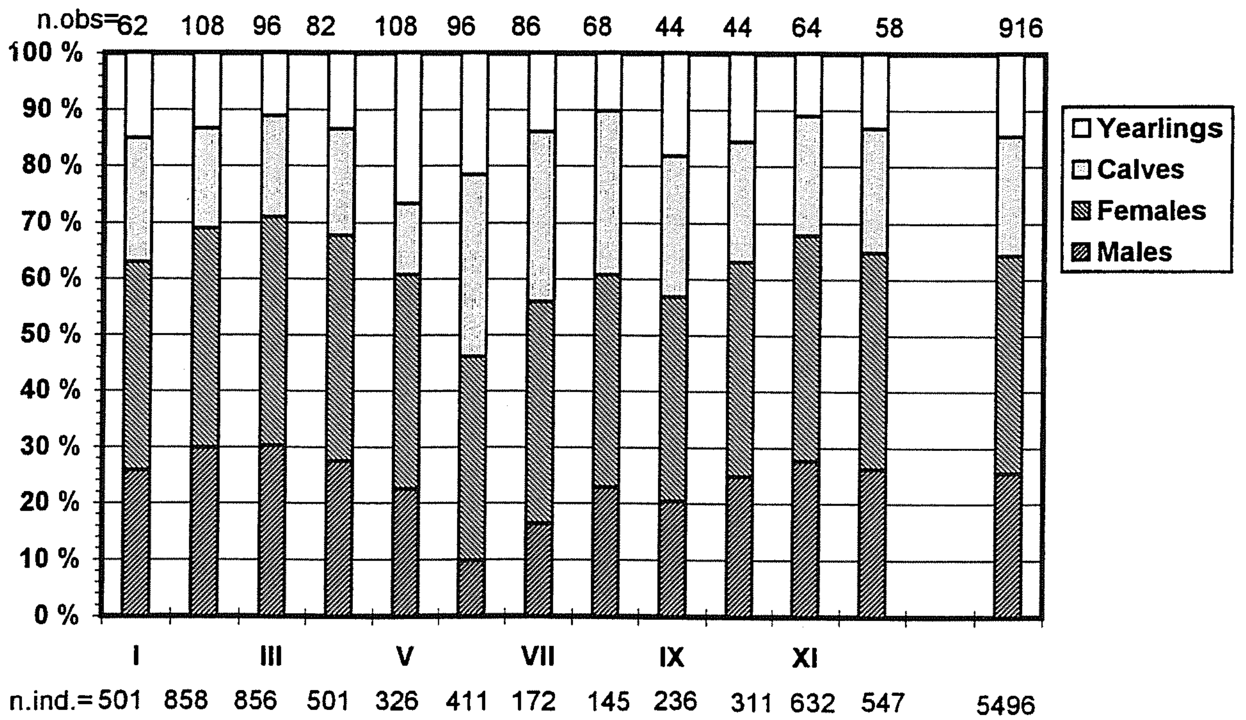


Fig. 4. The population structure of the wild forest reindeer as monthly means according to field observations for the periods of 1988-89 and 1993-94 combined.

When the ratio of calves and yearlings to females is discussed more in detail (Figs. 5 and 6), it can be noticed that almost all the reproductive females get calves (the calf/female ratio in May is > 90%). After May that ratio decreases until next

April, being steepest between July and Nowember/December. After this, now among the yearlings, the decrease in the ratio is slower. During the periods of 1986-87, 1988-89 and 1993-94 (number of observations 475, 373 and 543, respectively) the decrease in the ratio has been rather uniform, though resulting in 1988-89 in ca. 10 %-units smaller calf/female-ratio than during the other two periods. This is also visible in the yearling/female-ratio (Fig. 6). When these time periods are compared to the results from the middle of 80´s it is clear, that the decline in the survival rate during the latter periods is steeper resulting in less yearlings to grow up.

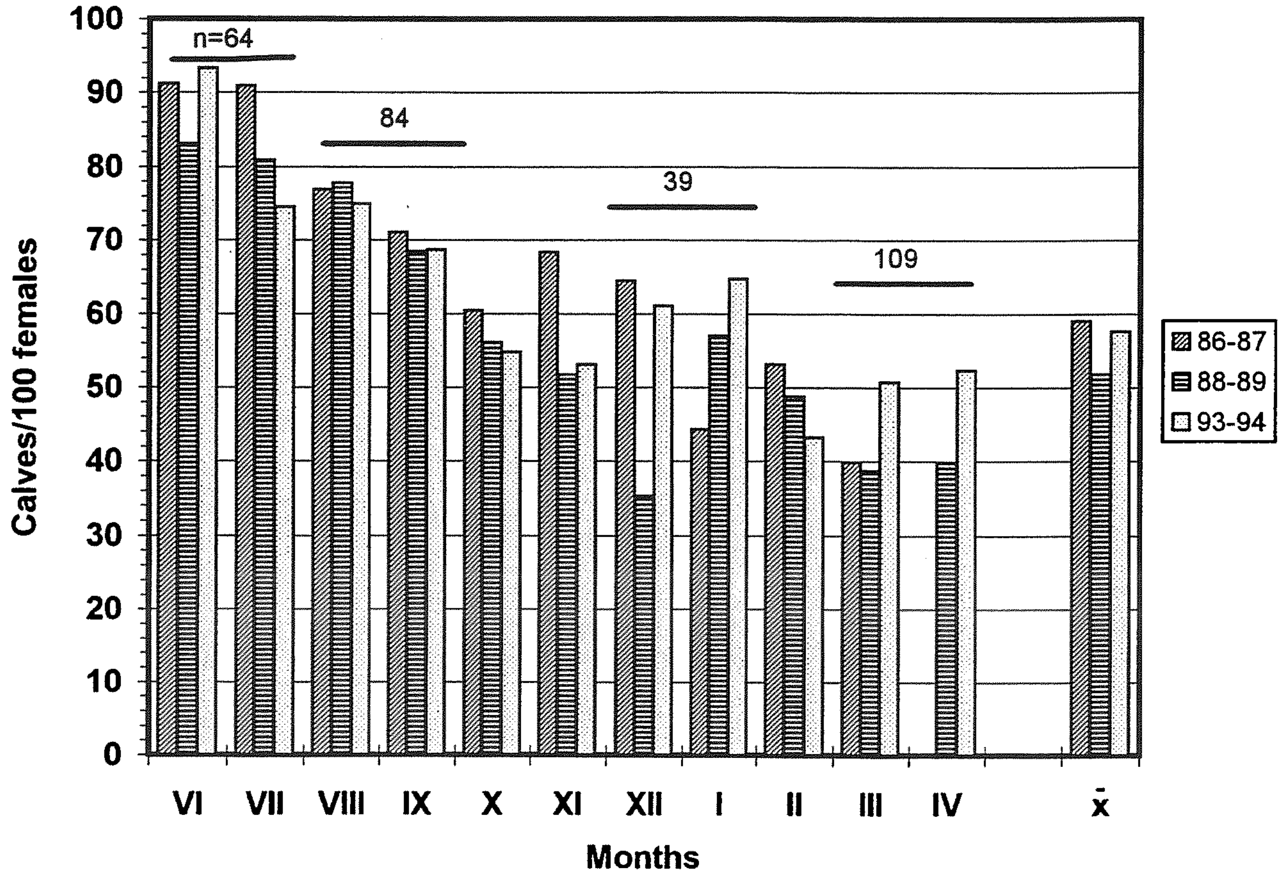


Fig. 5. The calf/female ratio in the wild forest reindeer in Kuhmo

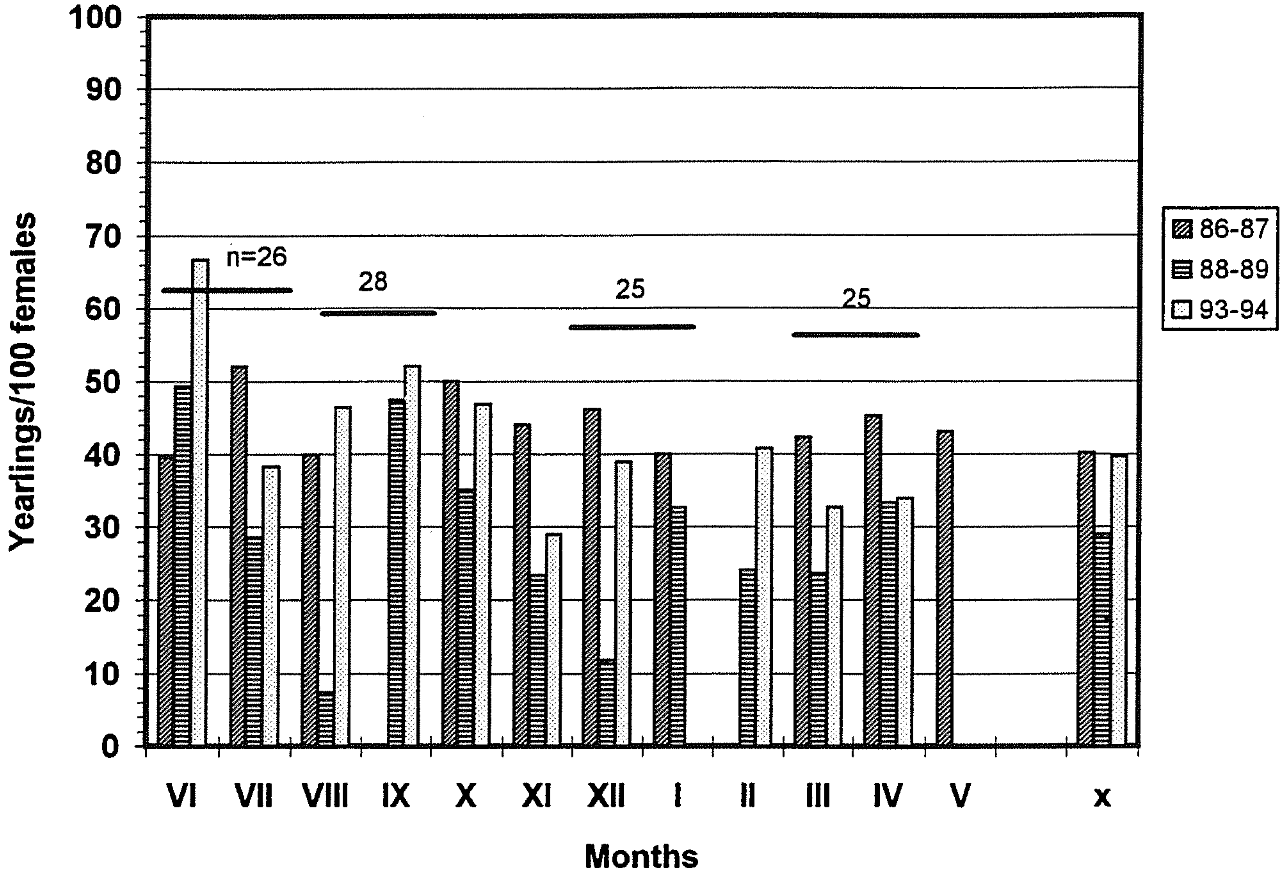


Fig. 6. The yearling/female ratio in the wild forest reindeer.

Causes of death

In Finland wild forest reindeer has been totally protected by law until 1993 and thus any legal hunting has not been regulating the number of individuals in the subpopulation. For the same reason most of the animals found dead in the area have been reported or delivered to the Zoological Museum in the University of Oulu. In addition to that the intensive research work carried out in Kuhmo has given information about dead animals and the reasons of their death. A special interest has been paid into the influence of large predators and also into human activities in that respect.

The first report of the causes of death was given by E. Lindgren et. al (1989) on the basis of the material collected in field and in the laboratory at the Zoological Museum between 1971-1988, most accurate observations being from the period 1979-1988 Additional material is now available also from the years 1993-94.

Table 2. Causes of death, in percentages, among wild forest reindeer according to the material collected on field and in the laboratory at the Zoological Museum.

Cause Years	Traffic accident	Large carnivores	Shot for hum. reasons	"Hunting accidents"	"Natural death"	Reason unknown	Number of observations
1979-88	5,9	36,4	12,5	4,5	3,4	37,5	98
1993-94	33,8	23,7	5,1	6,8	13,6	16,9	59

The death caused by traffic has increased strongly since 1988 as well as so called natural deaths. The reason for the last mentioned is mainly because of the difference in the classification and the more increased efforts to try to solve the reasons of death as accurately as possible in 1993-94. Natural deaths include ao. old age, deaths by rut fights, falling down from steep cliffs, death during parturition, starvation, drowning etc. Hunting accidents include pouching and becoming shot as a moose. "Shot for humanitarian reasons" is mainly performed by police or game warden because of an individual being badly injured, for instance, for being hitten by a car or a train - which in worst case, leads to the death of an animal, is here classified as a traffic accident. From all the dead animals found in 1993-94 have 38,1 % been males (2 juv., 6 ad. and 9 undetermined), 26,2 % females (4 juv., 3 ad. and 4 undet.), 21,4 % calves, 4,8 % yearlings and 9,5 % unclassified. The corresponding figures for all the individuals received in the Zoological Museum since 1969 (n=141) are as follows: males 28,4 %, females 23,4 %, calves 15,6 %, yearlings 13,5 % and unclassified 19,1 %.

The large predators have succeeded in hunting wild forest reindeer as follows: bear 1979-88 35 % and 1993-94 57% of all reindeer killed by predators, lynx 41 and 29 % respectively, wolverine 15/0 %, wolf 9/0 % and a dog 0/14 %.

A bear kills mainly calves in the summer time and occasionally also other animals. Lynx gets in most cases yearlings or females during winter when these are digging lichen under the snow and those which have been killed by wolverine or wolf, obviously have been in weak condition and thus been easy to catch.

There was an attempt to try to record the interactions between large carnivores and the reindeer by following all the tracks made by great predators between X.1988-VII.1989. Altogeter 320 trackings was performed as follows: wolverine 157, bear 39, lynx 84 and wolf 40. Carcases of a reindeer was met 4 times (wolverine 2 and lynx 2) and in addition to those a wolverine was observed to try to catch a reindeer twice, a wolf once and a lynx four times without success.

The seasonal distribution (Fig. 7) of the deaths observed shows two peaks in 1979-1988, during the winter (in February-April) and during the rut period (in September-October). The figure in 1993-1994 differs from that, the first peak occuring during the calving period (May-June), the next one in August (when the biotope change is taking place and the aggregation of the individuals before the rut begins) and the last one at the end of rut and the beginning of the autumn migration periods. During the deep winter (from December to April) only few individuals are found dead - most of them killed by the traffic and a few by a lynx.

The decrease in the number of the individuals of the subpopulation by the reasons known has been as follows: 1974-78 0,8 %, 1979-83 1,2 %, 1984-88 2,4 %, 1993 2,6 % and 1994 4,6 % (estimated population size in 1994 was 850 individuals) of the corresponding totals.

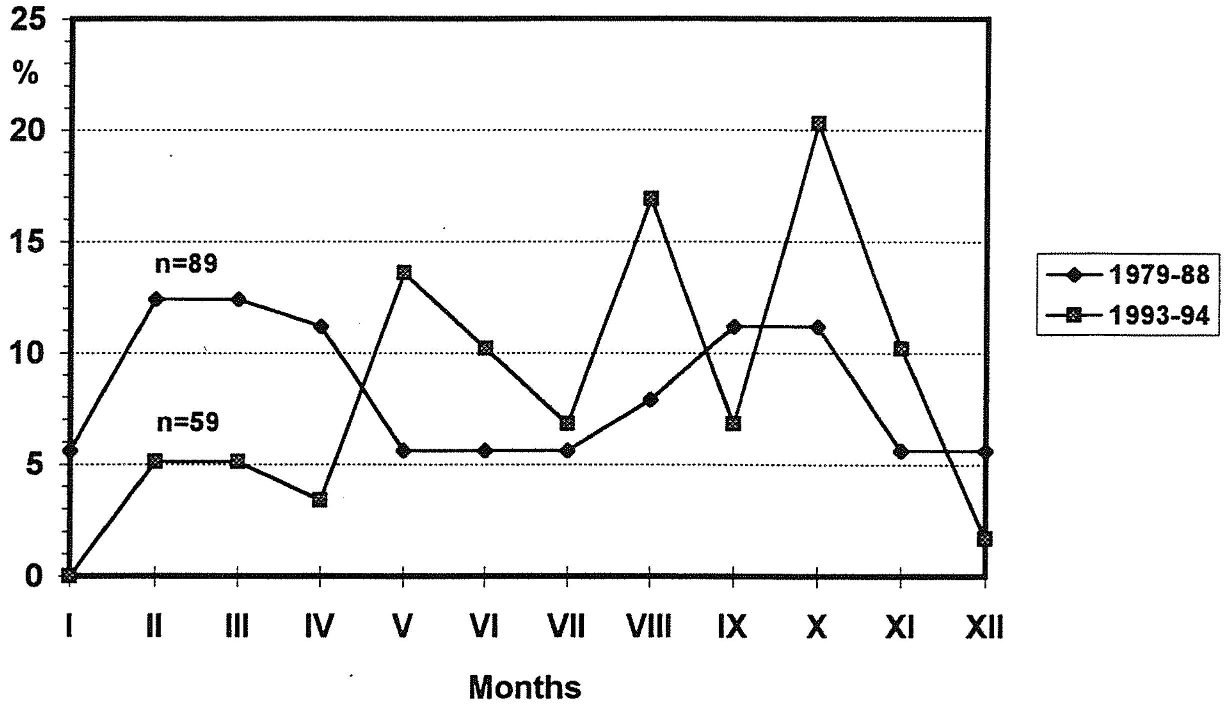


Fig. 7. Distribution in the observations of the dead individuals of the wild forest reindeer.

Parasitism and diseases

Parasitism includes here only two insect parasites, reindeer warble fly (*Oedemagena tarandi* L). and reindeer throat bot fly (*Cephenomyia trompe* Modeer), which are easy to observe during the dissection of the dead individuals in a laboratory. The Zoological Museum has received in all 132 different types of samples of wild forest reindeer in 1971-1990. From the individuals arrived as whole ones, larvae of *O. tarandi* have been counted from the inner surface of the skin (in all 51 reindeer). The larvae of *C. trompe* have been counted from the nasal cavities and throat of in all 68 heads of reindeer.

O. tarandi has been found in 22 individuals (in 14 males and 8 females), which equals in 43.1 % of all. The average number of larvae per an individual has been 116 ± 24 (max. 460 and min. 1). The seasonal distribution of the larvae met is shown in Fig. 8. *C. trompe* has been found in 7 individuals (in 4 males and 3 females), on average 16 ± 9 (max. 68, min. 1 larvae) dividing seasonally as follows: in March 1, in April 5 and in October 1 cases.

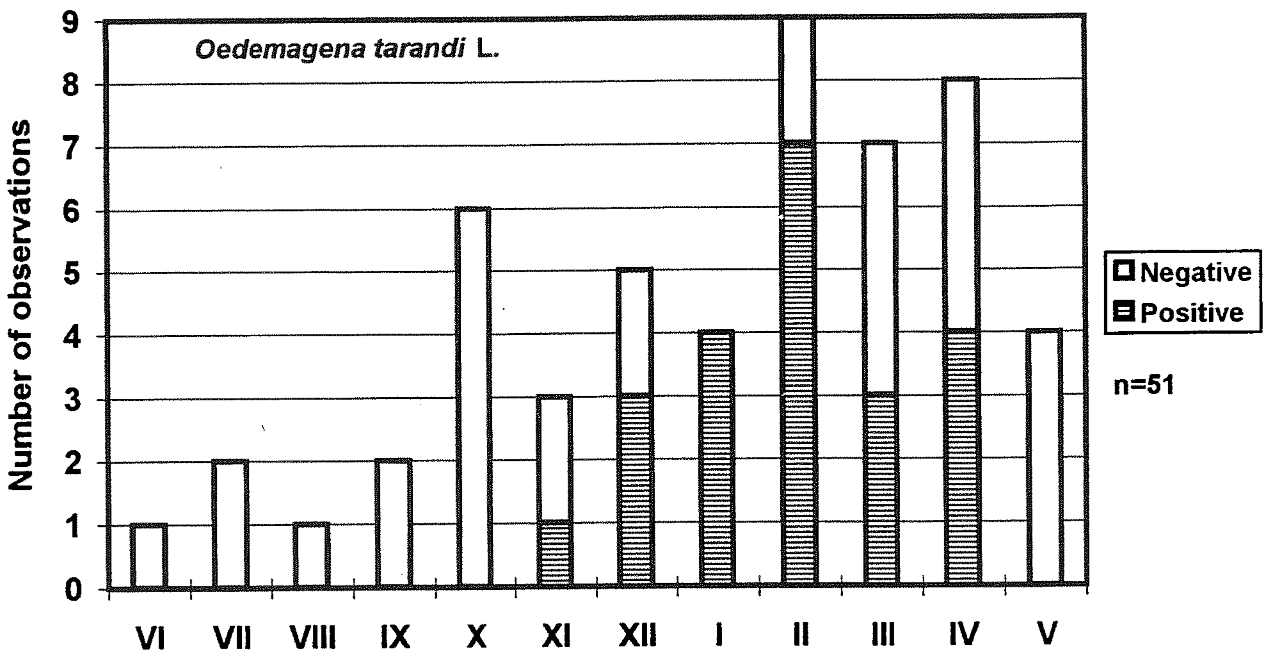


Fig. 8. The monthly distribution of the forest reindeer individuals from the Kuhmo-Kiitehenjärvi subpopulation observed for the existence of the reindeer warble fly (Oedemagena tarandi *L.) in 1971-90 at the Zoological Museum, University of Oulu.*

There is no evidence of these parasites having directly caused the death of a reindeer, but at least in two cases they may have had indirect influence on that. In one case a very weak individual was shot by authorities and an other one was hit by a car, being unable to move from the road. Both of them had lost weight strongly and both of them had many larvae of both the parasites above mentioned. Also one of the females carrying a radiotransmitter was very weak because of both the parasites. The individual itself recovered in during the summer 1994, but it lost its calf soon after the parturition, not being able to take care of it.

Any deseases have not, so far, been observed in a large scale. One adult male was found in November 1991 on the southern part of the reindeer husbandry area in a very weak condition being able to move only slowly and for short distances at a time. The individual was shot and during the dissection it was found out that its feet were infected by a bacterium (*Actinomyces pyogenes*), which can occasionally be found among semi domesticated reindeer in over-tight populations, especially in crowded feeding places.

Discussion

The Kuhmo-Lake Kiitehenjärvi subpopulation of wild forest reindeer has now inhabited the entire adminstrative district of Kuhmo and narrow streches of the neighbouring communes (Kostomuksha, Suomussalmi, Hyrynsalmi, Ristijärvi, Sotkamo, Valtimo and Lieksa, two last mentioned situating southwest of Kuhmo) in the summer time. The wintering area is still situated in a rather restricted area in the western part of Kuhmo, covering just about 1/7 of the size of the summer distribution area. The subpopulation has got its pioneer individuals from two directions, the bulk of them from east and later on in some extent also from southeast, from the direction of the lakes Leksozero and Ozero Tulos. The individuals inhabiting the area of Ruunaa, Lieksa in Finland are common with the area mentioned last.

The wild forest reindeer is well bound into its traditions and thus it commences its seasonal migrations along the known routes, though the investigative movements have brought new routes in use. The movements have not, so far, split the subpopulation into pieces - there are no new wintering areas, found, in spite of the fact that the widening of the summer area has given a reason to wait for it. Some signs of that can be observed, during the few last years, in the area of Lake Ontojärvi and further south of it (southwest of the centre of Kuhmo), where some tens of individuals have spent their winter. This herd, however, has kept in contact with the main part over the Lake Ontojärvi. There has also been a herd of 20-40 heads in the surroundings of Jonkeri, southernmost Kuhmo - in the vicinity of the Finnish-Karelian border. This herd has originated from the area of Tulos-Leksozero (the distance between Jonkeri and Lake Tulos is less than 30 km.) and has later joined into the main herd. Obviously, the saturation point of the subpopulation in question has not been reached yet, but is close to it.

The increase in the number of the individuals has taken place stepwise, being more rapid until the middle of 80´s than after that. The yearly increase in the number of individuals has been about 3 %, on average, between 1985-1994, which is very slow especially when taking the good reproductivity of the females (over 90 % of the adult females get calves) into account. The decrease in the number of calves reaching the stage of yearlings (counted as percentages/100 females) has increased and the calves born, are numbering as yearlings now about 20 %-units less than during the first half of the 80´s. This still leaves more potential for more rapid growth of the subpopulation than what has taken place. The mortality of the individuals, due to known reasons, summarizes about 4,6 % of the whole population in 1994. This is obviously an underestimation, because all the dead animals are not found and become into knowledge, but even as such it does not give reasonable means for explaining the slow growth of the subpopulation. When all the factors known effecting into the growthrate are summarized, it still leaves growth potential of about 10 % left, which is about threefold the growth observed.

Some of the wild forest reindeer have mixed into the herds of the semidomestic reindeer in their summer pastures (the areas of both the semidomestic reindeer and the wild forest reindeer have been overlapping and both of them are met year around in each others´groups) and disappeared in that manner. The number of these is not known, but the summer range of the wild forest reindeer as well as the number of them in the reindeer husbandry area, has continuously grown giving a possibility to assume thisas a remarkable rising problem. In order to prevent that, a fence along the southern border of the reindeer husbandry area has been constructed and has now reached a length of ca. 50 km. The influence of this fence is still not known, but the situation is under observation at the moment. There is also a possibility of the wild forest reindeer to disappear into the area of Karelia during the summer times. This has not been studied well enough, yet, but is under operation just now. A fact, is that there is a strong fence running along the border zone in the Karelian side, which is said to prevent the reindeer from moving further east (in fact for some kilometres, only) from the border between Finland and Karelia. The repairing and reconstruction of this fence, according to unofficial information, has taken place during the period 1982-85, the influence of which can be interpreted in Fig. 3.

The increase in the number of individuals and the widening of the summer range has resulted in changes in the use of the different portions of the landscape fragments. The portion of the human influenced habitats (fields, clear cuttings and sapling stands) has increased from ca. 10 % in 1985-87 to ca. 28 % in 1993-94. The same trend is observable in the winter ranges (from ca. 16 % in 1985-1987 to ca. 31 % in 1993-1994). The changes during the other seasons, spring and autumn, are about the same. As the mean of a whole year´s period, the decrease in the portion of pine forests is worth noticing. This is connected to the fact that the winter range as a whole has moved westwards from the immediate surroundings of the Lake Lentua after the lichen pastures have become worn and they have been substituted by former pine forests, now mainly clear cuttings and sapling stands, as well as to the fact that the amount of cutting of pine forests is contiuously increasing. The lichen pastures have been in good shape so far, but their regrowth after grazing is not as efficient as in covered pine forests. The cutting of pine (and spruce) forests in general can cause the reindeer to be forced to seek new areas in a short span of time. This in its turn can break the traditions and cause unscheduled movements of the individuals and have some harmful effects even on their survival. The most critical periods in this respect follow the autumn and spring migrations and especially at the time around parturition. Some signs of that has already been found: a newborn dead calf and two carcases of them torn into pieces by ravens on a clearcutting, a female with its newborn calf in the middle of a young sapling stand, all of these rather far from a suitable calving site and a bog.

The amount of the animals found dead has increased steadily during the whole observation period (from 0,8 % in 1974 - 78 to 4,6 % in 1994). The main reasons for the deaths are traffic accidents and large predators. The traffic density on the area hardly has increased markedly, but the number of the individuals crossing through roads has, because of the changes in the direction of the migration routes. Previously just one main migration route was crossing through a main road between the centres of Kuhmo and Lentiira, but nowadays several migration routes are crossing through more numerous main roads and a railway (from west to Kostomuksa, Karelia) in addition to the one mentioned before. This kind of development is quite understandable, because when the migration routes get longer and the number of individuals using them increases on an area where the network of roads is relatively dense, the probability of accident increases.

Among the large predators the bear has appeared to have increased its portion in killing reindeer from the percentage of ca. 35 (in 1979-88) to ca. 57 (1993-94) of all the reindeer killed by large predators. The rest of the deaths are mainly caused by lynx, other predators playing an unimportant role. The bear is the most numerous large predator in the area, rest of the species being each represented by about an equal share, according to the observations collected during the field work. It is obvious, that the numbers of the dead animals are underestimated, because all the dead individuals are not found - though the raven easily shows them - and duely recorded. For instance, small calves are often eaten by a bear so, that there are hardly any remnants left and also the distribution area of the wild forest reindeer is that much wide, that it is impossible to control it thoroughly for reasonable costs.

As for all, the wild forest reindeer has maintained its existence in Eastern Finland and formed there a permanent core, which is slowly increasing in number and expanding its distribution area. There seems to be circumstancial factors, part of them of anthropogenic nature, which are preventing the more rapid development of the subpopulation (in addition to the intrinsic ones), though there also are factors, so far unexplainable or uninterpretable, influencing on the subpopulation and its individuals in the same way.

Addendum (06.05.1996, K.H.): Since the material presented herein, more up-to-date information about the changes in the subpopulation in question has been gathered. 1) The fence along the southern boundary of the reindeer husbandry area has almost reached its final length now hindering most of the wild forest reindeer to move into that area. This positive change has influenced on the northwards leading migration routes mainly to turn back into the "original wild forest reindeer range". 2) The latest observations confirm the generation of a new wintering satellite on the southwestern part of the distribution area in the vicinity of the Lake Tipasjärvi. 3) The main herd has obviously reached the upper limit of the carrying capacity, which here seems to be at the level of 850-950 individuals, and some dispersion has taken place. The observed growth curve for the subpopulation well follows the expected logistic growth curve for the carrying capacity for 950 individuals (No 150_{1971} , $r = 0.16$; $c^2_{obs./K950} = 22.781$, $df = 18$, $a = 0.199$). 4) During the helicopter counting in February 1996, 1004 wild forest reindeer were found in the wintering area. The annual increase in the number of individuals is thus ca. 9 % since the previous counting in 1993. Most of the individuals, ca. 850 inds., were aggregated in the northern part of the wintering area, ca. 80 in the southernmost part of it (as a satellite) and the rest of them mainly southeast of the northern aggregation.

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Changes of the fish population structure of Lake Kiitehenjärvi over the 20 years (1972-1992)

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Abstract

Changes in the fish population structure of Lake Kiitehenjärvi over 20 years (1972-1992) were studied. Twelve fish species were found in the control catches of 1972-1973: freshwater salmon (*Salmo salar morpha sebago*), European cisco (*Coregonus albula*), whitefish (*C.lavaretus*), pike (*Esox lucius*), roach (*Rutilus rutilus*), ide (*Leuciscus idus*), minnow (*Phoxinus phoxinus*), burbot (*Lota lota*), ninespine stickleback (*Pungitius pungitius*), perch (*Perca fluviatilis*), ruff (*Gymnocephalus cernua*) and sculpin (*Cottus gobio*). Salmon, ide and minnow were not found in 1991-1992. In the early 1970s, perch and cisco were most abundant, whitefish and pike were common, roach was scarce and all other species were either rare or occurred as single individuals. Nowadays, perch is still dominant and whitefish is far more abundant, whereas pike is much less common. Some changes in the biological indices of individuals, most apparent in perch and whitefish populations, were revealed. In comparison with the 1972-1973 data the average and maximum size and weight of perch decreased, the average age of individuals declined and fewer age groups were reported. Sex ratio changed as well: the percentage of males increased from 26.1% in 1972-1973 up to 35.1% in 1991-1992. In 1973, the qualitative composition of perch food in Lake Kiitehenjärvi consisted of ten fish spices, in 1991 only of 5 species. Earlier studies showed that Lake Kiitehenjärvi was inhabited by sympatric populations of large and small low-rakered lake whitefish. Small whitefish with 32-38 gill rakers were scarce. In 1991-1992, the lake is still inhabited by large low-rakered whitefish and a similar small type. The number of small mid-rakered whitefish having 31-39 gill rakers substantially increased. Besides, whitefish with 41-43 gill rakers were found for the first time. Changes similar to those documented for perch were observed in roach population structure. It should be noted that Lake Kiitehenjärvi cisco, which was small in size and weigth before is still small. Pike number decreased sharply. It can thus be stated that fish population structure of Lake Kiitehenjärvi changed between 1972 and 1992.

Key words: changes, population structure, perch, whitefish, Lake Kiitehenjärvi

Introduction

Before the beginning of large-scale mining operations in the Kostomuksha iron deposit in the mid-1970s, Lake Kiitehenjärvi (water surface area 95.5 sq. km^2) had all the characteristics of a typical oligotrophic north taiga water body which was in its natural state. No human economic activities were conducted in the catchment area of the lake; there were hardly any inhabitants and no fisheries. It was, therefore, considered to be a reference lake that should be protected. Russian and Finnish scientists combined their efforts to preserve the environment in the state border zone. As a result, the Kostomuksha Nature Reserve which was organized in december 1983 became part of the The Nature Reserve Friendship. The results of the ichthyological investigations conducted of Lake Kiitehenjärvi in 1972-1973 provided a basis for assessing its initial state. The data obtained were published earlier (Pervozvansky et al. 1977, Pervozvansky 1986, 1986a). The study of the ichthyofauna was continued in 1991-1992. The present paper is an attempt to analyse changes in the fish population structure of Lake Kiitehenjärvi since 1972 using earlier and recent data.

Material and methods

Field observations on Lake Kiitehenjärvi were carried out on July 7-13 and September 10-12 in 1991 and on August 11-14, 1992. The bottom capron gill nets (7 units) with meshsizes 14-60 mm were used to obtain the data on various size groups of each fish species. The nets were positioned separately or 2-5 nets together in different localities of the lake at 2-10 m (sometimes down to 15 m) depth. Total weight and the number of fish specimens were measured for each species in each net catch. Further on, collection and treatment of the material were conventional (Pravdin 1966). The fork length was accepted as the principal length when measuring whitefish. The measure for perch, roach and pike was the length to the end of the tail. Age was determined in the laboratory with a binocular microscope MBS-1 (with a 8. eye-piece) by the scales for whitefish (75 ind.), pike (6 ind.) and roach (14 ind.) and by operculum for perch (203 ind.).

Results and discussion

Out of 12 fish species (Table 1) reported earlier (1972-1973) from Lake Kiitehenjärvi (Pervozvansky, 1986, 1986a), the following species were found in control catches: european cisco *Coregonus albula*, whitefish *C. lavaretus*, pike *Esox lucius*, roach *Rutilus rutilus*, burbot *Lota lota*, ninespine stickleback *Pungitius pungitius*, perch *Perca fluviatilis*, ruff *Gymnocephalus cernua* and sculpin *Cottus gobio*. Freshwater salmon *Salmo salar morpha sebago*, ide *Leuciscus idus* and minnow *Phoxinus phoxinus*, reported earlier from the lake, were not found in 1991-1992 catches, but this does not mean that the above species no longer live in the lake. It should be noted that the fish population structure of Lake Kiitehenjärvi has changed in the past twenty years. In the early 1970s, perch and cisco were most abundant, whitefish and pike were common, roach was scarce and all other species were either rare (burbot, minnow, salmon, ide) or occurred as single individuals (stickleback, ruff, sculpin). Nowadays, perch is still dominant and whitefish is far more abundant, whereas pike, which was ubiquitous in all parts of the lake, is much less common. The change in the number of cisco in the lake is hard to assess. Its share in summer net catches is small though it still dominated in perch food.

Table 1. Species composition and relative abundance of fish in Lake Kiitehenjärvi. 1- mass species; 2 - abundant; 3 - scarce; 4 - rare; 5 - single fish; - - not found in catches.

Fish speces	1972-1973	1991-1992
Freshwater salmon, *Salmo salar (L.) morpha sebago (Gerard)*	4	-
European cisco, *Coregonus albula (L.)*	1-2	2
Whitefish, *Coregonus lavaretus (L.)*	2	1-2
Pike, *Esox lucius L.*	2	3-4
Roach, *Rutilus rutilus (L.)*	3	3
Ide, *Leuciscus idus (L.)*	4	-
Minnow, *Phoxinus phoxinus (L.)*	4	-
Burbot, *Lota lota L.*	4	5
Ninespine stickleback, *Pungitius pungitius (L.)*	5	5
Perch, *Perca fluviatilis L.*	1	1
Ruff, *Gymnocephalus cernua (L.)*	5	5
Sculpin *Cottus gobio L.*	5	5

The quantitative indices, which reflect the above changes, are presented in Table 2. The relative increase in the proportion of pike in net catches observed in August 1992 in terms of number and biomass was due to low absolute catch, rather than a rise in pike number in the lake. Our observations have shown that the amount of fish caught per fishery unit (net/day) substantially decreased. It was 0.927 kg/net in July 1973, 0.373 kg/net in July 1991, 1.959 kg/net in August 1973 and 1.093 kg/net in August 1993.

Table 2. Relative abundance and biomass dynamics of major fish species in Lake Kiitehenjärvi (based on control net catches).

Fish species	Relative abundance, %		Relative biomass %		Relative abundance, %		Relative biomass, %	
	1973:1991: July		1973:1991:		1973:1992: August		1973:1992	
Perch	93.6	85.5	75.1	72.5	61.8	42.3	70.5	27.9
Pike	2.7	0.9	22.1	14.1	0.7	5.8	3.9	23.8
Whitefish	9.5	-	10.1	16.7	40.7	7.8	40.0	
Roach	3.7	3.2	2.8	3.2	16.7	9.6	17.6.	8.2
Cisco	-	0.9	-	0.1	4.1	1.9	0.2	0.1

In addition, some changes in the biological indices of individuals, most apparent in perch and whitefish populations, were revealed.

Perch

In 1991-1992 control catches perch varied in size from 9.3 to 37.8 cm and had a body mass of 17-1100 g and an age limit of 20+. In comparison with 1972-1973 data, the average and maximum size and weight of perch decreased, the average age of individuals declined and fewer age groups are reported. Thus, in the early 1970s (Pervozvansky et al. 1977, Pervozvansky 1986) 24 age groups of perch were described, fish aged 5 and older approaching 90% and those aged 10 to 15 being predominant. Nowadays, junior age groups (4 to 7) account for over 50%, whereas the proportion of large old fish (10 and older) declined to 30% of population number (Fig. 1).

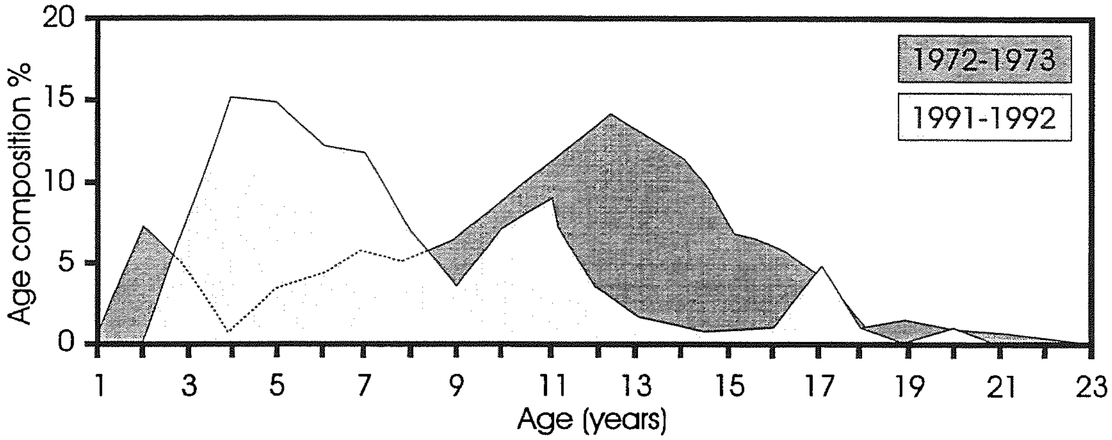

Fig. 1. Age composition of the perch population in Lake Kiitehenjärvi.

Their sex ratio changed as well. The percentage of males increased from 26.1% in 1972-1973 to 35.1% in 1991-1992 because females that usually form oldest groups of perch became less abundant. Analysis of perch growth data shows that linear and especially weight growth in individual age groups is highly variable (Table 3), which is characteristic of fish predators in general. It is fairly difficult, therefore, to compare the data of early 1970s with the data of 1990s.

However, all age groups of perch older than 12 in 1972-1973 catches often included fish weighing. Such large and quick-growing individuals are hardly met in perch population now. Out of 164 perch, in which the stomach contents were analysed in 1991-1992, 96 individuals (58.5%) had some food and the rest had no food. Of the individuals whose stomach was full at the time of catching, 26.1% had eaten fish and 69.8% preferred invertebrate, primarily benthic organisms, zooplankton being less common. Fish food was seldom (3.1%) found together with invertebrate food. The stomachs of perch behaving as predators (25 individuals, 1991) were observed to contain 5 prey fish species: cisco (6 %), ruff (8%), pike (4%), nine spine stickleback (4%), sculpin (4%) and some had digested fish which was impossible to determine (20%).

In 1973 the qualitative composition of perch food in Lake Kiitehenjärvi was far more varied and consisted of ten fish species. In addition to the beforementioned species, whitefish, perch, burbot, minnow and roach were encountered. Cisco is still predominant in perch ration, its percentage being practically unchanged. Whitefish is completely absent as a food item although it is now far more abundant. It seems that as the size and weight of perch diminished whitefish became the type of prey which was no longer easy to get.

Table 3. Body length and weight changes with age in perch of Lake Kiitehenjärvi (1991-1992) (average and limits).

Age, years	Length (ad), cm	Weight, g	n
3	10.4 (9.3-11.6)	19.5 (17-23)	14
4	11.6 (10.2-15.7)	26 (17.5-60)	31
5	14.6 (11.5-20.0)	52 (25-147)	30
6	12.1 (12.1-20.3)	78 (27-150)	25
7	18.2 (13.8-22.0)	105 (37-210)	24
8	18.5 (15.0-24.3)	120 (60-308)	14
9	23.0 (17.9-29.1)	256 (100-533)	7
10	21.6 (17.6-32.3)	198 (80-630)	14
11	27.2 (19.4-34.0)	408 (140-780)	17
12	25.9 (19.7-30.8)	374 (135-550)	7
13	24.0; 28.0; 28.0	260; 400; 430	3
14	19.5; 28.0	165; 450	2
15	31.8	724	1
16	28.2;31.8	530; 500	2
17	29.1 (25.9-33.7)	441 (350-670)	8
18	33.5; 34.8	750; 870	2
20	32.1; 37.8	680; 1100	2

The feeding pattern of the perch individuals that eat mainly non-fish food (30 individuals, July 1991) indicates no substantial changes in this group since the early 1970s (Table 4). The food items they basically consume are caddis fly (*Trichoptera*) larvae and subimago, mayfly (*Ephemeroptera*) larvae, including *Ephemera vulgata*, and chironomids. The ratio of the two principal benthic organism groups comprising the bulk of the food units has somewhat changed. Thus, the frequency of *Ephemeroptera* larvae occurence in perch food increased in 1991 though its percentage in the food weight dropped abruptly. Contrastingly, the frequency of *Trichoptera* larvae occurence remained the same whereas this invertebrate group now dominates in the food as weight is considered. Other groups of organisms, primarily various insect larvae and imago, are less common. The food of perch aged 3 to 5 consists largely of zooplankton especially *Eurycercus lamellatus* and *Latona setifera* (*Cladocera*). The fish stomach filling index varies from 1 to 200.8%. Its average value of 49.4% is slightly higher than the one obtained in 1973 (25.2%).

Whitefish

Earlier studies (Pervozvansky et al. 1977, Pervozvansky 1983, 1986, 1986a) showed that Lake Kiitehenjärvi was inhabited by sympatric populations of large and small low-rakered lake whitefish differing in size, weight, age, fecundity, growth rate and feeding pattern. Small whitefish with 32-38 gill rakers were scarce. In 1991-1992, new data on Lake Kiitehenjärvi whitefish ecology were obtained. The lake is still inhabited by large low-rakered whitefish and a similar small type. At the same time the number of small mid-rakered whitefish having 31-39 gill rakers substantially increased. Besides, whitefish with 41-43 gill rakers whose systematic position is not determined yet were found for the first time. The distribution of whitefish differing in raker number in 1991-1992 control catches (75 individuals) is shown in Fig. 2.

Table 4. Food composition of perch in Lake Kiitehenjärvi in 1973 and 1991.

Food components	1973, n=25 (ad) 12.0-29.0 cm		1991, n=30 (ad) 9.3-23.1 cm	
	frequency of occurence, %	weight, %	frequency of occurence, %	weight, %
Cladocera	12.0	0.47	60.0	1.38
Copepoda	-	-	16.7	0.02
*Odonata (L.)**	4.0	0.02	-	-
Ephemeroptera (L.)	56.0	49.26	73.3	6.87
Plecoptera (L.)	-	-	3.8	0.07
Coleoptera (L.)	8.0	0.05	-	-
Sialidae (L.)	12.0	0.28	-	-
Trichoptera (L.)	44.0	10.33	46.7	47.40
Trichoptera (Im.)	8.0	0.16	23.3	0.62
Chironomidae (L.)	12.0	0.28	76.7	3.13
Chironomidae (P.)	32.0	0.17	33.3	0.06
Insecta (L.) other	4.0	0.01	3.3	0.02
Insecta (Im.)other	-	-	3.3	0.85
Pisces (total):	20.0	37.97	3.3	29.60
cisco	4.0	15.16	-	-
perch	4.0	17.96	-	-
sculpin	4.0	0.78	-	-
digested fish	8.0	4.07	3.3	29.60
Plant residues	16.0	1.02	-	-
Index of fullness,%	0.5-83.0** 25.2		1-200.8 49.4	

* L - larvae, P - puppae, Im - imago, subimago; ** limits, average.

Age structure of distinct whitefish forms in Lake Kiitehenjärvi is represented in fig. 3. Individuals in the ages 3 and 4 dominated (57%) among small low-rakered whitefish in the 1990s. Fish individuals aged up to 7 were exceptional. Third-summer (2) fish constituted the modal age group and the maximum age was not over 5. The life span in the populations of large whitefish remained the same (14) but younger individuals (modal age group 6) are more often to be found in the catches. Fish older than 8 were met only occasionally. The growth rate of whitefish in Lake Kiitehenjärvi has changed since 1972-1973. No marked differences in the growth of large coeval low-rakered whitefish individuals were observed, whereas the ecological form of small lake whitefish defined earlier showed a slight decline in weight in fish older than 4. The differences may be due to increased whitefish number and to changes in the perch population structure of Lake Kiitehenjärvi that took place over the past twenty years. Nowadays, the perch population is dominated by junior fish whose feeding pattern is largely benthos based. This results in more active feeding competition between these two fish species.

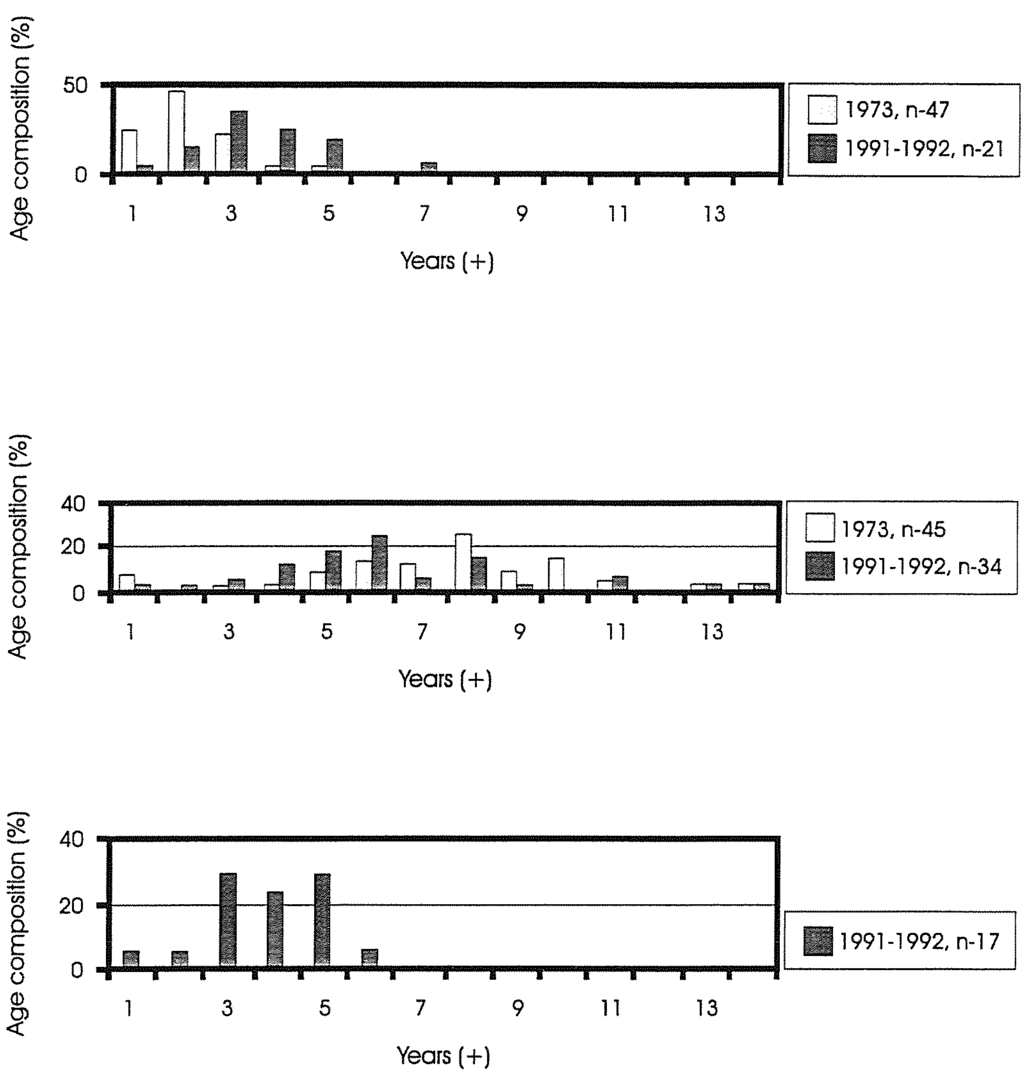

Fig. 2. Frequency of occurence of whitefish with various gill raker number in 1991-1992 control catches

The food of large low-rakered lake whitefish is still dominated by large benthic organisms. Caddis fly larvae *Trichoptera* and the molluscs *Pisidium* form the bulk of its food, other components being less common. The food of small lake whitefish is similar in qualitative composition to the type it consumed earlier.

Other fish species

Data on other fish species of Lake Kiitehenjärvi are so scanty that only some brief remarks can be made.

1. Roach catches in 1972-1973 most often contained large mature individuals 20-27 cm long and weighing 200-400 g at the age of 10 - 13 years. Marginal indices for roach in Lake Kiitehenjärvi were at that period as follows: legnth 30 cm, body weight 635 g and age 17 (Pervosvansky 1986).

In 1991-1992, roach (14 ind.) represented by 4 - 14+ years old fish, with the lenght of 16.0-25.3 cm and the body weight of 75-380g. Its life span and maximum size-weight characteristics decreased just like those of perch. Age, length and weight of the fish that reached maturity didn't change. Size-weight indices of roach in different years of observations are given below (Table 5).

Table 5. Size-weight indices of roach in different years of observations.

Age of fish	1972-1973 (n=226)		1991-1992 (n=14)	
	Length, cm	Weight, g	Length, cm	Weight, g
4	-	-	16.7	93
6	19.2	131	19.3	162
7	20.3	155	-	-
8	21.2	183	16.0	75
9	22.3	214	17.1	90
10	23.3	265	20.8	205
11	24.3	285	21.4	220
12	25.0	327	24.8	320
13	25.9	350	23.2	274
14	25.2	349	25.3	380

The growth irregularity revealed in 1991-1992 is possibly due to the small roach sampling volume and to the fact that the fish from different localities in the lake have certain individual distinctions in growth dynamics.

2. It should be noted that Lake Kiitehenjärvi cisco, which was small in size and body mass before (Pervozvansky 1982, 1986) is still small.

3. Pike number decreased sharply, as indirectly supported by a rise in the abundance of whitefish and the junior groups of perch that formed the bulk of pike food (Pervozvansky 1984, 1986).

Conclusion

It is known that anthropogenic impact on aquatic ecosystems in industrially developed areas causes water quality degradation and the disturbance of the structure of some water community elements including fish population. Biological characteristics of fish and their number changed in this process and when the supply of toxic substances into the water body is of long duration, morphological deviations in fish and pathological changes in many organs and their disfunction are observed.

The data of T. I. Moiseenko and V. A. Jakovlev (1990) show that the changes in growth and maturation rates, fat accumulation dynamics and increased mortality of older fish in Lake Imandra (Kola Peninsula) whitefish, living in the impact area of copper-nickel industry sewage (Monche bay), are accompanied by kidney anomaly (nephrolithiasis). According to the data of the same authors (Moiseenko & Jakovlev 1990) whitefish in the Belaya bay of Lake Imandra, which receives sewage from the apatite-nepheline works, had flabby muscles, swollen skin, ruffled scales, curvature of the spine (scoliosis) and other defects. There are more data indicating that external defects appear in various fish species inhabiting heavily polluted waters (Wunder 1975; Hanel 1988; Dethlefsen 1988; Moller 1991).

Such anomalies have not yet been reported from the fish living in the water bodies of River Kivijoki system which is the evidence of high water quality. Firstly, because Kostomuksha ore-dressing mill has not as yet been operating long and, secondly, its industrial sewage is not supplied to the water bodies of this water system. Therefore, the changes revealed in the structure of fish population in the previously unfished water bodies of Kostomuksha district and Lake Kiitehenjärvi should be explained by other reasons.

Northern oligotrophic lakes approach in some parameters mature ecosystems (Reshetnikov 1979, 1980). The production (biomass ratio is low in them and production) respiration ratio is about 1 (P/R 1). Hence the net production (including fish product) is small or close to zero in mature ecosystems. Besides, northern lakes are susceptible to externalities and the fish part of the community may change as a result of overfishing. It should be especially stressed that not only intensive fisheries but also local consumer fishing is meant here. The effect of this factor on the fish resources in the water bodies of River Kivijoki system was shown by us at the example of Lake Kiimasjärvi and Lake Nuokkijärvi (Pervozvansky 1981, 1986).

Intensive fisheries cause changes in certain species abundance, reduce life period of individuals, lower size-weight limits, modify sex ratio. As a rule, valuable fish species with long life cycle are substituted there with low-value species with high reproductive capacity. Besides, large, quickly growing individuals are the first to disappear from the population which results in the reduction of biological diversity and decrease in the stability of the population at large.

Thus, the materials available indicate that after 1980 Kostomuksha district water bodies and Lake Kiitehenjärvi as well were subject to intensive fisheries. Taking into account the fact that industrial fishing has never been conducted here before we must admit, paradoxical as it may seem, that the main reason for the changes described above is the uncontrolled fishing. The return of the fish part structure in the community of northern lakes to its initial natural condition would require at least 10 years (Reshetnikov 1980).

If the number and population structure of some fish species continue to change, then Lake Kiitehenjärvi may no longer be regarded as an undisturbed reference water ecosystem, as it was in the early 1970s before the beginning of large-scale mining of the Kostomuksha iron deposit.

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Lepidoptera of the Nature Reserve Friendship

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Abstract

The lepidopterous fauna of the Nature Reserve Friendship in eastern Finland and Russian Karelia was inspected in years 1991-1995 by lighttraps, baittraps, line censuses and eye observing. Different subareas were visited mostly in different years.

Altogether 654 lepidopterous species were found. From these 380 were so called Microlepidoptera and 272 Macrolepidoptera. Faunistically most interesting were *Lasionycta skraelingia* (Herrich-Schäffer), *Xestia gelida* (Sparre-Schneider), *Alcis jubatus* (Thunberg) and *Colotois pennaria* (Linnaeus) from macrolepidopterous species and *Alloclemensia mesospilella* (Herrich-Schäffer), *Niditinea truncicolella* (Tengström), *Caryocolum schleichi* (Christoph), *Cnaemidophorus rhododactylus* (Denis & Schiffermüller) and *Eudonia aequalis* (Palm) from microlepidopterous species. The most abundant species are presented for each subarea. New for the biogeographical province of Kainuu were following 15 species: *Colotois pennaria* (Linnaeus), *Amphipyra perflua* (Fabricius), *Lasionycta skraelingia* (Herrich-Schäffer), *Xestia gelida* (Sparre-Schnei-der), *Agrotis vestigialis* (Hufnagel), *Niditinea truncicolella* (Tengström), *Coleophora ramosella*(Zeller), *Brachmia rufescens* (Haworth), *Olethreutes concretanus* (Wocke), *Olethreutes dalecar-lianus* (Guenée), *Epiblema grandaevana* (Lienig &Zeller), *Phycitodes binaevellum* (Hübner), *Pammene luedersiana* (Sorhagen), *Cnaemidophorus rhododactylus* (Denis & Schiffermüller) and *Eudonia aequalis* (Palm).

Key words: Lepidopterous species, habitats, dominant types, eastern Finland, Russian Karelia

Introduction

The Nature Reserve Friendship was established on 1st of July 1990 by a law (Environmental ministry 1989). Its total area is 70500 hectares, of which 20500 ha are on Finnish side and 48000 hectares on Russian side . The reserve in Finland is composed of five subareas: Ulvinsalo (2500 ha), Elimyssalo (7300 ha), Iso-Palonen-Maariansärkät (3900 ha), Juortanansalo-Lapinsuo (3700 ha) and Lentua (5100 ha). On Russian side it contains an unbroken area of Kostamus.

The subareas with varying biotopes have been inspected relatively well with many methods (see Somerma and Väisänen 1990) up to the end of 1995. So far 63 % of lepidopteran species of the biogeographical province of Kainuu have been found from the reserve areas (Leinonen 1993).

Only scattered observations are avalaible from earlier years concerning these areas (Heikinheimo 1939, Mäkisalo 1981).

The aim of this article is to give a brief summary about the fauna of the Friendship Nature Reserve and to give the total species list so far observed and yearly reported by Leinonen (1992, 1993, 1996).

Study areas

In the subareas of the reserve there can be found many remarkable fens and bogs and old forests still in state of nature, which must be noteworthy reserves among other invertebrates also for certain lepidopterous species. During the research we tried to inspect the different habitats as thoroughly as possible paying however, special attention to the dominant types of each. Below is given a brief summary of the biotope features of the subareas (for further information see other articles in this issue).

In the area of Elimyssalo, there dominate mires, old spruce forests, woodlands and pine swamps. In addition, there can be found cultural biotopes gone wild in Levä- and Latvavaara hill biotopes. Perhaps the most interesting biotope is the old spruce forests at Löytövaara/Ristonsuo, where the age of trees is on average 200 years with a whole lot of fallen trunks. Dominating biotopes in the area of Iso-palonen and Maariansärkät are light pine heaths and eskers. There can be found also managed forests. The subarea of Juortanansalo-Lapinsuo is characterised by the richness of mires and old forests. The surroundings have been clearcut and ploughed largely. The subarea of Lentua is composed mostly of lakeshore- and island habitats. Also cultural biotopes and open pineheaths are dominant around the lake. Old spruce forests dominate the landscape of Ulvinsalo. The area of Kostamus is a kind of summary of the Finnish biotopes, but they all occur in the same unbroken unit.

Methods

The main methods used were light trapping both with a permanent collecting site and with varying sites with the aid of generator, bait-trapping, netting and eye-observing. For day-active butterflies also censusing routes (see Somerma and Väisänen 1990) were used. The collecting took place during the whole flight period of lepidopterans, i.e. from the end of April to the middle of October. Details about the collecting data are presented in table 1.

Table 1. Subareas, periods of inventory and methods in friendship park.

Subarea	Time	Number of light-traps	Number of bait-trapsline	Censusing	Number of visitdays
Elimyssalo	01.05.-30.08.1991	1+1(generator)	5	2000 m	25
Elimyssalo	01.05.-30.08.1992	1			5
Elimyssalo	01.05.-31.08.1993	2	3		15
Elimyssalo	01.05.-31.08.1994	2			5
Elimyssalo	01.05.-31.08.1995	2	8	2200 m	25
Iso-Palonen -Maarians.	01.05.-02.09.1992	2	10	3300 m	25
Juortanansalo - Lapinsuo	01.05.-31.08.1993	2	10	3100 m	25
Lentua	01.05.-26.08.1994	2+1(generator)	10	3000 m	25
Ulvinsalo	01.05.-12.10.1994	2			2
Ulvinsalo	01.05.-30.09.1995	2	4		16
Kostamus	08.06.-29.07.1993	1			6
Kostamus	18.07.-22.07.1994				5
Kostamus	25.05.-11.08.1995	1			2

Results and discussion

The total number of lepidoptera found in the area of the Nature Reserve Friendship is so far 272 species for macrolepidoptera and 380 species for microlepidoptera (see Appendix). The higher values on Finnish side date back to the clearly more active research on these subareas (Leinonen 1992, 1993 and 1996). The great proportion of Geometroidea, Noctuoidea and Tortricoidea is typical in the whole fauna, while Bombycoidea and Sphingoidea are poorly represented (Table 2). Family Arctiidae seems to be also present with very few members (Appendix). The same trend has been observed in the Kuusamo area, north of Kainuu (Itämies 1992).

TABLE 2. SUPRAFAMILIES OF LEPIDOPTERA IN FRIENDSHIP PARK AND IN KAINUU REGION(COMMENTARY OF ABBREVIATIONS:ELI.=ELIMYSSALO, ISO.=ISO-PALONEN, JUO.=JUORTANANSALO, LEN.=LENTUA,ULV.=ULVINSALO, KOS.=KOSTAMUS, F-S PARK=FRIENDSHIP PARK)

GROUP	ELI.	ISO.	JUO.	LEN.	ULV.	KOS.	F-S PARK RUSSIA	F-S PARK FINLAND	F-S PARK TOTAL	KAINUU TOTAL
MICROPTERIGIOIDEA	1	1	2	2	2	1	1	2	2	2
ERIOCRANIOIDEA	4	1	-	2	2	4	4	4	5	5
HEPIALOIDEA	2	1	2	1	2	2	2	2	2	3
NEPTICULOIDEA	6	6	3	4	4	5	5	9	9	23
INCURVARIOIDEA	8	6	3	4	11	7	7	14	15	20
COSSOIDEA	1	1	-	-	-	-	-	1	1	1
ZYGAENOIDEA	-	-	-	1	-	-	-	1	1	1
SESIOIDEA	5	1	-	2	2	1	1	5	6	10
TINEOIDEA	31	14	15	13	25	16	16	41	44	66
YPONOMEUTOIDEA	22	14	10	10	20	14	14	26	26	42
GELECHIOIDEA	78	44	28	45	48	26	26	87	90	143
TORTRICOIDEA	94	56	40	66	66	44	44	123	126	177
PYRALOIDEA	40	21	19	22	26	23	23	45	45	78
PTEROPHOROIDEA	10	7	5	6	5	7	7	10	10	16
MICROLEPIDOPTERA	302	173	127	178	212	150	150	370	380	587
PAPILIONOIDEA	22	21	16	27	13	17	17	33	34	59
BOMBYCOIDEA	5	3	1	5	3	3	3	6	6	10
GEOMETROIDEA	93	94	77	104	87	66	66	114	116	175
SPHINGOIDEA	2	-	-	1	1	-	-	2	2	8
NOCTUOIDEA	94	71	54	69	60	38	38	112	114	204
MACROLEPIDOPTERA	216	189	148	206	164	124	124	267	272	456
LEPIDOPTERA	518	362	275	384	376	274	274	637	652	1043

Results

Direct comparisons between different subareas are not so judged to do, because the collecting time was mostly different. Anyway some comments on the most abundant species can be presented.There are slight differences on the suprafamily level between different subareas of the Nature Reserve Friendship as well as between the Finnish and Russian parts of the reserve (Table 2). In the area of Elimyssalo *Jodis putata* (Linnaeus), *Rheumaptera subhastata* (Nolcken), *Xestia speciosa* (Hübner) and *Eana osseana* (Scopoli) occurred in great numbers in 1991. The most abundant species in the area of Iso-Palonen/Maariansärkät in 1992 were *Ematurga atomaria* (Linnaeus), *Eulithis populata* (Linnaeus) and *Epinotia solandriana* (Linnaeus). In the catch of Juortanansalo/Lapinsuo were dominating in 1993 *Callophrys rubi* (Linnaeus), *X. speciosa* and *Agriphila straminella* (Denis & Schiffermüller). During the inventory in summer 1994 at the district of Lentua, *E. populata* and *E. atomaria* occurred much more richly than other species. *Epinotia solandriana* and *E. caprana* (Fabricius) seemed to be among the first species to invade on the islands. In 1994 the area of Ulvinsalo was mostly characterised by *E. populata*. At Akonlahti in Kostamus *A. straminella* was very common. If we look at the food plants of those abundantly observed moths and butterflies (Seppänen 1970, Svensson 1993), we can easily find that they all are living on some common plant species or on a group of species. Therefore they have good possibilities to increase their populations at least on the basis of their food plant reserves. More or less they all are also typical forest species. *A. straminella* makes an exception while it favours more meadowlike biotopes.

The abundant species mentioned above are partly the same as Itämies (1992) has found in the area of Kuusamo. Most striking differences are to be seen with species *Entephria caesiata* (Denis & Schiffermüller), *Epirrita autumnata* (Borkhausen) and *Operophtera brumata* (Linnaeus), which did not occur in very great numbers in the Friendship Park, but instead at Kuusamo they covered great proportion of total catch. These species are known of their great fluctuations (Itämies et al. 1986, 1993), which explains of course why they are not necessarily always found in great numbers. What comes to *Xestia* species, one must keep in mind that they occur only every second year (Mikkola 1976) and in these areas it is odd years (Leinonen 1992, 1993, 1996). In the Oulanka area at Kuusamo *X. speciosa* is still among the most common *Xestia* species (Itämies 1992), while moving northwards to Värriötunturi fell area, Salla, it is not anymore caught at least with light traps so much (Pulliainen & Itämies 1988). The general knowledge about the microlepidopteras in Finland, what comes to their phenology, fluctuations and ecology, is still poorly known, which makes comparisons difficult. However, Itämies & Kyrki (1987) found in northern Finland how *E. osseana* and *E. solandriana* were among those moths occurring in great quantities and which also had clear fluctuations with peaks from one year to even three years. Naturally during the peak frequencies it is easy to observe such species, while in those years when their population densities decrease very low, they slip without finding quite easily.

Rarities

Alcis jubatus (Thunberg), a geometrid moth, was the only moth included among the threatened species of Finland (Rassi et al. 1991). The species is living on various Usneaceae (Seppänen 1970) and its distribution in Finland has radically diminished during last years due to decrease of lichens (Mikkola et al. 1989). It is delighting to see that the species has still some rather vital populations in Kainuu . They are, however, endangered due to increased clearcuttings and also to the general acidification of nature, which sweaps lichens away. *A. jubatus* is here rather close to its known northern limit of distribution (see Mikkola et al. 1989). *Lasionycta skraelingia* (Herrich-Schäffer) represented quite opposite case. The somewhat astonishing finding from Elimyssalo and Juortananasalo, moved the southern range of this species several hundred kilometres southwards (see e.g. Mikkola et al. 1977). It has been considered as a northern moth, but our records show that it can be found in Central Finland in suitable places, i.e. on bogs, too. Among *Xestia* moths there occurred also some specimens *of X. gelida*. Also this find moved the known area southwards. This species is a inhabitant of old primaeval spruce forests, the amount of which is drastically decreasing during last years. This may throw the species soon away from Kainuu, but at this moment it seems to hold.

As migratory or accidental defector cases were found from following species *Amphipyra perflua* (Fabricius), *Catocala adultera* (Ménétriés) and *Colotois pennaria* (Linnaeus). *C. adultera* is a typical migrant, which may have some permanent populations also locally (Mikkola 1967). *C. pennaria* is typically a fluctuative species (Kaisila 1962), which seems to have just now a wider phase going on. Rather similar is the case of *A. perflua*, which can now and then overwinter in Finland, but normally needs extra individuals from abroad (Kaisila 1962).

From butterflies one can pick up following species *Clossiana freija* (Thunberg) and *C. frigga* (Thunberg). Both ones are very characteristic on certain bogs and they have declined from southern Finland due to the drainage of bogs (Marttila et al. 1990). They can still be observed in northern Finland but not so much anymore, i.e. these observations at Kainuu are quite valuable, because they show that here these species have vital populations. The record of *Lycaena helle* (Denis & Schiffermüller) from Kostamus was a glad surprise. It was not observed on the Finnish side of the park. In Finland it is included among threatened species as a one needing monitoring (Rassi et al. 1991). This species is a typical meadow species, which has its closest occurrences not so far from Friendship Park (see Marttila et al. 1990). Old cultural surroundings inside the park seem quite suitable for this species, but so far we could not find it here.

Among so called microlepidopterans there were some species worth mentioning separately, too. *Alloclemensia mesospilella* (Herrich-Schäffer) can be taken as a good indicator of rich lushy habitat. It is living on *Ribes* species (Nielsen 1981), and according to our own observations mainly on wild bushes, not on cultivated ones. *Lypusa maurella* (Denis & Schiffermüller) is considered as a rare moth, which has records here and there in Finland (see Kerppola et al. 1995). *Niditinea truncicolella* (Tengström) is interesting because it has curious life habits, i.e. it is living in the nests of *Camponotus herculeanus* (Heinemann 1977). Here at Kainuu it seems to favour nests in natural sites, i.e. in old hollow dead standing trees, where the ant has its nest communities. *N. truncicolella* can surely be considered as an indicator of old primaeval forest. Really enjoyable was the finding of *Caryocolum schleichi* (Christoph) from Kostamus. The species could be a little bit expected, because its food plant, *Dianthus arenarius (*Linnaeus), has some populations on Räätäkangas some 90 km from Kostamus in Kainuu (Leinonen, pers comm). So far we do not know if *D. arenarius* grows in the area of Kostamus, but because this species is strictly monophagous (Huemer 1988), it must be growing there. Even from Finland it is not known more than from two small populations (Kerppola et al. 1995).

The finding of *Cnaemidophorus rhododactylus* (Denis & Schiffermüller) surprised us well. When we take into account its food plant *Rosa* spp. (Heinemann 1977), it is not so astonishing, because roses occur rather abundantly in Friendship Park. *Eudonia aequalis* (Palm) has not been known for many years yet (Palm 1989). It seems to have quite permanent and even rather abundant populations in the study areas. It looks like a species of forest areas in Finland, because Itämies & Mutanen (1996) have found it richly in the area of Pelkosenniemi, northern Finland also from forested area.

General remarks

Characteristic to the Finnish Park subareas is that the dominating biotope is different in each, while the Russian side has a large and unbroken area more or less in natural state. This gives good basis for comparing faunistic research and also offers excellent possibilities for future monitoring of species. Especially species indicating old primeval forest and bogs in natural state are important, because they are declining in vast areas and need so urgently to be studied more thoroughly. Based on these, one can perhaps develop different parametres to describe nature indices.

Drainage carried out close to protected bogs and fens seems to have pushed several species towards the center of bogs. Thus this kind of manouvers should not be done close to protected areas, but one should leave a buffering zone around them.

In general, the fauna of the Nature Reserve Friendship is now adequately known. The clearest lack are to found in following subareas. In Ulvinsalo the observation was broken accidentally by a bear, which broke the bait traps just before the flight of *Xestia* species was beginning. After that the area was not visited any more. Generally speaking the collecting of microlepidoptera larvae, especially the mining ones, would give in many cases more information of species and their distribution in the area. Because the main research was done during one year to one subarea, the year itself has great influence upon the results. During the inventory of Juortanansalo/Lapinsuo the weather conditions were not suitable, so the remapping of that area would be needed. If we could get a permanent light trap to Akonlahti, Kostamus, it would surely elucidate remarkably the composition of the moth fauna there.

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Appendix. The lepidopterous fauna of the Nature Reserve Friendship. Nomenclature followes Varis et al. (1995). Explanation to abbreviations. Eli.=Elimyssalo, Iso.= Iso-Palo- nen-Maariansärkät, Juo.= Juortanansalo-Lapinsuo, Len.= Lentua, Ulv.= Ulvinsalo, Kos.= Kostomuksha

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
MICROLEPIDOPTERA						
Micropteryx mansuetella (Zell.)	-	-	+	+	-	-
Micropteryx aureatella (Scop.)	+	+	+	+	+	+
Eriocrania unimaculella (Zett.)	+	-	-	-	-	+
Eriocrania sparmannella (Bosc)	-	-	-	-	-	+
Eriocrania cicatricella (Zett.)	+	+	-	-	-	-
Eriocrania sangii (Wood)	+	-	-	+	+	+
Eriocrania semipurpurella (Step.)	+	-	-	+	+	+
Hepiolus hecta (L.)	+	-	+	-	+	+
Hepiolus fusconebulosus (DeGeer)	+	+	+	+	+	+
Stigmella lapponica (Wocke)	+	-	-	+	+	+
Stigmella confusella (Wood & Wal.)	-	+	+	-	+	-
Stigmella nylandriella (Tengstr.)	-	+	-	-	+	+
Stigmella salicis (Stainton)	+	+	-	-	-	-
Stigmella sorbi (Stainton)	+	+	+	+	-	+
Stigmella lediella (Schleich)	-	+	+	+	-	+
Ectoedemia weaveri (Stainton)	+	+	-	+	+	+
Ectoedemia arcuatella (Herr.-Sch.)	+	-	-	-	-	-
Ectoedemia minimella (Zett.)	+	-	-	-	-	-
Nematopogon schwartziellus (Zell.)	+	-	-	-	+	-
Nematopogon magnus (Zell.)	+	+	-	-	-	+
Nematopogon swammerdamellus (L.)	+	+	-	+	+	-
Nematopogon robertellus (Clerck)	-	-	-	-	+	-
Nemophora amatella (Staudinger)	+	+	+	+	+	+
Phylloporia bistrigella (Haworth)	-	+	-	-	-	+
Incurvaria praelatella (Den. & S.)	-	-	-	-	+	-
Incurvaria oehlmanniella (Hübn.)	+	+	-	-	+	+
Incurvaria vetulella (Zett.)	+	-	-	-	+	-
Incurvaria circulella (Zett.)	-	-	-	-	+	-
Incurvaria pectinea (Haworth)	+	+	+	+	-	+
Alloclemensia mesospilella (H.& S.)	-	-	-	-	+	-
Lampronia capitella (Clerck)	-	-	-	-	+	-
Lampronia luzella (Hübner)	+	-	+	+	+	+
Lampronia rupella (Den. & Schi.)	-	-	-	-	-	+
Lypusa maurella (Den. & Schi.)	+	+	-	-	-	+
Dahlica lazuri (Clerck)	+	-	+	-	+	+
Taleporia tubulosa (Retzius)	+	+	-	+	+	-
Psyche norvegica (Schöyen)	+	-	-	-	-	+
Acanthopsyche atra (L.)	+	+	+	+	-	-
Pachytelia villosella (Ochsen.)	+	-	-	-	+	-
Phalacropterix graslinella (Bois.)	-	-	-	-	+	+
Sterrhopterix standfussi (Wocke)	+	-	-	+	+	-
Montescardia tessulatella (L.& Z.)	+	-	-	+	+	+
Infurcitinea ignicomella (H.& S.)	+	+	-	-	-	-
Agnathosia mendicella (D.& S.)	-	-	-	-	+	-
Haplotinea insectella (F.)	+	+	+	-	+	-
Nemapogon cloacellus (Haworth)	+	+	+	+	+	+

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Nemapogon wolffiellus (K.& S N.)	-	-	-	-	-	+
Nemapogon picarellus (Clerck)	+	+	-	-	+	-
Archinemapogon yildizei (Kocak)	-	-	-	-	+	-
Triaxomera fulvimitrella (Sod.)	+	-	-	-	-	-
Monopis laevigella (D.& S.)	+	-	+	+	+	-
Monopis weaverella (Scott)	+	+	+	+	+	-
Monopis spilotella (Tengström)	+	+	+	+	+	-
Niditinea fuscella (L.)	+	-	-	-	-	-
Niditinea striolella (Matsumura)	+	-	+	+	-	-
Niditinea truncicolella (Tengst.)	+	+	-	-	-	-
Tinea pellionella (L.)	-	-	+	-	-	-
Tinea svenssoni (Opheim)	-	-	+	-	-	-
Tinea trinotella (Thunberg)	+	-	-	-	-	-
Caloptilia populetorum (Zeller)	-	-	-	-	+	-
Caloptilia suberinella (Tengstr.)	+	+	+	+	+	+
Caloptilia elongella (L.)	+	-	+	+	+	+
Caloptilia betulicola (M.Hering)	+	+	-	+	+	+
Caloptilia stigmatella (F.)	-	-	-	-	-	+
Parornix betulae (Stainton)	+	+	-	-	+	-
Parornix scoticella (Stainton)	-	-	+	-	-	-
Parornix polygrammella (Wocke)	-	-	-	-	-	+
Phyllonorycter sorbi (Frey)	+	+	+	+	+	+
Phyllonorycter junoniellus (Zell.)	+	-	-	+	+	-
Phyllonorycter hilarellus (Zett.)	+	-	-	-	+	+
Phyllon. strigulatellus (L.& Z.)	+	-	+	-	+	+
Phyllonorycter anderidae (Flet.)	-	-	-	-	+	-
Phyllonorycter ulmifoliellus (Hü.)	+	+	-	-	+	-
Phyllocnistis labyrinthella (Bje.)	+	+	-	-	+	+
Roeslerstammia erxlebella (F.)	+	-	-	-	-	-
Bucculatrix cristatella (Zell.)	+	-	-	-	-	-
Bucculatrix nigricomella (Zell.)	+	-	-	-	-	-
Yponomeuta evonymellus (L.)	+	+	+	+	+	+
Yponomeuta sedellus (Treit.)	-	-	-	-	+	-
Euhyponomeutoides rufellus (Teng.)	+	-	-	-	-	+
Swammerdamia caesiella (Hübner)	+	+	-	-	+	-
Swammerdamia passerella (Zett.)	+	-	-	-	-	-
Swammerdamia compunctella (H.-S.)	+	+	+	-	+	+
Paraswammerdamia lapponica (W.Pe.)	+	+	-	-	+	+
Paraswammerdamia conspersella (T.)	+	+	+	+	+	+
Cedestis gysseleniella (Zell.)	+	-	-	+	+	-
Cedestis subfasciella (Stephens)	+	-	-	-	-	-
Ocnerostoma friesei (Svensson)	+	+	+	+	+	-
Argyresthia glabratella (Zell.)	+	+	+	-	+	+
Argyresthia abdominalis (Zell.)	+	+	-	-	+	+
Argyresthia aurulentella (Stain.)	+	-	-	-	+	+
Argyresthia pygmaeella (D.& S.)	+	+	+	+	+	+
Argyresthia sorbiella (Treit.)	+	+	-	+	+	+
Argyresthia retinella (Zell.)	+	-	-	-	-	-
Argyresthia conjugella (Zell.)	+	+	+	+	+	-
Argyresthia pulchella (L.& Z.)	-	+	-	-	+	-
Argyresthia semifusca (Haworth)	+	-	-	-	-	+
Ypsolopha asperella (L.)	-	-	-	-	+	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Ypsolopha parenthesella (L.)	+	+	+	+	+	+
Plutella xylostella (L.)	+	+	+	+	+	+
Glyphipteryx forsterella (F.)	+	-	-	-	-	-
Glyphipteryx haworthana (Steph.)	+	-	+	+	+	+
Lyonetia ledi (Wocke)	-	-	-	-	+	-
Semioscopis strigulana (F.)	+	-	-	-	-	-
Semioscopis avellanella (Hübner)	+	+	+	+	+	-
Semioscopis steinkellneriana (D.&S)	+	-	-	-	+	-
Depressaria badiella (Hübner)	-	-	-	-	+	-
Depressaria sordidatella (Tengs.)	+	+	+	+	+	-
Exaeretia ciniflonella (L.& Z.)	+	+	-	+	+	-
Agonopteryx heracliana (L.)	+	+	+	+	+	+
Agonopteryx angelicella (Hübner)	+	+	-	+	+	+
Pseudatemelia josephinae (Toll)	+	+	+	+	+	+
Schiffermuelleria similella (Hüb.)	+	+	+	+	+	+
Schiffermuelleria stipella (L.)	+	+	+	+	+	+
Schiffermuelleria obscurella (Bra.)	-	-	-	-	+	-
Borkhausenia fuscescens (Haworth)	+	+	-	+	+	-
Borkhausenia luridicomella (H-S.)	+	-	-	-	-	-
Pleurota bicostella (Clerck)	+	+	+	+	+	+
Elachista kilmunella (Stainton)	+	-	-	-	-	+
Elachista elegans (Frey)	+	-	-	-	-	-
Elachista albifrontella (Hübner)	+	-	-	+	-	-
Elachista nobilella (Zeller)	+	-	-	-	+	+
Elachista apicipunctella (Stai.)	+	-	-	-	+	-
Elachista humilis (Zeller)	+	-	+	-	-	-
Elachista canapennella (Hübner)	+	-	-	-	-	-
Elachista subalbidella (Schläger)	+	+	+	+	+	+
Biselachista utonella (Frey)	+	-	-	-	-	-
Biselachista albidella (Nylander)	+	-	-	-	-	-
Coleophora milvipennis (Zeller)	+	-	-	-	-	-
Coleophora serratella (L.)	+	-	-	-	-	+
Coleophora idaeella (Hofmann)	+	-	-	+	+	-
Coleophora vacciniella (H-S.)	+	-	-	+	+	-
Coleophora ledi (Stainton)	+	-	-	+	-	+
Coleophora plumbella (Kanerva)	+	+	+	+	-	-
Coleophora vitisella (Gregson)	+	+	-	+	-	-
Coleophora glitzella (Hofmann)	+	+	+	+	+	+
Coleophora murinella (Tengström)	+	+	-	-	+	-
Coleophora violacea (Ström)	+	-	+	-	-	-
Coleophora frischella (L.)	+	-	-	+	-	-
Coleophora deauratella (L.& Z.)	+	+	-	-	+	-
Coleophora mayrella (Hübner)	+	+	+	+	+	-
Coleophora glaucicolella (Wood)	+	+	-	-	-	-
Coleophora otidipennella (Hübner)	+	-	+	-	-	-
Coleophora alticolella (Zeller)	-	-	-	+	-	-
Coleophora virgaureae (Stainton)	+	+	+	+	+	+
Mompha idaei (Zeller)	+	+	+	+	+	+
Mompha conturbatella (Hübner)	+	+	+	+	+	+
Mompha lacteella (Stephens)	+	-	-	-	-	-
Mompha nodicolella (Fuchs)	+	+	+	-	+	-
Scythris potentillella (Zeller)	+	-	-	-	-	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Monochroa tenebrella (Hübner)	+	-	-	-	-	-
Bryotropha similis (Stainton)	+	-	-	+	+	-
Bryotropha galbanella (Zeller)	+	+	+	+	+	+
Bryotropha boreella (Douglas)	+	-	-	-	-	-
Bryotropha plantariella (Tengst.)	+	+	+	+	-	-
Exoteleia dodecella (L.)	+	+	+	-	+	+
Teleoides epomidellus (Tengst.)	+	-	-	+	+	-
Teleoides alburnellus (Zeller)	+	+	-	-	-	-
Teleoides notatellus (Hübner)	-	+	-	+	-	-
Teleoides proximellus (Hübner)	+	+	-	-	+	-
Teleioides paripunctellus (Thun.)	-	-	-	+	-	-
Teleiopsis diffinis (Haworth)	+	+	-	+	+	-
Chionodes lugubrellus (F.)	+	+	-	-	+	+
Chionodes luctuellus (Hübner)	-	-	-	-	+	-
Chionodes nubilellus (Zett.)	+	+	-	+	+	+
Chionodes continuellus (Zeller)	+	-	-	+	+	-
Chionodes electellus (Zeller)	+	-	-	-	+	-
Chionodes viduellus (F.)	+	-	-	+	+	-
Aroca velocella (Zeller)	+	-	-	-	-	-
Neofaculta infernella (H-S.)	+	+	+	+	+	+
Prolita sexpunctella (F.)	+	-	+	-	-	+
Athrips pruinosellus (L.& Z.)	-	+	+	+	-	-
Gnorimoshema epithymellum (Stau.)	+	-	-	-	+	-
Scrobipalpa murinella (Duponchel)	-	-	-	+	-	-
Scrobipalpa atriplicella (F.v Rö.)	+	-	-	-	-	-
Caryocolum schleichi (Christoph)	-	-	-	-	-	+
Caryocolum pullatellum (Tengst.)	+	+	+	+	+	-
Caryocolum cassellum (Walker)	+	-	-	-	-	-
Syncopacma cinctella (Clerck)	+	-	-	+	-	-
Syncopacma karvoneni (Hackman)	+	-	+	-	+	-
Hypatima rhomboidella (L.)	+	+	-	+	+	-
Dichomeris juniperella (L.)	+	+	-	+	+	-
Helcystogramma rufescens (Haworth)	+	+	-	-	-	-
Cossus cossus (L.)	+	+	-	-	-	-
Pandemis cerasana (Hübner)	+	-	-	+	+	-
Pandemis cinnamoneana (Treits.)	+	-	-	-	+	-
Pandemis heparana (D.& S.)	-	-	+	+	+	+
Argyrotaenia ljungiana (Thunb.)	+	+	+	+	-	-
Archips rosanus (L.)	-	-	-	+	-	-
Syndemis musculana (Hübner)	+	+	-	+	-	-
Aphelia viburnana (D.& S.)	+	-	-	-	-	-
Clepsis senecionana (Hübner)	+	+	+	+	+	+
Clepsis rurinana (L.)	-	-	-	+	+	+
Adoxophyes orana (Fischer v R.)	-	+	-	-	-	+
Lozotaenia forsterana (F.)	+	+	+	+	+	+
Epagoge grotiana (F.)	+	-	-	-	-	-
Philedone gerningana (D.& S.)	-	-	-	+	-	-
Eulia ministrana (L.)	+	+	+	+	+	+
Cnephasia asseclana (D.& S.)	+	-	+	+	+	-
Exapate congelatella (Clerck)	+	-	-	-	+	-
Eana argentana (Clerck)	+	+	-	-	+	+
Eana osseana (Scopoli)	+	+	+	+	+	+

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Eana incanana (Stephens)	-	+	-	-	-	-
Eana penziana (Thunberg)	+	+	+	+	+	+
Croesia bergmanniana (L.)	+	-	-	+	+	+
Acleris laterana (F.)	+	-	-	-	+	-
Acleris aspersana (Hübner)	+	+	+	-	+	-
Acleris notana (Donovan)	+	+	-	-	+	-
Acleris hastiana (L.)	+	+	-	-	+	-
Acleris lipsiana (D.& S.)	+	+	+	+	+	-
Acleris maccana (Treitschke)	+	+	+	+	+	+
Acleris emargana (F.)	+	+	+	+	+	-
Aethes cnicana (Westwood)	+	-	-	+	+	-
Aethes smeathmanniana (F.)	+	+	+	+	+	-
Aethes rutilana (Hübner)	+	-	-	-	-	-
Cochylidia subroseana (Haworth)	+	+	-	-	-	-
Cochylis dubitana (Hübner)	+	+	+	+	+	+
Cochylis nana (Haworth)	-	-	-	+	-	+
Sparganothis rubigundana (H-S.)	+	-	-	+	+	-
Celypha rufana (Scopoli)	-	-	-	-	+	-
Celypha rurestrana (Duponchel)	+	-	-	-	+	+
Celypha cespitana (Hübner)	-	-	-	+	-	-
Olethreutes ledianus (L.)	+	-	-	+	-	-
Olethreutes dalecarlianus (Guen.)	+	-	-	-	-	-
Olethreutes umbrosanus (Freyer)	-	-	-	+	-	-
Olethreutes obsoletanus (Zett.)	+	+	+	+	+	-
Olethreutes dissolutanus (Stange)	+	+	-	-	+	-
Olethreutes mygindianus (D.& S.)	+	+	+	+	+	+
Olethreutes arbutellus (L.)	-	-	-	-	+	+
Olethreutes tiedemannianus (Zel.)	+	-	-	-	-	-
Olethreutes lacunanus (D.& S.)	+	+	+	+	+	+
Olethreutes bipunctanus (F.)	+	+	+	+	+	+
Olethreutes olivanus (Treitschke)	+	+	-	+	+	+
Olethreutes palustranus (L.& Z.)	+	+	-	+	+	+
Olethreutes metallicanus (Hübner)	-	-	-	+	-	-
Olethreutes schulzianus (F.)	+	+	+	+	+	+
Olethreutes schaefferanus (H-S.)	-	-	-	-	-	+
Olethreutes turfosanus (H-S.)	+	-	+	-	+	+
Olethreutes concretanus (Wocke)	+	+	-	-	-	-
Olethreutes rivulanus (Scopoli)	+	+	+	+	+	+
Pseudohermenias abietana (F.)	-	-	-	-	+	-
Hedya dimidioalba (Retzius)	-	-	+	-	+	-
Hedya atropunctana (Zett.)	+	-	-	-	-	-
Hedya roseomaculana (H-S.)	+	-	-	-	-	-
Orthotaenia undulana (D.& S.)	+	+	+	+	+	+
Apotomis semifasciana (Haworth)	+	-	-	-	-	-
Apotomis infida (Heinrich)	+	-	+	+	+	-
Apotomis turbidana (Hübner)	+	+	-	-	+	-
Apotomis betuletana (Haworth)	+	+	+	+	+	-
Apotomis boreana (Krogerus)	+	-	-	-	-	-
Apotomis sororculana (Zett.)	+	-	-	-	+	-
Apotomis fraterculana (Krogerus)	+	-	-	-	-	-
Apotomis algidana (Krogerus)	-	-	+	-	-	+
Apotomis sauciana (Frölich)	+	-	+	-	-	+

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Bactra lancealana (Hübner)	+	+	+	+	-	-
Ancylis laetana (F.)	-	+	-	+	-	-
Ancylis uncella (Den.& Schi.)	+	+	-	-	-	-
Ancylis unguicella (L.)	+	+	+	+	+	+
Ancylis geminana (Donovan)	+	+	-	+	-	+
Ancylis subarcuana (Douglas)	-	-	-	+	-	-
Ancylis tineana (Hübner)	-	+	-	-	-	-
Ancylis badiana (Den.& Schi.)	+	+	+	+	+	+
Ancylis myrtillana (Treitschke)	+	+	+	+	+	+
Ancylis apicella (Den.& Schi.)	-	-	-	-	-	+
Epinotia indecorana (Zett.)	+	+	-	-	+	-
Epinotia solandriana (L.)	+	+	+	+	+	+
Epinotia brunnichana (L.)	+	+	+	+	+	+
Epinotia maculana (F.)	+	+	+	+	+	-
Epinotia caprana (F.)	-	-	-	+	-	-
Epinotia ramella (L.)	+	+	+	-	+	-
Epinotia demarniana (Fischer v R.)	+	-	-	-	-	-
Epinotia tetraquetrana (Haworth)	-	-	-	-	-	+
Epinotia nisella (Clerck)	+	+	+	+	+	-
Epinotia tenerana (Den.& Schi.)	+	-	-	-	-	-
Epinotia tedella (Clerck)	-	-	-	+	-	-
Epinotia signatana (Douglas)	-	-	-	-	+	-
Epinotia cruciana (L.)	+	-	-	+	+	+
Epinotia gimmerthaliana (L.& Z.)	+	-	-	+	-	-
Epinotia nanana (Treitschke)	+	-	-	-	-	-
Epinotia crenana (Hübner)	+	+	+	+	+	+
Rhobopota ustomaculana (Curtis)	+	+	-	+	+	+
Rhobopota naevana (Hübner)	+	+	+	+	+	-
Zeiraphera ratzeburgiana (Saxes.)	+	-	+	+	+	-
Gypsonoma nitidulana (L.& Z.)	+	-	-	+	+	-
Epiblema cynosbatellum (L.)	-	+	-	+	+	-
Epiblema grandaevanum (L.& Z.)	+	+	-	-	-	-
Eriopsela quadrana (Hübner)	+	-	-	+	+	-
Eucosma cana (Haworth)	-	-	-	+	+	-
Eucosma obumbratana (L.& Z.)	+	+	-	-	-	-
Eucosma aspidiscana (Hübner)	+	-	-	-	-	-
Rhyacionia pinicolana (Doubleday)	+	-	-	+	-	-
Retinia resinella (L.)	+	-	-	+	-	+
Latronympha strigana (F.)	+	+	-	+	+	+
Pammene luedersiana (Sorhagen)	-	-	+	-	-	-
Pammene populana (F.)	-	-	-	+	-	-
Cydia duplicana (Zetterstedt)	+	-	-	-	+	-
Cydia cosmophorana (Treitschke)	-	+	-	+	-	+
Cydia cognatana (Barret)	+	-	-	-	+	-
Cydia coniferana (Saxesen)	+	+	-	-	-	+
Cydia corollana (Hübner)	-	+	-	-	-	-
Cydia strobilella (L.)	-	-	-	+	-	-
Cydia jungiella (Clerck)	-	-	-	-	-	+
Cydia orobana (Treitschke)	+	-	-	-	-	-
Cydia compositella (F.)	+	-	-	-	-	-
Dicrorampha petiverella (L.)	+	-	-	-	-	-
Dicrorampha alpina (Treitschke)	+	-	-	-	-	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Dicrorampha plumbagana (Treits.)	+	-	-	-	-	-
Dicrorampha consortana (Stephens)	+	-	-	-	-	-
Dicrorampha agilana (Tengström)	+	-	-	-	-	+
Dicrorampha plumbana (Scopoli)	+	-	-	-	-	-
Anthophila fabriciana (L.)	-	-	-	-	-	+
Prochoreutis ultimana (Krulik.)	+	+	-	+	+	-
Choreutis diana (Hübner)	+	-	-	-	+	-
Paranthrene tabaniformis (Rott.)	+	-	-	-	-	-
Synanthedon scoliaeformis (Bork.)	+	-	-	+	-	-
Synanthedon culiciformis (L.)	+	-	-	-	-	-
Schreckensteinia festaliella (Hü.)	-	-	+	-	-	+
Epermenia chaerophyllella (Goeze)	-	-	-	+	-	-
Hellinsia osteodactyla (Zeller)	+	+	+	+	+	+
Hellinsia didactylites (Ström)	+	-	-	-	+	-
Hellinsia tephradactyla (Hübner)	+	+	+	+	+	+
Cnaemidophorus rhododactylus (D.&S)	+	-	-	-	-	-
Amplyptilia punctidactyla (Hawo.)	+	+	-	+	-	+
Stenoptilia pterodactyla (L.)	+	+	-	+	-	+
Gillmeria pallidactyla (Haworth)	+	+	+	+	+	+
Platyptilia tesseradactyla (L.)	+	+	-	-	-	+
Platyptilia gonodactyla (D.& S.)	+	-	+	-	-	-
Platyptilia calodactyla (D.& S.)	+	+	+	+	+	+
Dioryctria abietella (D.& S.)	-	+	-	-	-	+
Dioryctria mutatella (Fuchs)	+	-	-	-	-	-
Metriostola vacciniella (L.& Z.)	+	-	-	-	-	-
Metriostola betulae (Goeze)	+	-	-	-	-	-
Pyla fusca (Haworth)	+	+	-	+	+	+
Assara terebrella (Zincken)	+	-	-	-	+	-
Phycitodes binaevellus (Hübner)	+	+	-	-	-	-
Elophila nymphaeata (L.)	+	-	+	-	+	-
Nymphula stagnata (Donovan)	+	+	-	+	+	+
Donacaula mucronella (D.& S.)	+	-	-	-	-	-
Chrysoteuchia culmella (L.)	+	+	+	+	+	+
Crambus pascuellus (L.)	+	-	-	-	-	-
Crambus alienellus (Ger.& Kaul.)	+	-	+	-	+	+
Crambus heringiellus (H-S.)	+	+	+	+	-	+
Crambus pratellus (L.)	+	+	-	+	+	-
Crambus lathoniellus (Zincken)	+	+	+	+	+	+
Crambus hamellus (Thunberg)	+	+	+	+	+	+
Crambus perlellus (Scopoli)	+	+	-	+	+	+
Agriphila straminella (D.& S.)	+	+	+	+	+	+
Agriphila biarmica (Tengström)	+	-	-	-	-	+
Catoptria permutatella (H-S.)	+	-	+	-	+	+
Catoptria pinella (L.)	+	-	-	-	+	-
Catoptria margaritella (D.& S.)	+	+	+	+	+	+
Catoptria maculalis (Zett.)	+	+	-	+	+	-
Pediasia truncatella (Zett.)	+	-	-	-	-	-
Pediasia aridella (Thunberg)	+	-	-	-	-	-
Scoparia ambiqualis (Treitschke)	-	+	-	+	-	-
Scoparia ancipitella (La Harpe)	+	-	-	+	+	+
Eudonia aequalis (Palm)	+	-	+	+	-	+
Eudonia murana (Curtis)	+	-	+	+	+	+

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Eudonia sudetica (Zeller)	+	+	+	+	+	+
Evergestis pallidata (Hufnagel)	+	+	-	-	-	-
Titanio schrankiana (Hochenwarth)	+	-	-	-	-	-
Pyrausta porphyralis (D.& S.)	+	-	-	-	-	-
Mutuuraia terrealis (Treitschke)	+	+	+	-	-	-
Anania funebris (Ström)	+	-	+	-	+	-
Opsibotys fuscalis (D.& S.)	+	+	+	+	+	+
Udea lutealis (Hübner)	+	+	+	+	+	-
Udea nebulalis (Hübner)	-	-	-	-	+	-
Udea prunalis (Den.& Schi.)	+	-	-	+	+	+
Udea inguinatalis (Lie.& Zel.)	+	-	+	-	+	+
Udea decrepitalis (Herrich-Sc.)	+	+	+	+	+	+
Udea hamalis (Thunberg)	+	+	-	+	+	+
Adsicta statices (L.)	-	-	-	+	-	-
MACROLEPIDOPTERA						
Pyrgus centaureae (Rambur)	+	-	-	+	-	-
Carterocephalus palaemon (Pallas)	+	-	-	-	-	-
Carterocephalus silvicola (Meigen)	-	-	-	-	-	+
Papilio machaon (L.)	-	-	-	+	-	+
Leptidea sinapis (L.)	-	-	-	+	-	-
Pieris rapae (L.)	-	+	-	-	-	-
Pieris napi (L.)	+	+	+	+	+	+
Anthocharis cardamines (L.)	+	-	+	+	-	+
Colias palaeno (L.)	+	+	-	+	+	-
Callophrys rubi (L.)	+	+	+	+	+	+
Lycaena helle (Den.& Schi.)	-	-	-	-	-	+
Heodes virgaureae (L.)	+	+	+	+	-	-
Celastrina argiolus (L.)	-	-	-	+	-	-
Plebejus argus (L.)	+	+	-	+	+	-
Lycaides idas (L.)	+	-	-	+	+	+
Aricia artaxerxes (F.)	-	-	-	+	-	-
Eumedonia eumedon (Esper)	+	-	-	-	-	+
Vacciniina optilete (Knoch)	+	+	+	+	+	+
Cyaniris semiargus (Rottemburg)	-	+	-	+	-	-
Polyommatus icarus (Rottemburg)	-	-	-	+	-	-
Nymphalis antiopa (L.)	-	+	+	+	-	-
Aglais urticae (L.)	+	+	+	+	-	+
Brenthis ino (Rottemburg)	-	+	-	-	+	-
Boloria aquilonaris (Stichel)	+	+	-	-	+	+
Proclossiana eunomia (Esper)	+	+	+	+	+	+
Clossiana selene (D.& S.)	+	+	+	+	-	+
Clossiana freija (Thunberg)	+	+	+	+	+	-
Clossiana frigga (Thunberg)	+	-	+	-	-	-
Clossiana euphrosyne (L.)	+	+	+	+	+	+
Erebia ligea (L.)	+	+	+	+	+	+
Erebia embla (Thunberg)	+	+	+	+	-	+
Oeneis jutta (Hübner)	+	+	+	+	-	-
Coenonympha pamphilus (L.)	-	-	-	+	-	-
Coenonympha tullia (Müller)	+	+	+	+	+	+
Lasiommata petropolitana (F.)	-	+	-	+	-	-
Falcaria lacertinaria (L.)	+	-	-	+	+	-
Drepana falcataria (L.)	+	-	-	+	+	+

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Thyatira batis (L.)	+	-	+	+	-	-
Tethea or (Den.& Schi.)	+	+	-	+	+	-
Ochropacha duplaris (L.)	+	+	+	+	-	+
Achlya flavicornis (L.)	+	+	+	+	+	+
Archiearis parthenias (L.)	-	+	-	-	-	-
Geometra papilionaria (L.)	+	+	+	+	+	+
Jodis putata (L.)	+	+	+	+	+	+
Cyclophora albipunctata (Hufnagel)	+	+	+	+	+	-
Scopula ternata (Schrank)	+	+	+	+	+	+
Scopula immorata (L.)	-	-	-	+	-	-
Scopula floslactata (Haworth)	+	+	-	+	-	-
Idaea serpentata (Hufnagel)	-	-	-	+	-	-
Idaea pallidata (Den.& Schi.)	-	-	-	+	-	-
Scotopteryx chenopodiata (L.)	+	+	-	+	+	+
Xanthorhoe munitata (Hübner)	+	+	+	+	+	+
Xanthorhoe spadicearia (D.& S.)	+	+	+	+	+	+
Xanthorhoe ferrugata (Clerck)	-	+	-	-	+	-
Xanthorhoe montanata (D.& S.)	+	+	-	+	+	+
Xanthorhoe annotinata (Zett.)	+	+	+	+	+	+
Epirrhoe tristata (L.)	-	-	-	+	-	-
Epirrhoe alternata (Müller)	+	+	-	+	-	+
Entephria caesiata (D.& S.)	+	+	+	+	+	+
Lampropteryx suffumata (D.& S.)	+	-	-	-	+	+
Eulithis prunata (L.)	+	+	+	+	+	+
Eulithis testata (L.)	+	+	+	+	+	+
Eulithis populata (L.)	+	+	+	+	+	+
Ecliptopera silaceata (D.& S.)	+	+	+	+	+	+
Chloroclysta miata (L.)	+	-	-	-	+	-
Chloroclysta citrata (L.)	+	+	+	+	+	+
Chloroclysta infuscata (Tengst.)	+	+	+	-	-	-
Chloroclysta latefasciata (Stau.)	+	+	+	+	+	-
Chloroclysta truncata (Hufnagel)	+	+	+	+	+	+
Cidaria fulvata (Forster)	-	-	-	-	-	+
Plemyria rubiginata (D.& S.)	+	+	+	+	+	+
Thera variata (Den.& Schi.)	+	-	-	-	-	-
Thera obeliscata (Hübner)	+	+	-	-	+	-
Thera juniperata (L.)	+	-	-	+	+	-
Thera serraria (Lie.& Zel.)	-	-	+	-	+	-
Electrophaes corylata (Thunberg)	-	-	-	+	-	-
Hydriomena furcata (Thunberg)	+	+	+	+	+	+
Hydriomena impluviata (D.& S.)	+	+	+	+	+	+
Hydriomena ruberata (Freyer)	+	+	+	+	+	+
Coenocalpe lapidata (Hübner)	+	-	+	+	+	-
Spargania luctuata (Den.& Schi.)	+	+	+	+	+	+
Rheumaptera hastata (L.)	+	-	+	+	+	+
Rheumaptera subhastata (Nolcken)	+	+	+	+	-	+
Rheumaptera undulata (L.)	-	-	-	+	-	-
Epirrita autumnata (Borkhausen)	+	+	+	+	+	+
Operopthera brumata (L.)	+	-	+	-	+	+
Operopthera fagata (Scharfenberg)	-	-	-	-	+	-
Perizoma taeniatum (Stephens)	+	+	+	+	+	+
Perizoma affinitatum (Stephens)	+	+	-	-	+	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Perizoma alchemillatum (L.)	+	+	+	+	+	+
Perizoma blandiatum (D.& S.)	+	+	+	+	-	-
Perizoma albulatum (D.& S.)	+	+	+	+	-	+
Perizoma didymatum (L.)	+	+	+	+	+	+
Perizoma parallelolineatum (Retz.)	+	+	+	+	+	-
Eupithecia plumbeolata (Haworth)	+	+	-	-	+	+
Eupithecia abietaria (Goeze)	+	-	-	-	-	-
Eupithecia pygmaeata (Hübner)	-	-	-	-	-	+
Eupithecia venosata (F.)	+	-	-	-	-	-
Eupithecia intricata (Zetter.)	+	+	+	+	+	+
Eupithecia satyrata (Hübner)	+	+	+	+	+	+
Eupithecia absinthiata (Clerck)	+	-	-	-	-	-
Eupithecia assimilata (Doubled.)	+	-	-	-	-	-
Eupithecia vulgata (Haworth)	+	+	+	+	+	+
Eupithecia subfuscata (Haworth)	-	-	-	+	-	-
Eupithecia succenturiata (L.)	+	+	+	+	-	+
Eupithecia sinuosaria (Eversm.)	-	-	-	-	-	+
Eupithecia indigata (Hübner)	+	+	+	-	-	-
Eupithecia gelidata (Möschler)	+	+	-	+	-	-
Eupithecia virgaureata (Doubled.)	+	+	-	+	-	-
Eupithecia pusillata (D.& S.)	+	+	+	+	+	+
Eupithecia tantillaria (Boisduval)	-	-	-	+	-	-
Eupithecia conterminata (L.& Z.)	+	-	+	+	+	-
Eupithecia lanceata (Hübner)	+	-	-	-	-	-
Chloroclystis debiliata (Hübner)	+	-	-	+	+	+
Anticollix sparsatus (Treitschke)	-	+	-	-	-	+
Carsia sororiata (Hübner)	+	+	+	+	+	+
Venusia cambrica (Curtis)	+	-	-	-	+	-
Lobophora halterata (Hufnagel)	-	-	-	+	-	-
Hydrelia flammeolaria (Hufnagel)	-	+	-	-	-	-
Trichopteryx carpinata (Borkh.)	+	+	+	+	+	+
Lomaspilis marginata (L.)	+	+	+	+	+	+
Semiothisa notata (L.)	+	-	-	+	+	-
Semiothisa alternaria (Hübner)	-	-	-	+	-	-
Semiothisa liturata (Clerck)	+	+	-	-	-	-
Semiothisa clathrata (L.)	+	+	-	+	+	+
Semiothisa carbonaria (Clerck)	+	-	+	-	+	-
Itame loricaria (Eversmann)	+	+	+	+	+	+
Itame wauaria (L.)	+	+	+	+	+	+
Itame brunneata (Thunberg)	+	+	+	+	+	+
Plagodis pulveraria (L.)	+	+	+	+	+	+
Opisthograptis luteolata (L.)	-	+	+	+	+	-
Epione repandaria (Hufnagel)	+	+	+	+	+	+
Epione paralellaria (D.& S.)	+	+	+	+	+	+
Hypoxystis pluviaria (F.)	+	+	-	+	-	-
Selenia dentaria (F.)	+	+	+	+	+	+
Selenia tetralunaria (Hufnagel)	-	+	-	+	+	+
Epirranthis diversata (D.& S.)	+	+	+	+	+	+
Odontopera bidentata (Clerck)	-	+	-	+	+	-
Crocallis elinguaria (L.)	+	+	+	+	+	-
Colotois pennaria (L.)	+	-	-	-	+	-
Lycia lapponaria (Boisduval)	-	-	-	-	+	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Lycia hirtaria (Clerck)	+	+	+	+	+	+
Alcis repandatus (L.)	+	+	-	+	+	+
Alcis jubatus (Thunberg)	+	-	-	-	+	-
Arichanna melanaria (L.)	+	+	+	+	+	+
Ectropis crepuscularia (D.& S.)	+	+	+	+	+	+
Ematurga atomaria (L.)	+	+	+	+	+	+
Bupalus piniarius (L.)	-	-	-	+	-	-
Cabera pusaria (L.)	+	+	+	+	+	+
Cabera exanthemata (Scopoli)	+	+	+	+	+	+
Hylaea fasciaria (L.)	+	+	+	+	+	+
Parietaria vittaria (Thunberg)	+	+	+	+	+	+
Poecilocampa populi (L.)	+	+	-	-	+	+
Trichiura crataegi (L.)	+	+	+	+	+	-
Lasiocampa quercus (L.)	+	-	-	+	-	+
Macrothylacia rubi (L.)	+	+	-	+	-	-
Phyllodesma ilicifolium (L.)	-	-	-	+	-	-
Saturnia pavonia (L.)	+	-	-	+	+	+
Laothoe populi (L.)	+	-	-	+	+	-
Hyles gallii (Rottemburg)	+	-	-	-	-	-
Cerura vinula (L.)	-	-	-	+	-	-
Furcula furcula (Clerck)	+	-	-	-	+	+
Furcula bifida (Brahm)	+	-	-	-	+	-
Notodonta torva (Hübner)	+	-	-	-	+	+
Notodonta dromedarius (L.)	-	-	-	-	-	+
Pheosia tremula (Clerck)	+	-	-	-	-	-
Pterostoma palpinum (Clerck)	+	+	-	+	+	+
Ptilodon capucina (L.)	+	+	-	+	+	+
Odontosia carmelita (Esper)	-	-	-	-	+	+
Odontosia sieversi (Ménétriés)	-	+	-	+	+	+
Clostera curtula (L.)	-	-	-	-	+	-
Clostera pigra (Hufnagel)	+	+	-	+	+	-
Orgyia antiqua (L.)	+	-	-	+	+	-
Orgyia antiquoides (Hübner)	+	-	+	-	+	-
Dicallomera fascelina (L.)	+	-	-	-	-	-
Leucoma salicis (L.)	-	-	-	+	-	-
Thumatha senex (Hübner)	+	-	-	-	-	+
Parasemia plantaginis (L.)	+	-	-	+	+	-
Arctia caja (L.)	+	+	-	-	-	-
Diacrisia sannio (L.)	+	+	-	+	+	-
Phragmatobia fuliginosa (L.)	+	+	-	-	+	-
Polypogon tentacularius (L.)	-	+	-	-	-	-
Rivula sericealis (Scopoli)	-	-	-	-	+	-
Hypenodes humidalis (Doubleday)	+	+	-	+	-	-
Hypena proboscidalis (L.)	-	-	-	-	-	+
Scoliopteryx libatrix (L.)	+	+	+	+	-	-
Catocala adultera (Ménétriés)	-	+	+	-	+	-
Callistege mi (Clerck)	+	-	+	+	-	-
Euclidia glyphica (L.)	+	+	+	+	-	+
Nycteola degenerana (Hübner)	-	+	-	-	-	-
Colocasia coryli (L.)	-	+	-	-	+	-
Acronicta menyanthidis (Esper)	+	+	+	+	+	-
Acronicta auricoma (Den.& Schi.)	+	+	+	+	+	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Acronicta euphorbiae (D.& S.)	+	-	-	-	-	-
Diachrysia chrysitis (L.)	+	+	+	+	-	-
Polychrysia moneta (F.)	-	-	-	+	-	-
Plusia festucae (L.)	+	-	-	-	-	-
Plusia putnami (Grote)	+	-	-	+	-	-
Autographa macrogamma (Eversmann)	+	+	+	+	+	+
Autographa gamma (L.)	+	-	-	-	+	+
Autographa pulchrina (Haworth)	+	+	+	+	+	+
Autographa buraetica (Staudinger)	-	+	-	-	-	-
Autographa bractea (Den.& Schi.)	+	+	-	-	+	+
Syngrapha microgamma (Hübner)	+	+	-	-	-	-
Syngrapha interrogationis (L.)	+	+	+	+	+	+
Sympistis heliophila (Paykull)	+	+	-	+	-	+
Amphipyra perflua (F.)	+	-	-	-	-	-
Amphipyra tragopoginis (Clerck)	-	-	-	+	-	-
Platyperigea montana (Bremer)	+	-	-	-	-	-
Athetis pallustris (Hübner)	-	-	-	+	-	-
Hyppa rectilinea (Esper)	+	+	+	+	+	-
Enargia paleacea (Esper)	+	+	+	+	+	+
Parastichtis suspecta (Hübner)	+	+	+	+	+	+
Xanthia togata (Esper)	+	+	+	+	-	-
Xanthia icteritia (Hufnagel)	+	+	+	-	-	-
Agrochola circellaris (Hufnagel)	+	-	-	-	-	-
Agrochola helvolus (L.)	+	+	+	+	+	+
Brachionycha nubeculosa (Esper)	+	-	-	+	+	-
Dasypolia templi (Thunberg)	+	+	-	+	+	+
Brachylomia viminalis (F.)	+	-	-	-	+	-
Hillia iris (Zetterstedt)	+	+	+	+	-	+
Lithomoia solidaginis (Hübner)	+	+	+	+	+	+
Lithophane lamda (F.)	+	+	+	-	+	-
Lithophane consocia (Borkhausen)	+	+	-	-	-	-
Xylena vetusta (Hübner)	+	+	+	+	+	-
Mniotype adusta (Esper)	+	+	+	+	-	-
Apamea crenata (Hufnagel)	+	+	+	+	+	-
Apamea lateritia (Hufnagel)	+	+	+	+	-	+
Apamea rubrirena (Treitschke)	+	-	+	-	-	+
Apamea remissa (Hübner)	+	+	+	+	+	-
Photedes minima (Haworth)	+	+	-	+	+	-
Amphipoea oculea (L.)	+	+	-	+	-	-
Amphipoea fucosa (Freyer)	-	+	+	-	-	-
Amphipoea lucens (Freyer)	+	+	+	-	+	-
Hydraecia micacea (Esper)	+	+	-	+	-	-
Crypsedra gemmea (Treitschke)	+	+	+	+	-	-
Celaena haworthii (Curtis)	+	+	+	+	+	-
Chortodes pygminus (Haworth)	+	+	-	+	+	-
Anarta myrtilli (L.)	+	-	+	+	+	-
Anarta cordigera (Thunberg)	+	-	-	+	+	-
Lacanobia thalassina (Hufnagel)	+	+	-	+	-	-
Lacanobia suasa (Den.& Schi.)	+	-	-	-	-	-
Hada plebeja (L.)	-	+	+	+	+	-
Melanchra pisi (L.)	+	-	+	+	+	-

Species	Eli.	Iso.	Juo.	Len.	Ulv.	Kos.
Papestra biren (Goeze)	+	-	+	+	+	-
Polia trimaculosa (Esper)	+	+	-	+	+	-
Mythimna impura (Hübner)	+	+	+	+	+	-
Mythimna pallens (L.)	-	+	-	+	-	-
Orthosia gothica (L.)	+	+	+	+	+	+
Panolis flammea (Den.& Schi.)	-	+	-	-	-	-
Cerapteryx graminis (L.)	+	+	+	+	+	+
Lasionycta skraelingia (H-S.)	+	-	+	-	-	-
Ochropleura plecta (L.)	+	+	-	+	+	-
Diarsia mendica (F.)	+	+	+	+	+	+
Diarsia dahlii (Hübner)	+	+	+	-	-	-
Diarsia brunnea (Den.& Schi.)	+	+	-	+	-	-
Diarsia rubi (Vieweg)	+	-	-	+	-	-
Lycophotia porphyrea (D.& S.)	+	+	-	+	+	+
Chersotis cuprea (Den.& Schi.)	+	+	+	+	+	+
Eurois occultus (L.)	+	+	+	+	+	+
Graphiphora augur (F.)	+	+	+	+	-	+
Xestia speciosa (Hübner)	+	+	+	+	+	+
Xestia rhaetica (Staudinger)	+	-	+	+	+	+
Xestia sincera (Herrich-Schäffer)	+	-	+	-	+	+
Xestia distensa (Eversmann)	+	-	+	-	-	+
Xestia gelida (Sparre-Schneider)	+	-	+	-	+	-
Xestia alpicola (Zetterstedt)	+	+	+	+	+	+
Xestia tecta (Hübner)	+	-	+	-	-	+
Xestia baja (Denis & Schiffer.)	+	+	+	+	-	-
Coenophila subrosea (Stephens)	+	+	+	-	-	-
Cerastis rubricosa (Den.& Schi.)	+	+	+	+	-	-
Anaplectoides prasinus (D.& S.)	+	+	-	-	-	-
Protolampra sobrina (Duponchel)	+	+	+	+	+	+
Agrotis vestigialis (Hufnagel)	+	-	-	-	-	-

Coleoptera of the Nature Reserve Friendship with adjacent primeval forests

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Abstract

The Coleopteran fauna of the Nature Reserve Friendship has been studied since 1986, when the studies begun in Kostomuksha Nature Reserve. On the Finnish side the studies were made in 1991-1993 in six study areas situated in southern and eastern part of the Kainuu province. In Friendship Park, the Coleopteran fauna was studied in connection with the studies of the Lepidopteran fauna. The aim of these studies was on the other hand to increase our knowledge of the fauna in the Friendship Park and to evaluate the conservational importance of the old natural forests of Kainuu, which belong to the best preserved old forests of the southern half of Finland. The list of all species found in different study areas with short comments of the occurrence of rare or interesting species, as well as the list of threatened species found in the study areas is given.

Key words: Coleopteran fauna, conservational importance, old forests, rare and threatened species, Kostomuksha Nature Reserve, Kainuu

Introduction

Very little is known about the Coleopteran fauna of the areas belonging to the present Friendship Park, whereas more information is available concerning the fauna of more southern and northern parts of the Russian Karelia. Several Finnish coleopterologists made excursions and studied the fauna of northern and southern parts of the present Karelian Republic during the first decades of this century or even earlier. During the last decades the southern parts of Russian Karelia have been studied by the entomologists of Karelian Research Centre of Russian Academy of Sciences, Petrozavodsk and also by some Finnish entomologists (Siitonen & al. 1996).

There is also very little former data available concerning the Finnish part of the Friendship Park and its neighbouring areas, the province of Kainuu. In the northern part of Kainuu (Suomussalmi) Coleoptera have been collected by O. Sorsakoski in 1910-1920s, but unfortunately this material has not been published. The

Coleopteran fauna of the province Koillismaa (Kuusamo), situated to the north of Kainuu, is well known due to Oulanka Biological station (University of Oulu) and several private collectors, who have made excursions to this area.

Studies of the fauna the Kostomuksha Nature Reserve began in 1986 by the author (B. Kashevarov) second and the first results were published recently. In the Finnish Friendship Park studies were started in 1991 by the other author (I. Rutanen) and these studies mainly covered the unprotected old forest areas, situated outside the present area of the Friendship Park. These forests belong to the last and best preserved natural forests of the southern half of Finland and therefore the general faunistic information and especially data on threatened species in these areas were needed.

Study areas and methods

Kostomuksha Nature Reserve, which covers a uniform area of c. 47500 hectares of northern taiga, was formed in 1990 together with five Finnish nature reserves as part of an international Nature Reserve Friendship. The forests, only slightly disturbed by human activities, cover an area of 30000 hectares. About 5500 hectares of them are forested peatlands of different types. The lakes, largest of them Lake Kiitehenjärvi, cover a considerable part of the reserve.

The most common forest type in Kostomuksha Nature Reserve is dry pine dominated forest with undergrowth characterized by bilberry *(Vaccinium myrtillus)*, lingonberry *(V. vitis-idaea)*, heather *(Calluna vulgaris)* and lichens. Among the spruce forests the bilberry type is most common. Kostomuksha Nature Reserve is situated on the north-boreal vegetation zone or northern taiga zone.

In Kostomuksha Nature Reserve the Coleopteran fauna was studied in ten constant sampling sites which were selected in accordance with the variety of vegetation, but a lot of material was collected in its central, eastern and southern part also. Studied constant sampling sites represent the following type: old (more than 200 years) wet spruce forest. In Kostomuksha Nature Reserve in every sampling site ten pitfall traps were placed at a distance of about 5 to 8 meters from each other. As preservative 2 % formaldehyde solution was used. The main part of beetles was collected using this method. Also other collecting methods like hand picking of flowers, mushrooms, bracket fungi growing on dead trunks and logs or under bark, as well as sweeping net and water net were used. In late summer 1994 five window traps attached in burnt trunks of birches were used in a small forest fire area in Kostomuksha Nature Reserve.

The forests of the Finnish study areas in Kainuu are mainly spruce dominated old (over 100 years) forests with undergrowth characterized by bilberry. Because most of the threatened species dwelling in old forests are dependent on old deciduous trees, the study sites were selected so that the number of deciduous trees, especially aspens *(Populus tremula)*, was as high as possible. The Coleopteran fauna was studied in 1991-1993 in following six areas in the southeastern and eastern parts of Kainuu:

1. Peatland reserve of Teerisuo-Lososuo, Kuhmo, uniform grid 708-9:60, with four separate study sites: 1) old riverside spruce forest (Syväpuro),2) wet peatland (Isosuo), 3) old humid spruce forest with high frequency of aspens (Isokorkea) and 4) old humid spruce forest with many aspens (Rajapuro).

2. Honkavaara, Kuhmo, uniform grid 709:63, old spruce forest rich in aspens.

3. Louhivaara, Kuhmo, uniform grid 708:62, old forest area as Honkavaara.

4. Hiidenvaara, Sotkamo, uniform grid 707:56, with four separate study sites: 1) old spruce forest rich in aspens, 2) old logged area with old aspens preserved, 3) rich fen (Rytisuo), 4) ditched dry peatland (Löytösensuo).

5. Leppivaara, Kuhmo, uniform grid 712:66, two separate study sites: 1) old spruce dominated forest rich in aspens, 2) recently logged area with aspens and birches *(Betula sp.)* preserved.

6. Pyöriäisenvaara, Suomussalmi, uniform grid 719:62, in 1992 burned area of old, fresh spruce dominated forest rich in birches and with some aspens.

Study site 1 was studied in 1991, sites 2 and 3 in 1992, sites 4 and 5 in 1993 and site 6 in 1992 and 1993. Study areas 1-4 are situated in the middle boreal vegetation zone and areas 5 and 6 in the northern boreal zone.

In the study areas of Kainuu beetles were collected by using window flight traps of funnel type, in which two transparent acryl plates of 20x40 cm are placed crosswise above a funnel of about 20 cm diameter, under which a plastic bottle with preservative liquid (water, coarse salt and detergent) is attached. 10-15 window traps were set in each study site selectively near dead or damaged trees, preferably aspens, spruces, birches or willows *(Salix caprea)*. For litter-dwelling beetles, pitfall traps (plastic cups of 65 mm diameter and 170 ml volume) were used in study areas 1, 2, 3 and 4. Trapping period started approximately on the 20th of May and ended the 5th of October. The traps were emptied once a month on an average.

In connection with the study of the Lepidopteran fauna of Friendship Nature Reserve, carried out by R. Leinonen in 1991-94, the beetles caught with bait and light traps were determined. This material was collected in five separate areas forming the Finnish part of Friendship Park: Elimyssalo, Ulvinsalo, Iso-Palonen, Juortanansalo and Lentua.

Results

In the Karelian part of the Nature Reserve 342 species belonging to 46 families of Coleoptera have been found. Because most of the samples were collected with pitfall traps, the best known groups of beetles are Carabidae and litter-dwelling Staphylinidae. Seven species found in Kostomuksha are not reported from the Fennoscandian parts of Russia in the latest catalogue of north-European Coleoptera (Appendix 1).

In the Finnish study areas of the Nature Reserve Friendship and adjacent territories 622 species from 62 families have been found. Of the species found in the study areas of Kainuu, 257 (41%) are not reported from the province Kainuu in the latest distribution catalogue of north-European Coleoptera (Appendix 1). Of the 87 rare or interesting species, 11 are listed in Finnish red book (Table 1.). A more detailed description of the rare and interesting species is given in Appendix 2.

Table 1. Species included in the Finnish Red Book (Rassi & al. 1992a) found in the study areas (T= Teerisuo-Lososuo, H= Honkavaara, L= Louhivaara, Hi= Hiidenvaara, Le= Leppivaara, P= Pyöriäisenvaara, F= Finnish parts of the Friendship Nature Reserve, K= Kostomuksha Nature Reserve).

Rhantus fennicus (Dytiscidae)	-	-	-	-	-	-	-	K
Agathidium pulchellum (Leiodidae)	T	-	-	-	-	-	-	-
Agathidium pallidum (Leiodidae)	T	H	-	-	Le	P	-	-
Tachinus basalis (Staphylinidae)	T	-	-	-	-	-	F	-
Cyphaea latiuscula (Staphylinidae)	-	-	L	-	-	-	-	-
Lacon fasciatus (Elateridae)	-	-	-	-	-	-	F	-
Ampedus nigroflavus (Elateridae)	-	-	-	Hi	-	-	-	-
Zavaljus brunneus (Languriidae)	-	H	-	-	-	-	-	-
Triplax rufipes (Erotylidae)	-	H	-	-	-	-	-	-
Tragosoma depsarium (Cerambycidae)	-	-	-	-	-	-	F	-
Acmaeops septentrionis (Cerambycidae)	T	-	-	-	-	P	-	-

As it is seen in Appendix 1, there is a great difference in the Coleopteran fauna of different study areas due to the methods used. Using of the same methods with same sampling efforts on both sides of the boundary between Finland and Russia, will give more comparable information about the beetles of Fennoscandia, their distribution, abundance and preference of various biotopes. As Kostomuksha Nature Reserve represents a large area of old forests undisturbed by human activities, there is no doubt, that a lot of species included in the red lists of Finland, Russia or Karelia can be found here by using more effective collecting methods as e.g. window flight traps.

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APPENDIX 1. Species caught in the study areas (R/Fr= Russian part of Friendship N.R., F/Fr= Finnish part of Friendship N.R., T= Teerisuo-Lososuo, H= Honkavaara, L= Louhivaara, Hi= Hiidenvaara, Le= Leppivaara, P= Pyöriäisenvaara). *= Rare or interesting species, details of the occurrence is given in appendix 2. += Not reported from Kainuu or Russian part of Fennoscandia after Lindroth 1960 or Silfverberg 1992.

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Remarks
CARABIDAE									
Leistus terminatus (Hellwig)	x	x	x	x	x				
Notiophilus aquaticus (Linnaeus)	x	x							
Notiophilus palustris (Duftschmid)	x	x		x	x	x			
Notiophilus germinyi Fauvel	x	x							
Notiophilus reitteri Spaeth	x		x	x					
Notiophilus biguttatus (Fabricius)	x		x	x	x		x		
Loricera pilicornis (Fabricius)	x		x		x				
Carabus glabratus Paykull	x	x		x	x	x			
Carabus violaceus Linnaeus	x	x				x			
Cychrus caraboides (Linnaeus)	x		x	x	x			x	
Cicindela sylvatica Linnaeus	x	x							
Cicindela campestris Linnaeus	x								
Elaphrus uliginosus Fabricius	x								
Elaphrus cupreus Duftschmid	x	x							
Dyschirius politus (Dejean)	x								
Dyschirius septentrionum Munster	x								
Dyschirius globosus (Herbst)	x								
Miscodera arctica (Paykull)	x								
Patrobus assimilis Chaudoir	x		x		x	x			
Trechus rivularis (Gyllenhal)	x		x			x			+
Trechus rubens (Fabricius)	x		x				x		
Bembidion lampros (Herbst)	x								
Bembidion properans (Stephens)	x								
Bembidion grapii Gyllenhal		x	x		x				
Bembidion tetracolum Say	x								
Bembidion bruxellense Wesm.	x		x						
Bembidion obliquum Sturm	x								
Bembidion doris (Panzer)	x	x							
Bembidion quadrimaculatum (Linnaeus)	x								
Bembidion mannerheimii Sahlberg	x								
Tachyta nana (Gyllenhal)							x		
Pterostichus oblongopunctatus (Fabr.)	x		x	x	x	x			+
Pterostichus adstrictus Eschscholtz	x	x	x						
Pterostichus nigrita (Paykull)			x						
Pterostichus rhaeticus Heer	x	x	x			x			+
Pterostichus minor (Gyllenhal)	x								
Pterostichus strenuus (Panzer)	x								
Pterostichus diligens (Sturm)	x	x	x		x	x			
Calathus melanocephalus (Linnaeus)	x								
Calathus micropterus (Duftschmid)	x	x	x	x	x	x	x	x	
Sericoda quadripunctata (Degeer)	x								*
Platynus mannerheimii (Dejean)	x		x			x			*
Agonum gracile Sturm	x								
Agonum fuliginosum (Panzer)	x		x			x			
Agonum ericeti (Panzer)	x	x	x			x			

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Agonum sexpunctatum (Linnaeus)	x								
Amara similata (Gyllenhal)	x								
Amara nitida Sturm	x								
Amara communis (Panzer)	x								
Amara lunicollis Schiödte	x	x							
Amara famelica Zimmermann	x								
Amara erratica (Duftschmid)	x								*
Amara praetermissa (Sahlberg)							x		
Amara brunnea (Gyllenhal)	x		x	x					
Amara aulica (Panzer)	x								
Harpalus latus (Linnaeus)	x								
Harpalus quadripunctatus Dejean	x								
Bradycellus caucasicus (Chaudoir)	x								
Dromius agilis (Fabricius)	x	x	x	x	x	x		x	
Cymindis vaporariorum (Linnaeus)	x	x							
HALIPLIDAE									
Haliplus lineolatus Mannerheim	x								
Haliplus wehnckei Gerhardt	x								
DYTISCIDAE									
Hygrotus versicolor (Schaller)	x								
Hygrotus quinquelineatus (Zetterstedt)	x								
Coelambus novemlineatus (Stephens)	x								
Hydroporus fuscipennis Schaum	x								
Hydroporus puberulus LeConte	x								*
Hydroporus morio Aubé	x								
Hydroporus erythrocephalus (Linnaeus)	x								
Hydroporus melanarius Sturm			x						
Hydroporus longicornis Sharp			x						*
Hydroporus tristis (Paykull)	x		x						
Hydroporus umbrosus (Gyllenhal)	x								
Hydroporus incognitus Sharp	x	x	x				x		
Hydroporus striola Gyllenhal	x								
Hydroporus palustris (Linnaeus)	x								
Potamonectes assimilis (Paykull)	x								
Platambus maculatus (Linnaeus)	x								
Agabus guttatus (Paykull)	x		x						
Agabus melanarius Aubé	x		x						
Agabus affinis (Paykull)	x		x						
Agabus sturmii (Gyllenhal)							x		
Agabus arcticus (Paykull)	x	x							
Agabus lapponicus (Thomson)	x		x						
Agabus thomsoni (J.Sahlberg)	x								
Agabus erichsoni Gemminger & Harold	x								
Ilybius vittiger (Gyllenhal)	x		x						*
Ilybius crassus Thomson	x	x				x			
Ilybius subaeneus Erichson		x							
Ilybius guttiger (Gyllenhal)	x								
Ilybius similis Thomson	x								
Ilybius aenescens Thomson	x								

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Ilybius fuliginosus (Fabricius)	x								
Ilybius fenestratus (Fabricius)	x	x							
Rhantus suturellus (Harris)	x	x				x			
Rhantus fennicus Huldén	x								* +
Colymbetes paykulli Erichson	x	x							
Colymbetes striatus (Linnaeus)		x							
Dytiscus marginalis Linnaeus	x								
Dytiscus latissimus Linnaeus	x								
GYRINIDAE									
Gyrinus minutus Fabricius	x								
Gyrinus aeratus Stephens	x								
Gyrinus pullatus Zaitzev	x								
Gyrinus marinus Gyllenhal	x								
HYDROPHILIDAE									
Helophorus strigifrons Thomson		x							
Helophorus flavipes Fabricius					x				
Anacaena lutescens (Stephens)	x								
Laccobius minutus (Linnaeus)	x	x							
Enochrus affinis (Thunberg)	x								
Hydrobius fuscipes (Linnaeus)		x							
Cercyon borealis Baranowski		x							+
Cercyon lateralis (Marsham)	x	x							
Cercyon bifenestratus Küster		x							+
Cercyon unipunctatus (Linnaeus)		x							
Cercyon analis (Paykull)					x				
Megasternum obscurum (Marsham)	x		x			x			
Cryptopleurum minutum (Fabricius)		x					x		
PTILIIDAE									
Euryptilium saxonicum (Gillmeister)								x	+
Ptiliolum caledonicum (Sharp)				x					+
Ptinella johnsoni Rutanen								x	* +
Ptinella tenella (Erichson)					x				+
Pteryx suturalis (Heer)			x	x		x	x	x	+
Acrotrichis silvatica Rosskothen		x					x	x	+
Acrotrichis parva Rosskothen							x		+
Acrotrichis intermedia (Gillmeister)		x	x	x	x	x	x	x	
Acrotrichis fascicularis (Herbst)		x							+
Acrotrichis rugulosa Rosskothen		x	x	x	x		x		
LEIODIDAE									
Leiodes inordinata (J.Sahlberg)			x		x				* +
Leiodes silesiaca (Kraatz)		x							
Leiodes triepkii (Schmidt)		x							
Leiodes longipes (Schmidt)		x							* +
Leiodes picea (Panzer)		x		x					
Leiodes ruficollis J.Sahlberg			x		x				+
Leiodes obesa (Schmidt)	x	x							
Leiodes puncticollis (Thomson)			x						* +

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Leiodes gyllenhalii Stephens			x						+
Anisotoma humeralis (Fabricius)			x	x	x	x	x	x	+
Anisotoma axillaris Gyllenhal	x	x	x			x	x	x	
Anisotoma castanea (Herbst)			x	x	x	x			
Anisotoma glabra (Kugelann)	x	x	x	x	x	x	x	x	+
Anisotoma orbicularis (Herbst)			x						+
Amphicyllis globus (Fabricius)				x	x				
Agathidium pulchellum Wankowicz			x						*+
Agathidium pallidum (Gyllenhal)			x	x			x	x	*+
Agathidium rotundatum (Gyllenhal)			x	x	x		x		
Agathidium confusum Brisout de Barn.			x	x	x	x	x	x	+
Agathidium nigrinum Sturm			x	x	x	x		x	*+
Agathidium arcticum Thomson			x			x			*
Agathidium discoideum Erichson			x	x	x	x	x	x	*+
Agathidium nigripenne (Fabricius)			x	x	x		x	x	
Agathidium atrum (Paykull)			x	x					
Agathidium seminulum (Linnaeus)		x	x	x	x	x	x	x	
Agathidium pisanum Brisout de Barn.	x	x	x	x	x	x	x	x	+
SILPHIDAE									
Nicrophorus vespilloides Herbst	x	x	x	x		x	x		
Nicrophorus vespillo (Linnaeus)	x	x							+
Oiceoptoma thoracica (Linnaeus)	x	x				x			
Phosphuga atrata (Linnaeus)	x								
AGYRTIDAE									
Pteroloma forsstromii (Gyllenhal)	x		x						
CHOLEVIDAE									
Choleva lederiana Reitter	x		x	x	x				
Choleva glauca Britten	x		x	x					*+
Choleva sturmii Brisout de Barneville				x					*+
Sciodrepoides watsoni (Spence)		x	x	x	x	x	x	x	
Sciodrepoides fumatus (Spence)		x						x	+
Catops alpinus Gyllenhal	x	x	x	x	x				+
Catops longulus Kellner				x					*+
Catops coracinus Kellner	x		x	x					
Catops tristis (Panzer)	x	x	x	x	x		x	x	
Catops nigrita Erichson	x		x	x	x	x			
Catops nigricans (Spence)	x		x	x	x			x	+
COLONIDAE									
Colon brunneum (Latreille)			x						+
Colon appendiculatum (Sahlberg)		x							+
Colon serripes (Sahlberg)		x							+
SCYDMAENIDAE									
Nevraphes coronatus J.Sahlberg				x		x	x		+
Scydmoraphes minutus (Chaudoir)								x	+
Stenichnus collaris (Müller & Kunze)			x	x	x	x	x		+
Stenichnus bicolor (Denny)			x	x	x	x	x	x	+

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Microscydmus minimus (Chaudoir)							x	x	+
Euconnus claviger (Müller & Kunze)				x					* +
Scydmaenus hellwigii (Herbst)								x	* +
STAPHYLINIDAE									
Gabrius velox Sharp						x	x		
Gabrius expectatus Smetana			x	x	x	x	x	x	+
Gabrius trossulus (Nordmann)					x				
Philonthus puella Nordmann			x						+
Philonthus politus (Linnaeus)	x	x							
Philonthus succicola Thomson	x	x	x						
Philonthus nigriventris Thomson	x							x	
Philonthus cruentatus (Gmelin)		x							+
Philonthus varians (Paykull)		x	x						
Philonthus lederi Eppelsheim	x	x						x	* +
Philonthus nigrita (Gravenhorst)	x		x			x			
Platydracus fulvipes (Scopoli)	x					x			
Staphylinus erythropterus Linnaeus						x			
Ocypus fuscatus (Gravenhorst)	x	x	x			x			
Euryporus picipes (Paykull)					x	x			+
Quedius mesomelinus (Marsham)		x		x			x	x	
Quedius maurus (Sahlberg)								x	+
Quedius brevis Erichson			x			x		x	
Quedius tenellus (Gravenhorst)			x	x	x	x	x	x	
Quedius xanthopus Erichson		x	x	x	x	x	x	x	
Quedius plagiatus (Mannerheim)	x	x	x	x	x	x	x	x	
Quedius fuliginosus (Gravenhorst)	x		x			x			+
Quedius molochinus (Gravenhorst)	x	x	x	x	x	x			
Quedius limbatoides Coiffait	x			x					
Quedius nitipennis (Stephens)			x	x					
Quedius fulvicollis (Stephens)	x						x		
Gyrohypnus atratus (Heer)				x					+
Nudobius lentus (Gravenhorst)		x					x	x	
Xantholinus linearis (Olivier)	x								
Xantholinus tricolor (Fabricius)	x		x		x				+
Xantholinus laevigatus Jacobsen						x			
Othius lapidicola Kiesenwetter			x	x		x			
Othius volans J.Sahlberg	x								
Othius myrmecophilus Kiesenwetter			x	x					+
Atrecus pilicornis (Paykull)			x	x	x	x	x	x	
Lathrobium terminatum Gravenhorst	x		x			x			
Lathrobium rufipenne Gyllenhal			x			x			
Lathrobium fulvipenne Gravenhorst				x		x			
Lathrobium brunnipes (Fabricius)		x	x	x		x			
Euaesthetus bipunctatus (Ljungh)			x			x			
Stenus juno (Paykull)	x								
Stenus lustrator Erichson	x		x						
Stenus clavicornis (Scopoli)	x								
Stenus boops Ljungh		x							
Stenus melanarius Stephens	x								
Stenus morio Gravenhorst					x				

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Stenus carbonarius Gyllenhal			x						
Stenus opticus Gravenhorst	x								
Stenus pubescens Stephens	x	x							*+
Stenus umbratilis Casey	x	x							+
Stenus bifoveolatus Gyllenhal	x		x						
Stenus impressus Germar	x								
Stenus palustris Erichson	x		x						
Stenus flavipalpis Thomson			x						
Oxyporus maxillosus Fabricius			x						+
Megarthrus sinuatocollis (Lacordaire)		x	x	x	x				
Magarthrus fennicus Lahtinen				x					
Proteinus brachypterus (Fabricius)	x		x	x	x				
Eusphalerum lapponicum (Mannerheim)							x		+
Acrulia inflata (Gyllenhal)		x	x	x	x	x	x		
Hapalaraea melanocephala (Fabr.)		x	x	x	x	x	x	x	
Hapalaraea nigra (Gravenhorst)		x							
Hapalaraea linearis (Zetterstedt)				x	x		x		+
Hapalaraea clavigera (Luze)	x						x		*+
Omalium rivulare (Paykull)	x	x	x	x					+
Omalium septentrionis Thomson	x	x							
Omalium strigicolle Wankowicz			x						
Omalium caesum Gravenhorst		x	x	x			x		
Phloeonomus monilicornis (Gyllenhal)			x		x			x	*+
Phloeonomus planus (Paykull)		x							
Phloeonomus lapponicus (Zetterstedt)		x	x	x	x		x	x	
Phloeonomus pusillus (Gravenhorst)		x	x		x		x	x	
Phloeonomus sjobergi Strand		x	x	x	x	x		x	+
Phloeonomus punctipennis Thomson				x					+
Deliphrum tectum (Paykull)	x		x	x	x				
Olophrum fuscum (Gravenhorst)	x		x			x			
Olophrum assimile (Paykull)	x								
Olophrum consimile (Gyllenhal)	x	x	x			x	x		
Olophrum rotundicolle (Sahlberg)	x	x	x		x	x			
Arpedium quadrum (Gravenhorst)			x		x	x			
Eucnecosum brachypterum (Grav.)	x		x	x			x		
Eucnecosum brunnescens (J.Sahlberg)			x		x				*
Acidota crenata (Fabricius)	x		x			x			
Psephidonus plagiatus (Fabricius)	x	x							
Anthophagus omalinus Zetterstedt	x	x	x	x	x	x	x	x	
Anthophagus caraboides (Linnaeus)		x				x	x	x	
Coryphium angusticolle Stephens	x		x	x	x	x	x	x	+
Eudectus giraudi Redtenbacher			x		x			x	*
Scaphisoma agaricinum (Linnaeus)	x	x	x	x		x	x	x	
Scaphisoma boleti (Panzer)							x		*+
Scaphisoma subalpinum Reitter			x	x	x	x	x	x	+
Scaphisoma boreale Lundblad	x		x	x	x	x	x		+
Scaphisoma assimile Erichson		x							+
Syntomium aeneum (Müller)			x				x	x	
Carpelimus corticinus (Gravenhorst)							x		
Anotylus rugosus (Fabricius)							x		

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Olisthaerus substriatus (Paykull)	x		x						
Trichophya pilicornis (Gyllenhal)		x					x		+
Mycetoporus monticola Fowler			x			x			*+
Mycetoporus lepidus (Gravenhorst)	x	x	x	x	x	x		x	
Mycetoporus maeklini Bernhauer							x		*+
Mycetoporus clavicornis (Stephens)					x				
Mycetoporus niger Fairmaire & Laboulb.	x		x	x					
Mycetoporus maerkeli Kraatz					x				*+
Mycetoporus punctus (Gravenhorst)	x		x	x					+
Ischnosoma longicorne (Mäklin)			x	x		x	x		
Ischnosoma splendidum (Gravenhorst)	x		x	x	x	x	x	x	
Bryoporus cernuus (Gravenhorst)	x		x			x	x		
Bryoporus crassicornis (Mäklin)							x		*+
Lordithon thoracicus (Fabricius)	x	x	x	x					
Lordithon exoletus (Erichson)			x						*+
Lordithon trimaculatus (Paykull)		x	x	x	x		x		+
Lordithon lunulatus (Linnaeus)	x		x	x	x	x	x	x	+
Lordithon speciosus (Erichson)		x	x		x	x	x	x	+
Bolitobius cingulatus Mannerheim		x							
Sepedophilus littoreus (Linnaeus)		x	x		x		x	x	
Sepedophilus testaceus (Fabricius)		x	x	x	x	x	x	x	
Sepedophilus marshami (Stephens)					x				+
Tachyporus obscurellus Zetterstedt					x				
Tachyporus obtusus (Linnaeus)		x							
Tachyporus chrysomelinus (Linnaeus)			x						
Tachyporus dispar (Paykull)			x						+
Tachyporus atriceps Stephens				x					
Tachyporus transversalis Gravenhorst	x		x			x			
Tachyporus pulchellus Mannerheim						x			
Tachinus rufipes (Linnaeus)	x								
Tachinus elegans Eppelsheim	x		x	x		x			*+
Tachinus pallipes (Gravenhorst)	x	x	x	x	x		x	x	
Tachinus proximus Kraatz	x		x	x					
Tachinus rufipennis Gyllenhal		x							+
Tachinus atripes J.Sahlberg			x						*
Tachinus subterraneus (Linnaeus)		x							+
Tachinus basalis Erichson		x	x						*+
Tachinus corticinus Gravenhorst	x								
Tachinus laticollis Gravenhorst	x		x	x					
Tachinus marginellus (Fabricius)	x								
Tachinus elongatus Gyllenhal	x	x	x	x					
Aleochara brevipennis Gravenhorst	x			x					
Aleochara villosa Mannerheim		x							+
Aleochara fumata Gravenhorst		x							+
Aleochara moerens Gyllenhal	x	x			x			x	
Oxypoda lugubris Kraatz	x		x						+
Oxypoda elongatula Aubé							x		
Oxypoda procerula Mannerheim			x	x	x	x			
Oxypoda operta Sjöberg	x		x	x					*+
Oxypoda longipes Mulsant & Rey							x		+
Oxypoda vittata Märkel			x						*

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Oxypoda spectabilis Märkel	x		x	x				x	
Oxypoda funebris Kraatz			x						+
Oxypoda skalitzkyi Bernhauer		x	x	x	x	x	x	x	
Oxypoda umbrata (Gyllenhal)	x			x	x		x	x	
Oxypoda abdominalis (Mannerheim)	x								
Oxypoda alternans (Gravenhorst)				x		x			+
Oxypoda annularis (Mannerheim)			x	x	x	x	x	x	
Oxypoda soror Thomson					x				+
Oxypoda formiceticola Märkel				x					+
Oxypoda bicolor Mulsant & Rey				x					*+
Oxypoda haemorrhoa (Mannerheim)								x	
Acrostiba borealis Thomson			x		x		x		+
Ischnoglossa elegantula (Mannerheim)			x	x		x	x	x	
Ischnoglossa obscura Wunderle								x	*+
Dexiogyia corticina (Erichson)							x		+
Thiasophila angulata (Erichson)						x			
Haploglossa villosula (Stephens)		x	x	x	x	x		x	+
Haploglossa marginalis (Gravenhorst)						x		x	*+
Mniusa incrassata (Mulsant & Rey)				x					+
Pentanota meuseli Bernhauer		x							+
Phloeopora testacea (Mannerheim)			x	x	x		x		
Phloeopora corticalis (Gravenhorst)				x					+
Phloeopora concolor (Kraatz)		x	x			x	x	x	
Gnypeta coerulea (Sahlberg)		x							
Schistoglossa curtipennis (Sharp)							x		+
Aloconota subgrandis (Brundin)							x		+
Liogluta granigera (Kiesenwetter)	x			x					+
Liogluta micans (Mulsant & Rey)	x		x	x	x		x		
Liogluta microptera Thomson	x			x					+
Liogluta alpestris (Heer)	x								
Geostiba circellaris (Gravenhorst)			x			x			
Dadobia immersa (Erichson)			x	x	x		x	x	+
Atheta arctica (Thomson)	x	x	x		x		x	x	
Atheta hygrobia (Thomson)		x							+
Atheta luridipennis (Mannerheim)							x		+
Atheta talpa (Heer)							x	x	
Atheta subtilis (Scriba)		x	x	x	x		x	x	
Atheta myrmecobia (Kraatz)		x	x	x	x		x	x	
Atheta fungi (Gravenhorst)	x		x	x	x	x	x		
Atheta amplicollis (Mulsant & Rey)	x								+
Atheta lateralis (Mannerheim)	x	x	x	x			x	x	+
Atheta sodalis (Erichson)		x	x	x	x	x		x	
Atheta gagatina (Baudi)	x	x							+
Atheta pandionis Scheerpeltz								x	*+
Atheta pallidicornis (Thomson)		x					x		*+
Atheta trinotata (Kraatz)		x							
Atheta flavipes (Gravenhorst)		x				x		x	
Atheta eremita (Rye)			x			x			+
Atheta cinnamoptera (Thomson)		x							+
Atheta aeneipennis (Thomson)	x		x	x	x	x			

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Atheta parapicipennis Brundin			x						+
Atheta lapponica J.Sahlberg			x	x	x				+
Atheta atramentaria (Gyllenhal)		x							
Atheta hypnorum (Kiesenwetter)	x		x	x	x	x			
Atheta brunneipennis (Thomson)	x		x						+
Atheta incognita (Sharp)			x				x		+
Atheta procera (Kraatz)							x		+
Atheta diversa (Sharp)		x	x	x	x				+
Atheta strandiella Brundin		x							+
Atheta pilicornis (Thomson)		x	x	x	x	x	x	x	+
Atheta acutangula Hanssen			x						* +
Atheta boleticola J.Sahlberg	x		x		x				+
Atheta crassicornis (Fabricius)	x	x							
Atheta paracrassicornis Brundin	x	x	x	x	x				+
Atheta euryptera (Stephens)		x	x			x	x		
Atheta nigricornis (Thomson)		x		x	x	x		x	+
Atheta nigritula (Gravenhorst)	x								
Atheta picipes (Thomson)	x	x	x				x	x	+
Dinaraea aequata (Erichson)	x		x		x		x		+
Dinaraea linearis (Gravebhorst)			x				x		+
Dinaraea arcana (Erichson)			x	x			x	x	
Lyprocorrhe anceps (Erichson)				x					
Acrotona aterrima (Gravenhorst)		x							
Amischa nigrofusca (Stephens)		x	x		x	x			+
Amischa bifoveolata (Mannerheim)				x			x		+
Pachyatheta cribrata (Kraatz)							x		+
Drusilla canaliculata (Fabricius)	x		x		x	x			
Zyras humeralis (Gravenhorst)	x		x	x	x	x	x	x	
Zyras cognatus (Märkel)						x			+
Lomechusa pubicollis Brisout de Barnev.							x		* +
Gyrophaena affinis Mannerheim				x	x		x		+
Gyrophaena fasciata (Marsham)	x								
Gyrophaena williamsi Strand			x		x				+
Gyrophaena orientalis Strand	x		x						+
Gyrophaena bihamata Thomson	x								
Gyrophaena joyi Wendeler	x								*
Gyrophaena strictula Erichson					x				+
Gyrophaena boleti (Linnaeus)				x			x		
Bolitochara mulsanti Sharp	x		x	x					+
Bolitochara pulchra (Gravenhorst)	x			x	x	x			
Phymatura brevicollis (Kraatz)		x							* +
Leptusa pulchella (Mannerheim)			x	x	x	x	x		
Leptusa norvegica Strand				x					*
Euryusa castanoptera Kraatz			x	x			x	x	+
Anomognathus cuspidatus (Erichson)			x	x			x	x	+
Homalota plana (Gyllenhal)			x	x			x	x	+
Cyphaea curtula (Erichson)			x	x			x		+
Cyphaea latiuscula Sjöberg					x				* +
Placusa depressa Mäklin							x		
Placusa tachyporoides (Waltl)		x	x		x		x		
Placusa incompleta Sjöberg			x	x	x				

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Placusa cribrata Johnson & Lundberg		x			x				+
Placusa suecica Johnson & Lundberg		x							+
Placusa atrata (Mannerheim)	x	x					x	x	+
Autalia impressa (Olivier)	x			x					
Autalia longicornis Scheerpeltz				x	x				+
Holobus apicatus (Erichson)			x						+
Myllaena intermedia Erichson	x		x		x				+
Myllaena minuta (Gravenhorst)						x			
Gymnusa brevicollis (Paykull)	x		x						
PSELAPHIDAE									
Bibloporus bicolor (Denny)			x	x	x		x	x	+
Bibloporus minutus Raffray			x	x	x		x	x	+
Euplectus piceus Motschulsky			x						+
Euplectus decipiens Raffray			x	x					+
Euplectus punctatus Mulsant			x	x	x	x	x	x	+
Euplectus karstenii (Reichenbach)			x	x		x	x	x	
Euplectus fauveli Guillebeau				x	x	x			+
Bryaxis puncticollis (Denny)								x	+
Bryaxis bulbifer (Reichenbach)					x				+
Pselaphus heisei Herbst			x		x	x			
SPHAERITIDAE									
Sphaerites glabratus (Fabricius)	x		x						
HISTERIDAE									
Plegaderus vulneratus (Panzer)			x	x	x				
Gnathoncus buyssoni Auzat		x					x		+
Margarinotus striola (Sahlberg)	x								
Platysoma deplanatum (Gyllenhal)						x			*+
CLAMBIDAE									
Clambus punctulum (Beck)			x						
Clambus armadillo (Degeer)			x		x		x	x	+
SCIRTIDAE									
Microcara testacea (Linnaeus)		x							+
Cyphon palustris Thomson		x							+
Cyphon kongsbergensis Munster	x	x							
Cyphon variabilis (Thunberg)		x	x	x	x	x		x	
Cyphon punctipennis Sharp	x	x	x	x	x		x	x	
Cyphon padi (Linnaeus)	x	x	x	x	x	x			+
SCARABAEIDAE									
Geotrupes stercorarius (Linnaeus)	x	x							
Geotrupes stercorosus (Scriba)	x	x							
Aphodius rufipes (Linnaeus)	x	x	x		x				
Aphodius depressus (Kugelann)							x		
Aphodius tenellus Say	x						x		
Aphodius borealis Gyllenhal		x							
Aphodius lapponum Gyllenhal	x							x	

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Aphodius piceus Gyllenhal	x	x	x					x	
Aphodius scybalarius (Fabricius)		x							
Potosia cuprea (Fabricius) ssp. metallica (Herbst)	x	x							
Trichius fasciatus (Linnaeus)	x	x	x			x	x		
LUCANIDAE									
Platycerus caprea (Degeer)	x	x		x	x				
ELMIDAE									
Elmis aenea (Müller)	x								
DRYOPIDAE									
Dryops anglicanus Edwards	x								*
LYCIDAE									
Dictyoptera aurora (Herbst)	x		x	x	x			x	
Pyropterus nigroruber (Degeer)		x							+
Platycis minuta (Fabricius)			x					x	+
LAMPYRIDAE									
Lampyris noctiluca (Linnaeus)						x			+
CANTHARIDAE									
Cantharis figurata Mannerheim		x				x			
Cantharis paludosa Fallén			x			x			
Rhagonycha testacea (Linnaeus)			x						
Rhagonycha limbata Thomson	x	x							
Rhagonycha elongata (Fallén)		x							
Rhagonycha atra (Linnaeus)	x	x		x	x	x	x	x	
Absidia schoenherri (Dejean)	x	x	x	x	x	x	x	x	
Malthinus biguttatus (Linnaeus)	x	x					x	x	
Malthinus punctatus (Geoffroy)		x							+
Malthodes flavoguttatus Kiesenwetter	x	x	x						
Malthodes misellus Kiesenwetter		x							+
Malthodes fuscus (Waltl)	x	x	x	x	x		x	x	
Malthodes guttifer Kiesenwetter	x	x	x	x	x	x	x	x	
Malthodes marginatus (Latreille)	x	x	x	x	x	x	x	x	
Malthodes pumilus (Brébisson)					x				
Malthodes crassicornis (Mäklin)						x			+
Malthodes brevicollis (Paykull)	x		x	x	x	x		x	+
ELATERIDAE									
Lacon conspersus (Gyllenhal)	x	x							*
Lacon fasciatus (Linnaeus)		x							*
Athous subfuscus (Müller)	x	x	x	x	x	x	x	x	
Harminius undulatus (Degeer)				x				x	
Denticollis linearis (Linnaeus)	x	x	x			x			
Denticollis borealis (Paykull)							x		* +
Cidnopus aeruginosus (Olivier)	x								
Liotrichus affinis (Paykull)	x	x		x	x				

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Orithales serraticornis (Paykull)	x	x			x	x	x	x	
Actenicerus sjaelandicus (Müller)			x						
Selatosomus impressus (Fabricius)	x	x							
Selatosomus melancholicus (Fabricius)	x	x							
Eanus costalis (Paykull)	x	x	x	x	x	x	x		
Ampedus pomonae (Stephens)	x	x							
Ampedus nigroflavus (Goeze)						x			*+
Ampedus balteatus (Linnaeus)							x		
Ampedus tristis (Linnaeus)	x	x				x	x		
Ampedus nigrinus (Herbst)	x	x	x	x	x	x	x	x	
Sericus brunneus (Linnaeus)	x	x			x	x	x		
Melanotus castanipes (Paykull)		x	x	x	x	x	x	x	
Dalopius marginatus (Linnaeus)	x	x							
BUPRESTIDAE									
Buprestis rustica Linnaeus		x							
Anthaxia quadripunctata (Linnaeus)	x					x			
BYRRHIDAE									
Cytilus sericeus (Forster)		x							
Cytilus auricomus (Duftschmid)		x				x			
Byrrhus fasciatus (Forster)	x								
Byrrhus arietinus Steffahny			x	x					
DERMESTIDAE									
Dermestes murinus Linnaeus		x							
Trogoderma glabrum (Herbst)		x							+
Globicornis emarginata (Gyllenhal)						x			*
Anthrenus museorum (Linnaeus)		x							
ANOBIIDAE									
Episernus angulicollis Thomson				x			x	x	*
Ernobius explanatus (Mannerheim)				x	x			x	
Anobium thomsoni (Kraatz)				x	x				+
Microbregma emarginata (Duftschmid)					x		x		
Hadrobregmus pertinax (Linnaeus)				x			x	x	
Dorcatoma dresdensis Herbst		x	x	x		x	x	x	+
Dorcatoma robusta Strand		x						x	
LYMEXYLIDAE									
Hylecoetus dermestoides (Linnaeus)		x	x	x	x	x	x	x	
TROGOSSITIDAE									
Ostoma ferruginea (Linnaeus)	x	x	x		x				
CLERIDAE									
Thanasimus formicarius (Linnaeus)	x						x		
Thanasimus femoralis (Zetterstedt)				x	x				
MELYRIDAE									
Dasytes niger (Linnaeus)						x	x		

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Dasytes obscurus Gyllenhal	x						x		
KATERETIDAE									
Brachypterus urticae (Fabricius)	x								
NITIDULIDAE									
Epuraea concurrens Sjöberg			x						* +
Epuraea pallescens Stephens		x			x				
Epuraea laeviuscula (Gyllenhal)		x						x	
Epuraea deubeli Reitter			x					x	+
Epuraea thoracica Tournier		x			x		x	x	
Epuraea angustula Sturm	x	x	x	x	x		x	x	
Epuraea oblonga (Herbst)		x			x		x	x	
Epuraea fussi Reitter		x					x		* +
Epuraea boreella (Zetterstedt)	x	x	x	x	x		x	x	
Epuraea dolosa Kirejtshuk		x	x	x			x	x	* +
Epuraea marseuli Reitter		x	x	x	x		x	x	
Epuraea pygmaea (Gyllenhal)		x	x	x	x	x	x	x	
Epuraea binotata Reitter							x		+
Epuraea placida Mäklin		x	x				x	x	
Epuraea terminalis (Mannerheim)	x	x	x	x	x		x	x	+
Epuraea biguttata (Thunberg)		x	x	x			x	x	
Epuraea variegata (Herbst)		x	x	x	x				+
Epuraea silacea (Herbst)		x				x	x		+
Epuraea aestiva (Linnaeus)		x	x		x		x	x	
Epuraea melina (Erichson)		x						x	* +
Epuraea rufomarginata (Stephens)	x	x	x	x	x	x	x	x	
Epuraea contractula J.Sahlberg	x	x	x			x	x	x	+
Omosita depressa (Linnaeus)	x	x							
Soronis punctatissima (Illiger)		x							+
Soronia grisea (Linnaeus)		x							
Ipidia binotata Reitter				x					* +
Pocadius ferrugineus (Fabricius)			x			x	x		
Cychramus luteus (Fabricius)			x						+
Glischrochilus hortensis (Geoffroy)		x	x			x	x	x	
Glischrochilus quadripunctatus (Linn.)	x	x	x	x		x	x	x	
Pityophagus ferrugineus (Linnaeus)		x	x	x	x	x	x	x	+
Cybocephalus politus (Gyllenhal)	x								
SPHINDIDAE									
Sphindus dubius (Gyllenhal)								x	+
Arpidiphorus orbiculatus (Gyllenhal)			x	x	x		x		+
RHIZOPHAGIDAE									
Rhizophagus grandis Gyllenhal								x	* +
Rhizophagus depressus (Fabricius)		x		x					+
Rhizophagus ferrugineus (Paykull)		x	x	x	x		x	x	
Rhizophagus dispar (Paykull)	x		x	x	x	x	x	x	
Rhizophagus nitidulus (Fabricius)			x	x	x	x	x	x	
Rhizophagus parvulus (Paykull)		x	x	x	x		x	x	
Rhizophagus cribratus Gyllenhal		x	x	x	x	x	x		+

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
CUCUJIDAE									
Dendrophagus crenatus (Paykull)		x	x	x	x		x	x	
Pediacus fuscus Erichson	x	x					x	x	*
Cryptolestes abietis (Wankowicz)				x					
Cryptolestes alternans (Erichson)								x	
CRYPTOPHAGIDAE									
Henoticus serratus (Gyllenhal)								x	*+
Pteryngium crenatum (Fabricius)			x						+
Cryptophagus abietis (Paykull)			x						
Cryptophagus badius Sturm			x	x	x		x	x	
Cryptophagus lysholmi Munster				x				x	*+
Cryptophagus plagiatus Poppius				x				x	*+
Cryptophagus lapponicus Gyllenhal	x	x	x	x	x	x	x	x	+
Cryptophagus instabilis Bruce			x				x	x	
Cryptophagus confusus Bruce			x	x	x	x	x		*+
Cryptophagus dorsalis Sahlberg		x			x			x	+
Cryptophagus corticinus Thomson	x							x	*
Cryptophagus scanicus (Linnaeus)		x				x			
Cryptophagus setulosus Sturm				x		x	x		+
Spavius glaber (Gyllenhal)						x		x	
Antherophagus pallens (Linnaeus)						x		x	+
Caenoscelis subdeplanata Bris. de Barn.								x	+
Caenoscelis ferruginea (Sahlberg)			x	x	x		x	x	+
Atomaria impressa Erichson			x	x	x		x		+
Atomaria morio Kolenati			x	x					+
Atomaria ornata Heer			x						+
Atomaria peltata Kraatz			x	x	x		x	x	+
Atomaria fuscata (Schönherr)		x							+
Atomaria zetterstedti (Zetterstedt)	x								
Atomaria lewisi Reitter		x							+
Atomaria hislopi Wollaston							x		+
Atomaria apicalis Erichson			x						+
Atomaria umbrina (Gyllenhal)			x			x			+
Atomaria fuscicollis Mannerheim			x	x		x	x		
Atomaria subangulata J.Sahlberg				x	x				*+
Atomaria abietina Reitter					x			x	*+
Atomaria badia Erichson			x		x		x		*+
Atomaria affinis (F.Sahlberg)			x	x	x		x		*+
Atomaria bella Reitter			x	x	x	x	x	x	*+
Atomaria pulchra Erichson			x	x	x			x	*
Atomaria atrata Reitter		x	x	x	x		x	x	+
Atomaria procerula Erichson			x	x	x			x	+
LANGURIIDAE									
Zavaljus brunneus (Gyllenhal)				x					*+
EROTYLIDAE									
Triplax aenea (Schaller)		x		x			x	x	
Triplax russica (Linnaeus)	x	x	x	x	x	x	x	x	

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Triplax scutellaris Charpentier		x	x	x	x	x	x	x	
Triplax rufipes (Fabricius)				x					* +
Dacne bipustulata (Thunberg)	x			x	x	x	x		+
PHALACRIDAE									
Phalacrus substriatus Gyllenhal	x								
CERYLONIDAE									
Cerylon histeroides (Fabricius)		x	x	x	x	x	x	x	
Cerylon ferrugineum Stephens			x	x	x	x	x	x	
Cerylon deplanatum Gyllenhal			x	x	x		x	x	+
ENDOMYCHIDAE									
Leiestes seminigra (Gyllenhal)						x			* +
Endomychus coccineus (Linnaeus)			x	x				x	
COCCINELLIDAE									
Scymnus haemorrhoidalis Herbst					x				
Myzia oblongoguttata (Linnaeus)			x						
Calvia quatuordecimguttata (Linnaeus)	x								
Hippodamia septemmaculata (Degeer)	x								
Coccinella trifasciata Linnaeus	x								
Coccinella septempunctata Linnaeus	x								
Coccinella magnifica Redtenbacher		x							
Coccinella hieroglyphica Linnaeus	x		x						
CORYLOPHIDAE									
Orthoperus punctatus Wankowicz			x						+
Orthoperus atomus (Gyllenhal)			x		x			x	
LATRIDIIDAE									
Latridius hirtus Gyllenhal	x		x	x	x	x	x	x	+
Latridius consimis Mannerheim			x	x	x	x	x	x	+
Latridius minutus (Linnaeus)		x	x		x	x	x	x	
Latridius nidicola (Palm)					x			x	* +
Enicmus fungicola Thomson		x	x	x	x	x	x	x	+
Enicmus planipennis Strand				x	x				* +
Enicmus apicalis J.Sahlberg				x	x			x	* +
Enicmus rugosus (Herbst)		x	x	x	x	x	x	x	+
Stephostethus pandellei (Bris.de Barn.)		x	x	x			x	x	+
Stephostethus rugicollis (Olivier)		x	x	x	x	x	x	x	+
Cartodere constricta (Gyllenhal)								x	+
Corticaria pubescens (Gyllenhal)							x		
Corticaria lapponica (Zetterstedt)	x		x					x	+
Corticaria orbicollis Mannerheim			x	x	x		x	x	* +
Corticaria interstitialis Mannerheim	x	x	x	x			x	x	+
Corticaria rubripes Mannerheim	x		x	x	x		x	x	
Corticaria polypori J.Sahlberg					x				+
Corticaria longicollis (Zetterstedt)	x		x	x	x	x		x	+
Corticaria crenicollis Mannerheim						x	x		*
Corticaria lateritia Mannerheim		x							

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Corticaria obsoleta Strand				x				x	*
Corticaria ferruginea Marsham			x					x	
Cortinicara gibbosa (Herbst)	x				x				+
Corticarina obfuscata Strand								x	+
BYTURIDAE									
Byturus tomentosus (Degeer)	x	x					x		
CISIDAE									
Cis lineatocribratus Mellié	x		x					x	*+
Cis alter Silfverberg						x			*+
Cis jacquemartii Mellié		x	x		x		x	x	+
Cis glabratus Mellié							x		+
Cis comptus Gyllenhal			x			x		x	
Cis hispidus (Paykull)		x	x	x	x	x	x	x	+
Cis boleti (Scopoli)		x	x	x	x	x	x	x	
Cis punctulatus Gyllenhal				x	x		x		
Cis dentatus Mellié				x					*+
Ennearthron laricinum (Mellié)			x				x		+
Orthocis alni (Gyllenhal)		x	x	x	x				
Sulcacis affinis (Gyllenhal)						x			+
Ropalodontus strandi Lohse			x	x		x	x		
Octotemnus glabriculus (Gyllenhal)			x			x			+
COLYDIIDAE									
Synchita humeralis (Fabricius)				x					+
Lasconotus jelskii (Wankowicz)				x	x				*
MYCETOPHAGIDAE									
Litargus connexus (Geoffroy)								x	+
Mycetophagus piceus (Fabricius)				x		x	x		+
Mycetophagus multipunctatus Fabricius	x	x							+
Mycetophagus fulvicollis Fabricius				x		x			*
Mycetophagus populi Fabricius				x					*+
OEDEMERIDAE									
Calopus serraticornis (Linnaeus)			x						
Oedemera virescens (Linnaeus)	x					x			+
PYTHIDAE									
Pytho depressus (Linnaeus)	x			x					
PYROCHROIDAE									
Schizotus pectinicornis (Linnaeus)						x			
SALPINGIDAE									
Rabocerus foveolatus (Ljungh)		x	x	x	x				
Sphaeriestes stockmanni (Biström)							x		*+
Salpingus ruficollis (Linnaeus)	x	x	x	x	x		x	x	

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
ANTHICIDAE									
Omonadus floralis (Linnaeus)			x						+
MELOIDAE									
Meloe violaceus Marsham	x								
STENOTRACHELIDAE									
Stenotrachelus aeneus (Paykull)	x		x		x	x	x	x	
TENEBRIONIDAE									
Bolitophagus reticulatus (Linnaeus)		x	x		x	x	x	x	
Corticeus suturalis (Paykull)				x					* +
Corticeus linearis (Fabricius)								x	
Mycetochara flavipes (Fabricius)			x	x	x	x	x		
Mycetochara obscura (Zetterstedt)		x		x	x	x			
ANASPIDAE									
Anaspis bohemica Schilsky					x	x	x		+
Anaspis frontalis (Linnaeus)								x	
Anaspis marginicollis Lindberg		x		x	x	x	x	x	+
Anaspis arctica Zetterstedt		x	x		x	x	x	x	
MORDELLIDAE									
Curtimorda maculosa (Naezen)		x				x			
TETRATOMIDAE									
Tetratoma ancora Fabricius				x			x	x	
MELANDRYIDAE									
Hallomenus binotatus (Quensel)			x	x	x				+
Hallomenus axillaris (Illiger)			x			x			+
Orchesia micans (Panzer)	x	x	x	x	x	x	x	x	+
Orchesia minor Walker						x			* +
Orchesia fasciata (Illiger)				x	x				
Abdera flexuosa (Paykull)				x					+
Abdera triguttata (Gyllenhal)				x	x			x	+
Xylita laevigata (Hellenius)		x	x	x	x	x	x	x	
Xylita livida (Sahlberg)					x				* +
Zilora ferruginea (Paykull)				x					
CERAMBYCIDAE									
Tragosoma depsarium (Linnaeus)		x							* +
Asemum striatum (Linnaeus)	x							x	
Tetropium castaneum (Linnaeus)	x		x	x	x				
Tetropium fuscum (Fabricius)					x				
Rhagium mordax (Degeer)	x	x	x				x	x	
Rhagium inquisitor (Linnaeus)	x	x	x				x	x	
Oxymirus cursor (Linnaeus)	x	x							
Brachyta interrogationis (Linnaeus)	x	x							
Acmaeops septentrionis (Thomson)			x					x	*
Acmaeops pratensis (Laicharting)							x		

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Alosterna tabacicolor (Degeer)			x	x	x				+
Anoplodera maculicornis (Degeer)						x			
Anoplodera reyi (Heyden)	x	x							
Anoplodera virens (Linnaeus)	x	x		x			x		
Judolia sexmaculata (Linnaeus)			x				x		
Leptura quadrifasciata Linnaeus		x							
Necydalis major Linnaeus						x			
Callidium coriaceum Paykull	x			x					
Callidium violaceum (Linnaeus)	x								
Xylotrechus rusticus (Linnaeus)		x				x			
Lamia textor (Linnaeus)	x								
Monochamus sutor (Linnaeus)	x	x	x						
Pogonocherus fasciculatus (Degeer)	x	x	x					x	
Acanthocinus aedilis (Linnaeus)	x	x							
CHRYSOMELIDAE									
Donacia crassipes Fabricius	x								
Donacia sparganii Ahrens	x								
Donacia thalassina Germar	x								
Plateumaris discolor (Herbst)	x	x							
Plateumaris sericea (Linnaeus)	x								
Syneta betulae (Fabricius)		x	x		x			x	
Clytra quadripunctata (Linnaeus)	x								
Cryptocephalus labiatus (Linnaeus)	x								
Bromius obscurus (Linnaeus)	x	x			x				
Chrysolina staphylaea (Linnaeus)	x								
Phaedon concinnus (Stephens)		x							
Chrysomela populi Linnaeus	x								
Linaeidea aenea (Linnaeus)	x								
Gonioctena viminalis (Linnaeus)	x								
Gonioctena pallida (Linnaeus)		x							
Phratora vulgatissima (Linnaeus)	x	x							
Phratora polaris Sparre Schneider	x								
Phratora laticollis (Suffrian)		x							+
Phratora vitellinae (Linnaeus)	x	x			x	x	x		
Galerucella sagittariae (Gyllenhal)		x	x						
Lochmaea caprea (Linnaeus)	x	x	x			x			
Lochmaea suturalis (Thomson)	x	x							
Aphthona erichsoni (Zetterstedt)			x			x			
Longitarsus suturellus (Duftschmid)			x						+
Altica chamaenerii Håk.Lindberg			x						+
Lythraria salicariae (Paykull)			x						
Chaetocnema sahlbergii (Gyllenhal)			x			x			
ATTELABIDAE									
Byctiscus betulae (Linnaeus)		x							
Deporaus betulae (Linnaeus)	x								
APIONIDAE									
Apion apricans Herbst	x								
Apion violaceum Kirby	x								

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re- marks
Apion curtirostre Germar	x								
Apion simile Kirby			x	x	x				+
CURCULIONIDAE									
Otiorhynchus nodosus (Müller)	x	x	x	x	x	x	x	x	
Otiorhynchus scaber (Linnaeus)			x	x	x	x			
Phyllobius maculicornis Germar	x								
Polydrusus pilosus Gredler				x	x			x	
Polydrusus undatus (Fabricius)	x	x					x	x	
Polydrusus ruficornis (Bonsdorff)	x	x		x			x	x	
Strophosoma capitatum (Degeer)	x	x			x			x	
Grypus equiseti (Fabricius)			x						
Notaris acridulus (Linnaeus)			x						
Dorytomus tremulae (Fabricius)				x		x	x		+
Dorytomus edoughensis Desbr. des Loges							x		
Acalyptus sericeus Gyllenhal		x							
Anthonomus pinivorax Silfverberg								x	+
Rhynchaenus salicis (Linnaeus)					x				
Rhynchaenus foliorum (Müller)	x								
Rhyncolus ater (Linnaeus)	x		x		x	x		x	+
Rhyncolus sculpturatus Waltl	x						x	x	+
Magdalis phlegmatica (Herbst)							x		
Hylobius piceus (Degeer)	x	x	x	x				x	
Hylobius abietis (Linnaeus)	x	x	x				x	x	
Hylobius pinastri (Gyllenhal)	x		x	x	x		x		
Pissodes pini (Linnaeus)	x			x			x	x	
Pissodes gyllenhalii (Sahlberg)		x		x			x	x	
Pissodes harcyniae (Herbst)			x	x	x	x	x		
Pissodes piniphilus (Herbst)	x						x		
Micrelus ericae (Gyllenhal)		x							+
Zacladus geranii (Paykull)	x					x			
SCOLYTIDAE									
Hylurgops glabratus (Zetterstedt)	x	x	x	x	x	x	x	x	
Hylurgops palliatus (Gyllenhal)	x	x	x	x	x			x	
Hylastes brunneus Erichson		x	x	x	x		x	x	
Hylastes cunicularius Erichson	x	x	x	x	x	x	x	x	
Hylastes opacus Erichson							x	x	
Xylechinus pilosus (Ratzeburg)		x	x	x	x	x	x	x	
Tomicus minor (Hartig)	x	x							
Tomicus piniperda (Linnaeus)	x	x			x		x		
Dendroctonus micans (Kugelann)	x		x						+
Phloeotribus spinulosus (Rey)		x		x	x			x	
Polygraphus subopacus Thomson		x	x	x	x				
Polygraphus poligraphus (Linnaeus)			x						+
Polygraphus punctifrons Thomson			x	x	x	x	x		
Scolytus ratzeburgi Janson								x	+
PItyogenes chalcographus (Linnaeus)	x	x	x	x	x		x	x	
Pityogenes quadridens (Hartig)							x		+
Pityogenes bidentatus (Herbst)	x			x			x		+
Orthotomicus proximus (Eichhoff)	x								

	R/Fr	F/Fr	T	H	L	Hi	Le	P	Re-marks
Orthotomicus suturalis (Gyllenhal)					x				
Orthotomicus laricis (Fabricius)							x		+
Ips acuminatus (Gyllenhal)							x		
Ips typographus (Linnaeus)	x		x				x	x	
Ips amitinus (Eichhoff)			x		x		x	x	+
Dryocoetes autographus (Ratzeburg)		x	x	x	x	x	x	x	
Dryocoetes hectographus Reitter			x	x	x	x	x		
Crypturgus subcribrosus Eggers			x	x	x	x			+
Crypturgus hispidulus Thomson				x	x	x	x	x	
Trypodendron proximum (Niijima)	x			x	x			x	*+
Trypodendron lineatum (Olivier)		x	x	x	x		x	x	
Trypodendron signatum (Fabricius)	x	x	x	x	x		x	x	+
Trypophloeus bispinulus Eggers							x		+
Cryphalus saltuarius Weise			x	x	x				
Pityophthorus micrographus (Linnaeus)								x	
Pityophthorus lichtensteinii (Ratzeburg)		x					x		

APPENDIX 2. Rare or interesting species in the study areas.

CARABIDAE

Sericoda quadripunctata (Degeer)
In eastern Fennoscandia a widespread species, which is strongly attracted by fire. It is found in most fire places soon after the fire has gone out, but it is rarely observed, because it is mostly dwelling under the bark on stems, branches or stumps damaged by fire. This species was once found in Kostomuksha (B.K.leg.).

Platynus mannerheimii (Dejean)
A species depending on old, dark and moist forests with fallen, decaying trunks. It lives under the bark of logs, in *Sphagnum* or in litter.In eastern Fennoscandia this species is not very uncommon, but it is seldom found outside the old forests. In our study areas it was found in great numbers in Teerisuo-Lososuo (Syväpuro and Rajapuro) (I.R. leg.) and also in Kostomuksha (B.K.leg.).

Amara erratica (Duftschmid)
This species with circumpolar distribution is not uncommon in the northern parts of Fennoscandia and southernmost it is found in the province Kainuu. It is also known from the northern parts of the Russian Karelia. It occurs most often in open places with moraine soil and grass vegetation. This species was found in Kostomuksha (B.K. leg.).

DYTISCIDAE

Hydroporus puberulus LeConte
A rare species with circumpolar distribution, which is found throughout the northern Fennoscandia. Most often it is found in small water bodies situated in open places and overgrown with moss or grass. A few specimens of this species were found at Ehrimenvaara, Kostomuksha Nature Reserve, in July 1991 and 1993 (I.R. leg., A.N.Nilsson det.)

Hydroporus longicornis Sharp
This rare boreomontan species is widespread in Fennoscandia and it is most often found in small, acid water bodies filled with *Sphagnum* in dark and moist spruce forests. One specimen of this species was caught with pitfall trap in Teerisuo-Lososuo (Isosuo).

Ilybius vittiger (Gyllenhal)
This north-European species is found in most areas of northern Fennoscandia south to Central-Finland, but it is rare in the southern parts of its distribution area. It is found once in Syväpuro area, near Teerisuo-Lososuo.

Rhantus fennicus Huldén
This rare species was described recently after two specimens found in a small lake Elimysjärvi surrounded by old forest in the Finnish part of the Friendship Nature Reserve (Huldén 1982). Subsequently the species has been found also at two localities in northern Sweden (Nilsson 1986, Nilsson & al. 1995). Additionally, there are three old records of this species from Russia: Kalininskaja, Leningradskaja and Moskovskaja oblast (Nilsson 1989). In 1988 the other of us (B.K.) found one female of this species in the lake Mustankivenlampi, Kostamuksha Nature Reserve. The species is classified in the Finnish red book as vulnerable (Rassi & al. 1992a).

PTILIIDAE

Ptinella johnsoni Rutanen

This recently described species has showed to be widespread in Finland, but because of its small size (about 1 mm) it is easily neglected. It was once found under the bark of a log of spruce with white fungus growth, but most observations of this species are based on catching with car net on forest roads or with window trap. So far the species is known only from Finland and Sweden. In Kainuu this species was found once in Pyöriäisenvaara forest fire area in 1993.

LEIODIDAE

Leiodes inordinata (J.Sahlberg)

A typical species of boreal spruce forests, with underground characterised by thick moss layer. This species is caught with window trap in the most old forest areas in south and central-Finland. Several specimens of this species were found in Teeri-Lososuo 1991 and one specimen in Louhivaara in 1992.

Leiodes longipes (Schmidt)

This is a rare species found earlier only five or six times in Finland. It was caught with light trap in the Finnish part of Friendship Nature Reserve (Viiksimo) in August 1991 (R.Leinonen leg., S.Lundberg det.).

Leiodes puncticollis (Thomson)

This fairly uncommon species is widespread in northern Europe and it is found in different types of forests, where it is dwelling in moss or litter. One specimen was caught with window trap in Teeri-Lososuo in 1991.

Agathidium pulchellum Wankowicz

This species was found for the first time in Fennoscandia in Sweden in 1971 (Lundberg 1977, 1978). Later on it is found in five places in Finland. It is a rare species of dark natural spruce forests, which is highly depending on decaying deciduous wood, preferably aspen *(Populus tremula)*, with fungus growth. Two specimens of this species were caught with window trap in Teeri-Lososuo (Isokorkea) in 1991. In the Finnish red list this species is classified as endangered (Rassi & al 1992a).

Agathidium pallidum (Gyllenhal)

Like the former, this species is also depending on decaying deciduous wood attached by fungi in dark and moist, old spruce forests. After the observations made in Norway (Strand 1938), Sweden (Palm 1947), and during the past few years in Finland the species prefers coarse decaying birch-wood *(Betula sp.)* with fungus growth. It is found during the last years in several old forest areas in south- and north-Finland. In the study areas of Kainuu this species was caught with window traps in four places: Teeri-Lososuo (Isokorkea), Honkavaara, Leppivaara and Pyöriäisenvaara. In the Finnish red list this species is classified as rare (Rassi & al.1992a).

Agathidium nigrinum Sturm

An uncommon species, which is found only in natural spruce forests, where it is dwelling in bracket fungi or on slime molds growing on decaying trunks of birch, aspen or other deciduous trees. In Kainuu this species was caught in all study areas but Leppivaara.

Agathidium arcticum Thomson
Like the former, this is also a fairly uncommon species, especially in south Finland, but it is more common in the north. It is also an old forest dweller and it is found on bracket fungi or slime molds of e.g. birch-trunks. The species has showed to be in Kainuu much more rare than the former, and it is found only in Teeri-Lososuo (Isokorkea) and in Hiidenvaara.

Agathidium discoideum Erichson
Like the most species of this genus, this is also a typical old-forest species and it is caught most often with window traps set nearby old, decaying trunks with fungus growth of deciduous trees, preferably aspen. In suitable places this species is often caught in great numbers. In all of our study areas of Kainuu it was caught in numbers.

CHOLEVIDAE

Choleva glauca Britten and *C. sturmii* Brisout de Barneville
Both species are underground-dwellers living in burrows of voles or other small mammals. They are species with southern distribution in Finland and are in Kainuu on the northern border of their area. Both species were caught with pitfall traps in Honkavaara, the former only in Teeri-Lososuo (Syväpuro). The first mentioned species was found also in Kostomuksha (B.K. leg.).

Catops longulus Kellner
A rare species found in vole nests or burrows, in carcasses and excrements of different animals in forests. This species was caught once with pitfall trap in Honkavaara.

SCYDMAENIDAE

Euconnus claviger (Müller & Kunze)
A rare myrmecophil species found in ant-hills *(Formica sp.)* or ant-nests in hollow trunks *(Lasius sp.)*. It was caught once with window trap in Honkavaara.

Scydmaenus hellwigii (Herbst)
This southern species lives in ant-nests, especially such existing in decaying, hollow trees. It was caught in great numbers with window traps in the forest fire area Pyöriäisenvaara. Earlier this species has not been found so far in the north in Finland.

STAPHYLINIDAE

Philonthus lederi Eppelsheim
This staphylinid beetle, originating in Siberian taiga, was for the first time found in Finland in 1983 (Muona 1984). Nowadays it is widespread in northern Finland and Sweden and it is not uncommon in the coniferous forests of this area. This species lives in elks dung and has become more common along with the increase of the elk populations. In our study areas this species was found at Pyöriäisenvaara (I.R. leg.) and in the most study sites of the Finnish part of Friendship Park, where it has been caught with bait traps (R.Leinonen leg.).

Stenus pubescens Stephens
A rare and locally occurring species with southern distribution. It was found on sandy shore with sparse Carex-vegetation of the Lake Kamennoye, Kostomuksha Nature Reserve, in 1991 (I.R. leg.). Later on it was found on about the same kind of shore in the Finnish side of Friendship Park at Lake Viiksimonjärvi, Kuhmo. These are the northernmost finds of this species in Fennoscandia.

Hapalaraea clavigera (Luze)
A fairly rare species living under the bark of dead trunks of both conifers and deciduous trees, often in forest fire areas. This species was found once during the same year logged area in Leppivaara and once in burnt forest in Kostomuksha Nature Reserve, in both cases with window trap (I.R. leg.).

Phloeonomus monilicornis (Gyllenhal)
A fairly rare species, which lives under bark of recently dead trunks of spruce, pine or deciduous trees. This species occurs as imago usually during the cold season. Found several times in the study areas: Teeri-Lososuo (Isokorkea), Louhivaara and Pyöriäisenvaara.

Eucnecosum brunnescens (J.Sahlberg)
A litter-dwelling species with northern distribution. The species was found in pitfall traps in Teeri-Lososuo (Syväpuro) and in Louhivaara.

Eudectus giraudi Redtenbacher
A northern species like the former living under loose bark with fungus growth of different kinds of trunks, both conifers and deciduous trees. It was caught with window traps in Teeri-Lososuo, Louhivaara and Pyöriäisenvaara.

Scaphisoma boleti (Panzer)
A rare species with southern distribution, which lives in decaying trunks with fungus growth or on bracket fungi. It was caught once at the logged area of Leppivaara.

Mycetoporus monticola Fowler
In the north widespread and not uncommon,but in the south of Finland rare species. Like all the species of this genus it is a litter-dweller, living in moss and decaying fallen leaves in forests. This species was caught with pitfall traps in Teeri-Lososuo (Syväpuro) and in Löytösensuo near Hiidenvaara.

Mycetoporus maeklini Bernhauer
A rare northern species, which was caught twice with window traps in the old forest of Leppivaara.

Mycetoporus maerkeli Kraatz
This is a fairly rare but widespread species, which is more common in the north than in the south. It was caught once with window trap in Louhivaara.

Bryoporus crassicornis (Mäklin)
A rare species found in leaf litter, moss and mushrooms. It is maybe most often caught in flight. One specimen of this species was caught with window trap in the old forest of Leppivaara.

Lordithon exoletus (Erichson)
A species living in earth-growing mushrooms and boleti. It is nowadays widespread and not uncommon in the whole south- and central-Finland. For the first time it was reported from Finland in 1940's. It was caught once with pitfall trap in Teeri-Lososuo (Isokorkea).

Tachinus elegans Eppelsheim
A typical species of boreal spruce forests in natural condition originating in Siberian taiga. It is most often found in rotten mushrooms in late summer. In suitable places it can be found in great numbers. More than one hundred specimens of this species were caught with pitfall traps at Teeri-Lososuo (Isokorkea, Rajapuro and Syväpuro), single specimens also at Honkavaara and Hiidenvaara.

Tachinus atripes J.Sahlberg
A rare species with northern distribution, which was caught once with pitfall trap in Teeri-Lososuo (Isokorkea).

Tachinus basalis Erichson
This holarctic species is a type species of boreal coniferous forests in natural condition. It was reported for the first time in Fennoscandia in 1975 (Lundberg 1978). Later on the species has been found in several new localities in east- and central-Finland but not in other Nordic countries. Some specimens of this species were caught with pitfall traps in Teeri-Lososuo (Isokorkea) and once it was found in a rotten false morel *(Gyromitra esculenta)* at Honkavaara (J.Muona leg.). It was also caught with bait traps in Lentua and Juortanansalo (R.Leinonen leg.). In the red book of Finland this species is classified as rare (Rassi & al. 1992a).

Oxypoda operta Sjöberg
This species belongs also to the type species of the natural spruce forests, where it lives in the burrows and nests of small mammals and in suitable places it can be found in numbers. It was caught with pitfall traps in Teeri-Lososuo (Isokorkea), Honkavaara and Kostomuksha Nature Reserve (B.K. leg.). This species is not reported earlier from the Fennoscandian part of Russia (Silfverberg 1992).

Oxypoda vittata Märkel
This is a rare species living in nests of ants, after Palm (1972) it prefers the nests of *Lasius fuliginosus.* It was found once in Teeri-Lososuo (Isokorkea).

Oxypoda bicolor Mulsant & Rey
A fairly rare species, which lives in leaf litter and moss preferably in humid forests and marshes (Palm 1972). It was caught once with window trap at Honkavaara.

Ischnoglossa obscura Wunderle
The first Finnish record of this recently described species (Wunderle 1990) was made in the oak forest of Ruissalo, Turku, in 1990 (S.Lundberg leg.). One specimen of this species was caught with window trap in the forest fire area of Pyöriäisenvaara in 1993. This species is living under bark or in decaying wood of dead trunks.

Haploglossa marginalis (Gravenhorst)
This rare species lives in bird- and ant-nests in hollow, rotten stems. It was found twice in the study area: Hiidenvaara (old, logged area) and Pyöriäisenvaara (forest fire area).

Atheta pandionis Scheerpeltz
This is for the Finnish fauna new species, which has been reported for the first time from Finland from Kuirivaara, Puolanka after a male specimen caught with bait trap in 1994 (R.Leinonen leg.) (Rutanen & al., manuscript). Two specimens, male and female, were found in the material collected in old spruce forest near the forest fire area of Pyöriäisenvaara with bait traps in 1993 (R.Leinonen leg.). The first records of the species were made in Norway in nests of osprey *(Pandion haliaetus)* and buzzard *(Buteo buteo)*, but the later observations from Sweden (Lundberg 1984) and Finland indicate that the species is an old forest dweller and is not exclusively a nidicole.

Atheta pallidicornis (Thomson)
A fairly uncommon species of old natural forests, where it is found in mushrooms *(Pleurotus)* or bracket fungi *(Polyporus)* growing on decaying trunks of deciduous trees. This species was caught with window trap in the old forest of Leppivaara.

Atheta acutangula Hanssen
A rare species, which after Palm (1970) lives in rotten mushrooms growing on earth or trees. It was found once in Teeri-Losonsuo (Isokorkea).

Lomechusa pubicollis Brisout de Barneville
This is a fairly uncommon myrmecophil species. Two specimens were caught with window traps at the old forest of Leppivaara.

Gyrophaena joyi Wendeler
This is a mycetobiont species, which develops in mushrooms growing on decaying trunks or stumps of deciduous trees. It is a fairly rare species and it was found once in Kostomuksha Nature Reserve near Ehrimenvaara in mushrooms growing on a decomposed trunk by the side of a forest road (I.R. leg.).

Phymatura brevicollis (Kraatz)
A rare and locally occurring species, which is found under bracket fungi growing on dead trunks of both conifers and deciduous trees, most often spruce or birch, in dense and dark spruce forests (Palm 1968). In our study areas this species was found only once at Teeri-Lososuo (Rajapuro) under polypore fungus growing in a dead trunk of birch.

Leptusa norvegica Strand
This is a rare species living under loose bark of conifers. It was caught once with window trap at Honkavaara.

Cyphea latiuscula Sjöberg
A rare species of natural coniferous forests, where it lives under bark of standing, dying old spruces attached by bark beetles *(Polygraphus)* or longhorn beetles *(Tetropium)*. Several specimens of this species were caught at Louhivaara with window trap, which was set on a robust dying spruce. This species is classified as rare in the Finnish list of threatened species (Rassi & al. 1992a).

HISTERIDAE

Platysoma deplanatum (Gyllenhal)
A fairly rare species, which lives under bark of different deciduous trees, preferably aspen. Three specimens were caught with a window trap set close by a dead standing trunk of aspen in the logged area of Hiidenvaara.

DRYOPIDAE

Dryops anglicanus Edwards
An uncommon hygrophilous species, which is found in stagnant water of bogs or swamps of different kind. Two specimens of this species were caught in Kostomuksha Nature Reserve on the swampy shore of Lake Mustankivenlampi (I.R. leg.).

ELATERIDAE

Lacon conspersus Gyllenhal and *L. fasciatus* (Linnaeus)
Fairly uncommon saproxylic species, which are living under bark of robust dead trunks of deciduous trees with fungus growth. Both species were found in Ulvinsalo (Rasinvaara) (B.K. & I.R. leg.) and *L. conspersus* is also found in Kostomuksha Nature Reserve (B.K. leg.). The latter species is classified as declined in the Finnish red list (Rassi & al. 1992a).

Denticollis borealis (Paykull)
A fairly rare species, which is living in dead standing or fallen trunks or stumps of birch. This species prefers warm sunny locals and is therefore found most often in burnt or recently logged areas (Palm 1951). One specimen was caught in the logged area of Leppivaara with window trap.

Ampedus nigroflavus (Goeze)
This is a rare saproxylic species, living in decaying trunks of aspen or birch. One specimen was found at Hiidenvaara under bark of a robust log of aspen (B.K. leg.). It is listed as rare species in the red book of Finland (Rassi & al. 1992a).

DERMESTIDAE

Globicornis emarginata (Gyllenhal)
A fairly rare species living under bark of rotten trunks and stumps of deciduous trees. It was caught with window trap at the old logged area with robust standing aspens in Hiidenvaara.

ANOBIIDAE

Episernus angulicollis Thomson
This widespread, northern species, which is living in dead trunks of spruce, not only in nature, but also in e.g. barns made of timber. Some specimens of this species were caught with window traps at Honkavaara, Leppivaara and Pyöriäisenvaara.

NITIDULIDAE

Epuraea concurrens Sjöberg
A rare species, which was recently reported as new to Europe (Rutanen 1993). Earlier it was known from Central-Siberia. This species belongs to the fauna of the boreal taiga and it is known from about ten localities from Finland and also from the Fennoscandian part of Russia (Gumbaritsa). In Kainuu the species was found in Teeri-Lososuo (Isokorkea and Rajapuro) and in the National park of Hiidenportti. All new records of this species have been made in old natural forests on polyporus fungi growing on dead birch-trunks or with window traps.

Epuraea fussi Reitter
A rare species, the biology of which is incompletely known. One specimen of this species was caught with window trap at Leppivaara.

Epuraea dolosa Kirejchuk
This recently described species (Kirejchuk 1995) has been found in great numbers in the materials collected with bait traps for moths in different parts of Kainuu, most specimens at the forest fire place Pyöriäisenvaara (R.Leinonen leg.). Several specimens were caught also with window traps at Teeri-Lososuo (Isokorkea), Honkavaara, Leppivaara and Pyöriäisenvaara.

Epuraea melina (Erichson)
This species, which develops in nests of bumble-bee *(Bombus sp.)* has been collected in great numbers with bait traps (R.Leinonen leg.). One specimen was caught also with window trap in Pyöriäisenvaara.

Ipidia binotata Reitter
A typical old forest species with southern distribution, which is not reported farther north than in southern Kainuu. It is found usually under loose bark of dead standing spruces. One specimen was caught with window trap at Honkavaara.

RHIZOPHAGIDAE

Rhizophagus grandis Gyllenhal
This fairly rare and local species is found in burrows of the bark beetle *Dendroctonus micans* at the base of old spruces. It was caught once in the fire place of Pyöriäisenvaara.

CUCUJIDAE

Pediacus fuscus Erichson
In the southern half of Finland a fairly uncommon, but in the north not rare species, which is often found in great numbers in forest fire places. Several specimens of this species were caught at Pyöriäisenvaara.

CRYPTOPHAGIDAE

Henoticus serratus (Gyllenhal)
A widespread and fairly common species, which is strongly attracted by forest fire. It was found in great numbers at Pyöriäisenvaara, but not at all in other study areas.

Cryptophagus lysholmi Munster
A fairly rare species, which is found under bark with fungus growth on dead standing trunks of conifers. One specimen of this species was caught with window traps both at Honkavaara and Pyöriäisenvaara.

Cryptophagus plagiatus Poppius
A very rare species, which has been reported from Finland only five or six times, all finds are from in Lapland or Kuusamo. The new finds from Kainuu are the southernmost records of this species in Finland. Our knowledge concerning the biology of this species is very poor, but after Bruce (1936) it is found in decaying leaf litter, and Palm (1951) has found this species under bark with fungus growth of

dead birch. Three specimens of the species were caught with window traps in our study areas: one at Honkavaara and two at the forest fire place Pyöriäisenvaara, where the traps were hanged out on the burnt trunks of birch.

Cryptophagus confusus Bruce
This species, which earlier was regarded as rare, has showed to be not uncommon, but it is found only in the best preserved natural forests with old aspens. It is caught often with window traps set nearby the trunks of aspen. In our study areas of Kainuu this species was found at all sites but Pyöriäisenvaara, where aspens were almost lacking.

Cryptophagus corticinus Thomson
A typical species prefering burnt wood, which is mostly found in small numbers at almost every forest fire place. This species was caught at both fire places of our study: Pyöriäisenvaara and Kostomuksha.

Atomaria subangulata J. Sahlberg, *A. abietina* Reitter, *A. badia* Erichson, *A. affinis* (FSahlberg), *A. bella* Reitter and *A. pulchra* Erichson
All these species are typical old forest-dwellers, which are found under loose bark of dead trunks with fungus growth or on bracket fungi. Of these species *A. bella* and*A. pulchra* are the most common, the others fairly uncommon. *A. pulchra* seems to prefer burnt wood. All these species (except *abietina*) were caught in numbers with window traps at the most of our study areas. *A.abietina*, which is a rare species, was caught once at Louhivaara and once at Pyöriäisenvaara.

LANGURIIDAE

Zavaljus brunneus (Gyllenhal)
A very rare species, reported from Finland only five or six times. It is developing in dead trunks and stumps of different deciduous trees, e.g. birch, aspen or alder *(Alnus sp.)*. Two specimens of this species were caught with a window trap, which was set nearby a dead trunk of aspen at Honkavaara. This species is classified in the Finnish red list as rare (Rassi & al. 1992a).

EROTYLIDAE

Triplax rufipes (Fabricius)
A rare species with southern distribution. It is found in mushrooms *(Pleurotus)* growing on the trunks of deciduous trees. The populations of this species have strongly declined during the last decades in Finland and the species is listed in the red book of Finland as rare (Rassi & al. 1992a).

ENDOMYCHIDAE

Leiestes seminigra (Gyllenhal)
In south- and central-Finland widespread and in old natural forests not an uncommon species. It is found under the loose bark with fungus growth of different kinds of dead trunks, both deciduous trees and conifers. The species was caught once at our study areas of Kainuu, at Hiidenvaara.

LATRIDIIDAE

Latridius nidicola (Palm)
This species, which lives in nests of different animals like birds, squirrel or ants, most often in such existing in hollow trunks. It was caught at two localities in our study areas: Louhivaara and Pyöriäisenvaara.

Enicmus planipennis Strand
This is a widespread but fairly uncommon species found under bark of decaying trunks with fungus growth of both deciduous trees and conifers. It was caught in numbers with window flight traps at both Honkavaara and Louhivaara.

Enicmus apicalis J.Sahlberg
Like the former species, but rarer and with more northern distribution. It is found in dead trunks of different deciduous trees with fungus growth. This species was caught three times at the study area: Honkavaara, Louhivaara and Pyöriäisenvaara.

Corticaria orbicollis Mannerheim
In northern Finland not an uncommon species, which is found under bark with fungus growth of both deciduous and coniferous trees. It was caught in numbers at the most of our study areas in Kainuu.

Corticaria crenicollis Mannerheim
A widespread but rare species, which is -like the most other species of this genus-depending on dead wood with fungus growth. It was caught at the study areas of Kainuu only twice: Hiidenvaara and Leppivaara.

Corticaria obsoleta Strand
This is also a widespread, but fairly rare species, and it has been found mostly on recently dead, standing trunks of spruce with fungus growth. Four specimens of this species were caught with window traps at Honkavaara and Pyöriäisenvaara.

CISIDAE

Cis lineatocribratus Mellié
A fairly uncommon species found in bracket fungi growing on trunks of birch or spruce. This species was caught with both pitfall and window traps at Teeri-Lososuo and Pyöriäisenvaara.

Cis alter Silfverberg
A widespread but fairly rare species, which is found in bracket fungi growing on different species of trees. It was caught only once in Kainuu, at Hiidenvaara.

Cis dentatus Mellié
A widespread but rare species, living in decaying wood with bracket fungi, but also in decomposing leaf litter under deciduous trees or in mouldy needles under spruces (Palm 1959). In the study areas of Kainuu this species was caught only once at Honkavaara.

COLYDIIDAE

Lasconotus jelskii (Wankowicz)
A widespread, but fairly uncommon species, living in recently by bark-beetles *(Polygraphus)* killed trunks of spruce. It was caught in numbers both at Honkavaara and Louhivaara with window traps set near dead, standing trunks of spruce.

MYCETOPHAGIDAE

Mycetophagus fulvicollis Fabricius
An fairly uncommon species, which is found usually under bark of deciduous trees (birch or aspen) with fungus growth, but also sitting on the underside of bracket fungi on decaying trunks or stumps. After Saalas (1923) this species is also found on the trunks of spruce with the polypore fungus *Trichaptum abietinum.* In Kainuu this species was caught with window traps at Honkavaara and Hiidenvaara.

Mycetophagus populi Fabricius
This is also a fairly rare species found in the inner parts of decaying trunks with fungus growth of deciduous trees , preferably aspen or alder (Palm 1959). It was caught once with window trap at Honkavaara.

SALPINGIDAE

Sphaeriestes stockmanni (Biström)
In south and central-Finland widespread and not uncommon species strongly prefering burnt wood. It is found regularly in forest fire places, often in great numbers. This species was caught once in the recently logged area of Leppivaara, but it was not found in the forest fire areas of Pyöriäisenvaara and Kostomuksha.

TENEBRIONIDAE

Corticeus suturalis (Paykull)
A widespread, but fairly rare species of old spruce forests. It is depending on dead or dying, standing spruces, killed by bark-beetles *(Polygraphus).* One specimen of this species was caught with window trap at Honkavaara.

MELANDRYIDAE

Orchesia minor Walker
An uncommon, widespread species, which develops in different kinds of bracket fungi, but after Palm (1959) especially in branches of deciduous trees with fungus growth. It was caught once at the logged area with old standing aspens of Hiidenvaara.

Xylita livida (Sahlberg)
A typical species of old, dark and humid spruce forests, where it is living in the wood of decaying logs of spruce with fungus growth. The species is rare in Kainuu, at our study areas it was caught only once, at Louhivaara.

CERAMBYCIDAE

Tragosoma depsarium (Linnaeus)
A rare and strongly declined species, which is depending on thick, decaying logs of pine. It is still found in the best preserved natural pine forests of east-Finland. This species belongs to the list of threatened species of Finland as vulnerable (Rassi & al. 1992a). One specimen was caught with light trap at Rajakangas south of Ulvinsalo in August 1995 (R. Leinonen leg.).

Acmaeops septentrionis (Thomson)
A widespread, but in South-Finland nowadays rare species, all recent finds of which are made in north-Finland. This species develops in spruce, exceptionally also in pine and it prefers trees damaged by fire (Palm 1957). Four adults of the species were caught with window traps at the fire place of Pyöriäisenvaara and one larva (S. Lundberg det.) with pitfall trap at Teeri-Lososuo (Isokorkea). In the red book of Finland this species is classified as rare in North-Finland (Rassi & al. 1992a).

SCOLYTIDAE

Trypodendron proximum (Niijima)
Recently as new to Finland reported species (Muona 1990), which seems to be widespread and not very uncommon in the largest part of the country. This species is developing in spruce, but also in pine and it is often found in forest fire places (Muona 1994). It was found at our study areas in Honkavaara and Louhivaara and in the forest fire places of Pyöriäisenvaara and in Kostomuksha .

Distribution of some blood-sucking Arthropoda of the Kostomuksha area

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Abstract

The blood-sucking Arthropoda living near the Kostomuksha iron deposit has not been studied earlier. Our primary objectives were to reveal blood-sucking Arthropoda that may carry diseases and to study their species composition and distribution. Ixodoidea, Gamasoidea, biting midges, mosquitoes, black flies and horseflies were investigated.

Key words: mosquitoes, black flies, gnats, species distribution, diseases, Kostomuksha

Introduction

Ticks that carry tick-borne encephalitis and infest Karelian horned cattle with babesiasis were thoroughly searched for because the Kostomuksha deposit lies near the northern boundary of the distribution areas of *Ixodes ricinus* , *persulcatus*, *I. apronophorus* and *I. trianguliceps* (occurs as far as Louhi) which can spread the above mentioned diseases among small mammals (Bobrovskikh 1989).

Hamasoidae which carry diseases and retain their roots in native foci are of great epizoological importance. In the taiga zone they spread the viruses of tick-borne encephalitis, Ricketsia, Q fever, the bacteria of tularemia and other infections. When Gamasoidea are in the circulation chain of viruses in the native foci of diseases, they transfer the viruses to rodents and small insectivorous mammals. Therefore, the viruses are preserved for a long time in native foci of diseases.

When it gets warm in the study area, blood-sucking Diptera cause a great harm to farm animals and people working in the forest and in the field. In addition, blood-sucking insects carry some diseases such as tularemia, Karelian fever, arboviral infections etc. After sucking blood from a sick man or animal, they can transfer a virus via their saliva (Lutta 1970).

Methods

Our studies were carried out near Lake Kontokki in late June - early August 1974. Ixodoidea and Gamasoidea were collected by conventional methods, small mammals with Gero traps (Novikov 1953). 130 animals were caught and examined.

When studying blood-sucking Diptera, attention was mainly given to adult insects. They were caught using an entomological landing net, a Skufyin trap and a A. S. Monchadsky & Z. A. Radzivilovskaya (1947) bell. Besides, larvae and pupae were sampled for species determination. Adult insects were put on cotton wool mattresses, and small individuals were placed in dry capsules. Ticks and blood-sucking Diptera larvae were fixed with 70% alcohol. The age composition of mosquito populations was studied using Detinova method (1962).

Results and discussion

Ixodidae

The animals examined represented three species: common shrew *Sorex araneus* L. (45 ind.), European bank vole *Clethrionomys glareolus* Sc. (30 ind.) and field vole *Microtus agrestis* L. (55 ind.). They are the main hosts of ticks, but in the Kostomuksha area they proved to be uninfected. The northernmost localities from which cattle and taiga ticks are reported lie at 63°19' - 63°20' N. The Kostomuksha area is 1° further north than the boundaries for the habitats of *I. ricinus*, *I. persulcatus* and *I. apronophorus*. The absence of these species in the study area indicates that they have spread northwards. *I. trianguliceps* was not found either, although it was reported from Louhi, East Karelia, and is considered as an ubiquitous species.

Gamasoidea

Our study has shown that common shrew, European bank vole and field vole are the animals most heavily infested with Gamasoidea (Table 1). Gamasoidea are represented by 22 species of 17 genera (Table 2). Facultative and obligate hematophages account for 85%, *Laelaps hilaris*, *Hyperlaelaps arvalis*, *Hirstionyssus eusoricis* and *H. isabellinus* being most abundant. They are of epizoological interest as potential carriers of viruses. The number of Gamasoidea on animals varies with climate and season. Most of the Gamasoidea found can adapt themselves to various host feeders.

Table 1. Infestation of small mammals with Gamasoidea.

Animal species	Number of animals studied	Percentage of infested animals	Infestation intensity	Abundance index		Number of species
				max	aver	
Common shrew	45	55.5	45	6.5	3.56	16
European bank vole	45	63.3	8	3	1.9	8
Field vole	55	92.7	26	6.2	5.7	19

Table 2. Species composition and abundance of Gamasoidea infesting small mammals.

Species	Common shrew		European bank vole		Field vole	
	abundance	abundance index	abundance	abundance index	abundance	abundance index
Parasitus fimetorum	-	-	-	-	1.8	0.018
Pergamasus crassipes	2.2	0.04	-	-	-	-
Paragamasus lapponicus	-	-	-	-	1.8	0.018
Eugamasus kraepelini	2.2	0.02	-	-	5.45	0.05
E. oudemansi	6.6	0.06	13.3	0.13	7.27	0.07
E. remberti	8.8	0.08	23.3	0.3	10.8	0.14
Eugamasus sp.	2.2	0.02	13.3	0.43	1.8	0.03
Poecilochirus necrophori	2.2	0.04	-	-	1.8	0.018
Parasitidae gen. sp.	4.2	0.04	-	-	3.63	0.07
Veigaia nemorensis	-	-	-	-	1.8	0.02
Euryparasitus emarginatus	4.2	0.04	-	-	-	-
Cyrtolaelaps mucronatus	4.2	0.04	3.3	0.03	-	-
Macrocheles glaber	6.6	0.06	-	-	3.63	0.12
Phytoseiidae gen. sp.	-	-	-	-	1.8	0.02
Hypoaspis heselhausi	-	-	-	-	1.8	0.02
Eulaelaps stabularis	2.2	0.02	16.6	0.16	5.45	0.07
Laelaps hilaris	6.6	0.06	-	-	72.7	3.7
Hyperlaelaps arvalis	2.2	0.06	-	-	21.8	0.4
Haemogamasus nidi	-	-	-	-	12.7	-.18
H. ambulans	2.2	0.02	20.0	0.4	10.9	0.11
Hirstionyssus isabellinus	2.2	0.02	40.0	0.6	27.2	0.7
H. eusoricis	37.7	2.8	6.6	0.06	1.8	0.18

Blood-sucking Diptera

In the Kostomuksha area, mosquitoes and black flies are predominant blood-sucking Diptera. Horseflies and biting midges are far less common. Biting midges (family Ceratopogonidae) are represented by 6 species (Table 3). *Culicoides pulicaris* accounts for over 90% of all the biting midges collected. *C. fascipennis* and *C. grisescens* and *C. obsoletus* are found as single insects. In South and Central Karelia, *C. fascipennis* is known to be an abundant species which makes up about 79% of biting midges (Glukhova 1962). In the Kostomuksha area *C. fascipennis* is scarce which is probably due to bad weather with frequent rains and a decline in day temperatures. For the same reason summer began much later for biting midges in 1974. It was not until early August that they became more abundant.

Table 3. Species composition of biting midges (family Ceratopogonidae).

Species	Number of midges collected	
	Abs.	Percentage of total number
Culicoides pulicaris (L.)	281	90.06
C. fascipennis (Staeg.)	14	4.48
C. chiopterus (Mg.)	3	0.97
C. obsoletus (Mg.)	1	0.32
C. albicans (Winn.)	10	3.2
C. grisescens Edw.	3	0.97

Mosquitoes (family Culicidae) are represented by 8 species of 2 genera (Table 4). Adults are dominated by *Aedes punctor, A. communis* and *A. diantaeus* and preimaginal stages by *Culiseta bergrothi*. Mosquitoes of the genus *Culiseta* species begin to fly later than those of the genus *Aedes*. Therefore, our material collected in July, consisted largely of larvae and pupae of the genus *Culiseta*.

Table 4. Species composition of mosquitoes and black flies.

Species	Aquatic stages		Imago	
	Number	%	Number	%
Mosquitoes				
Culiseta alaskaensis	66	17.1	-	-
C. bergrothi	286	69.4	-	-
Aedes excrucians	-	-	88	6.4
A. flavescens	-	-	43	3.1
A. communis	36	9.4	496	35.7
A. punctor	16	4.1	555	39.9
A. diantaeus	-	-	206	14.8
A. pullatus Cog.	-	-	1	0.1
Black flies				
Eusimulium aureum	2	0.05	-	-
E. latizonum	5	0.13	1	0.23
Schonbaueria	-	-	4	0.89
Gnus rostratum	-	-	2	0.45
Odagmia ornata	-	0.03	-	-
Simulium tuberosum	18	0.45	-	-
S. truncatum Lundstr	3909	99.24	10	2.23
S. austeni	1	0.03	1	0.23
S. morsitans	3	0.07	431	95.97

The authors wish to thank Dr. Z. V. Usora for determination of black flies. It has been shown by studying ovular follicle maturation in female mosquitoes that most of them were on the second gonotrophic cycle and only a few females on the third one (Table 5). The more gonotrophic cycles a female does, the more dangerous it is epidemiologically.

Table 5. Age composition of mosquito populations.

Species	Number of females examined	Gonotrophic cycles					
		Females that laid no eggs		Females that laid eggs once		Females that laid eggs twice	
		Number	%	Number	%	Number	%
Aedes communis	45	6	13.3	37	82.3	2	4.4
A. punctor	44	9	20.4	34	77.4	1	2.2
A. diantaeus	29	6	20.7	22	75.8	1	3.4
A. excrucians	7	2	28.5	5	71.5	-	-
A. flavescens	1	-	-	1	-	-	-
A. pullatus	1	1	-	-	-	-	-

Mosquitoes are produced in voids between stones, topographic depressions, holes formed near the roots of trees, artificial ditches and trenches, water bodies scattered in the forest and on polluted meadows.

Black flies (family Simuliidae) are represented by 9 species of 5 genera (Table 4). *Simulium truncatum*, a predominant aquatic phase, and *S. morsitans*, a prevalent adult phase, are abundant. According to Usova (1961), they are widespread in both Karelia and the Murmansk region. The bulk of black flies are produced in river and creek rapids.

Horseflies (family Tabanidae) are not numerous. Sixteen species of five genera have been revealed (Table 6). *Chrysops relictus, Hybomitra lurida* and *H. nitidifrons confiformis* were most abundant. Considerable annual variation in abundance is typical. Low number and poor species composition are observed in cold and rainy years. Most horseflies are produced on fens, transitional bogs, polluted land as well as low on lake shores and river banks.

The daily activity of blood-sucking Diptera is assessed by controlling the abundance of all gnat types. Mosquitoes are most active at sunset and sunrise, Black flies in the morning and evening hours, biting midges in the evening and horseflies at the hottest time of day.

Parasite studies carried out in the vicinity of Kostomuksha have revealed a variety of all types of gnats and an abundance of mosquitoes and black flies. It is difficult to take antilarval measures because gnats are produced at various places scattered over large areas.

Table 6. Species of family Tabanidae.

Species	Number of horseflies collected Abs.	Percentage of total number
Chrysops caecutiens	1	0.3
Ch.relictus	72	19.8
Hybomitra bimaculata	2.8	10
H. lurida	57	15.6
H. arpadi	7	1.9
H. tarandina	2	0.5
H. nitidifrons confiformis	167	46.0
H. lapponica	3	0.8
H. lundbecki	5	1.4
H. borealis	1	0.3
H. muehlfeldi	2	0.5
H. distinguenda	1	0.3
H. montana	16	4.6
Atylotus fulvus	4	1.1
Heptatoma pellucens	1	0.3
Haematopota pluvialis	14	3.8

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Diptera collected with Malaise traps in the Kostomuksha Nature Reserve

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Abstract

127 Dipteran species of the families Limoniidae, Tipulidae, Bolitophilidae, Keroplatidae, Diadocidiidae, Mycetophilidae, Hybotidae, Dolichopodidae, Piophilidae, Clusiidae, Acartophthalmidae, Dryomyzidae, Heleomyzidae, Scatophagidae, Muscidae were collected with Malaise traps in the Kostomuksha Nature Reserve, Russian Karelia. 38 species are reported from this region for the first time.

Key words: Diptera, fauna, Russian Karelia

Introduction

The fauna of Diptera in Kostomuksha Nature Reserve has not been studied earlier, with exception of particular groups of blood-sucking and benthic flies (see Bykova & Marshalova; Ryabinkin, this publication). Thus the present study, is the first contribution to the Knowledge of the Dipteran fauna in the area. The study started in 1993 and lasted for tree years.

Sampling sites

The trapping was conducted in six points in of the reserve (Fig. 1). Localities 1,2 were situated near the Lake Kiitehenjärvi shore, about 30 km west-southwest of Kostomuksha (64°31'N 30°14'E), sites 3-6 stretched along River Kivijoki, 12 km south of Kostomuksha (64°28'N 30°35'E). All sampling sites were located in the hummocked region between 190-250 meters above sea level. There has not been any cuttings since the Second World War, but two forest fires have affected this territory since 19th century.

The sites 1 and 2 were in a pine stand (about 110 years old) of *Vaccinium myrtillus* site type dominated by spruce and birch. *Sorbus aucuparia* and *Juniperus communis* were common in the undergrowth, *Vaccinium myrtillus, V. vitis-idaea* and mosses (*Hylocomium, Pleurozium*) dominated in the ground-layer. The localities 3-5 were placed in older and practically pure pine stands (150 - 200 years old) of *Vaccinium vitis-idaea* site type. The site 6 was in 100-120 years old spruce-pine stand of *Vaccinium myrtillus* site type with birch and aspen. The ground layer consisted mainly of *Vaccinium myrtillus* and *Pleurozium schreberi* with scattered patches of *Sphagnum* and ferns.

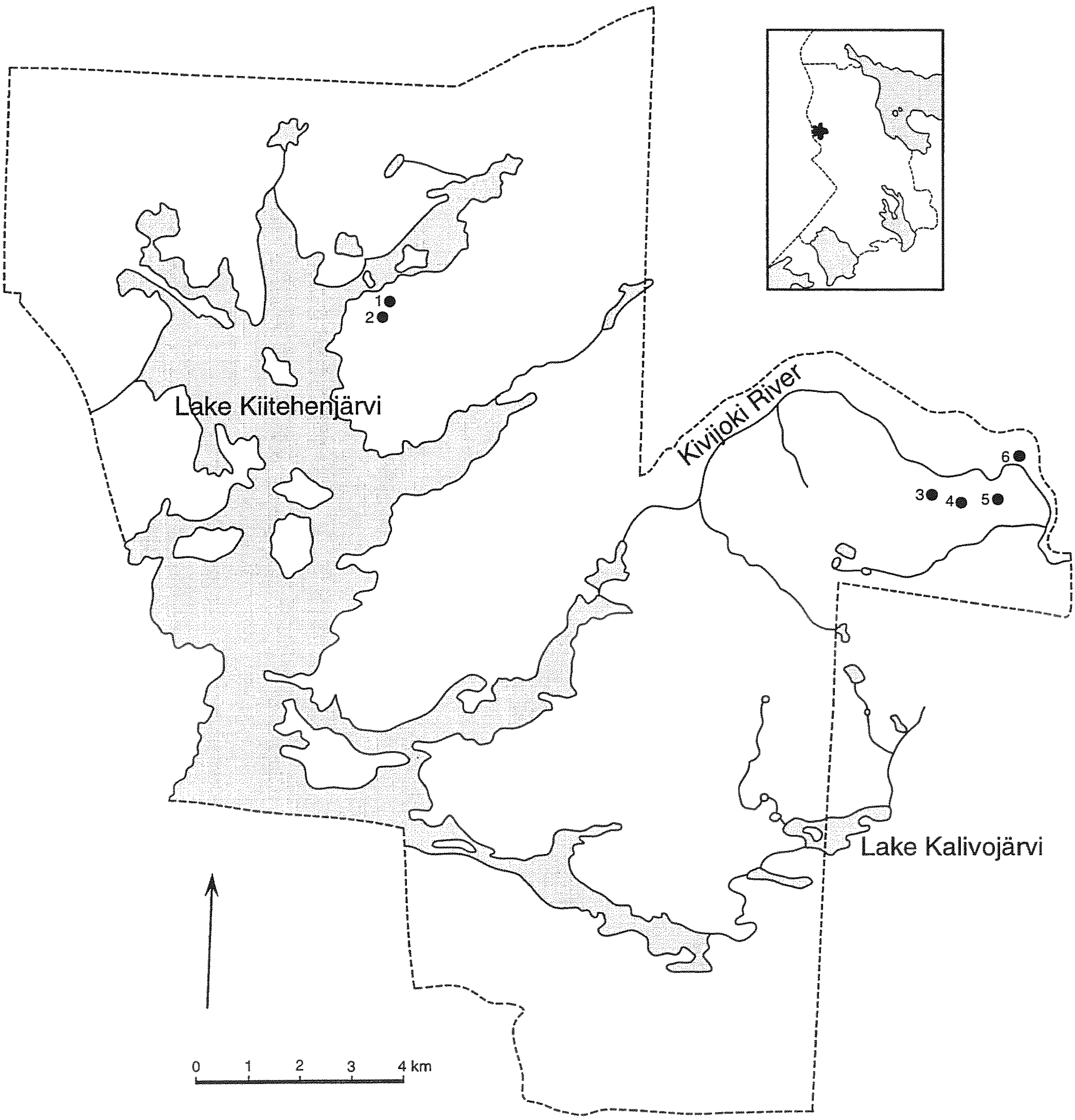

Fig. 1. Collecting localities in Kostomuksha Nature Reserve. The map of Karelia in upper right corner shows the location of the reserve near Karelian-Finnish border.

Material and methods

Material was collected in July-August in 1993-1995 during several visits to Kostomuksha Nature Reserve. We used mainly Malaise traps for collecting, since they have given good results for Diptera and Hymenoptera in Sweden (Löhr 1990), Norway (Søli 1994; Økland, 1994), Russian Karelia (Yakovlev & Polevoi 1991) and Finland (Polevoi 1995). Portable Malaise traps (Townes1972) were used permanently during the visits and checked after two to three days. Selective net samples were taken as well.

Only Diptera were taken for further processing. The flies of families Limoniidae, Tipulidae, Bolitophilidae, Keroplatidae, Diadocidiidae, Mycetophilidae, Hybotidae, Dolichopodidae, Piophilidae, Clusiidae, Acartophthalmidae, Dryomyzidae, Heleomyzidae, Scatophagidae and Muscidae (partly) were identified to the species level. The other families represented in the catches (Ceratopogonidae, Simuliidae, Chironomidae, Anisopodidae, Sciaridae, Cecidomyiidae, Phoridae, Stratiomyidae, Syrphidae, Psilidae, Lauxaniidae, Anthomyiidae, Sphaeroceridae) were left untreated and are not included in the list. The higher classification follows Krivosheina & Zaitzev (1989). Nomenclature on the genus and species level is based mainly on the Check list of Finnish Diptera (Hackman 1980a 1980b). Modern approaches for Sciaroidea (Väisänen 1984 Zaitzev 1994) are also considered. The specimens are deposited in the Forest Research Institute (Petrozavodsk).

Results

Among 1430 Dipteran specimens collected, 127 species were identified. They are given in the following list. Species preceded by asterisk (*) are reported from Russian Karelia for the first time. The species list given here is the first contribution to the knowledge of the fauna of forest flies in the region.

SPECIES LIST

TIPULOIDEA
Limoniidae

Pediciinae
Ula sylvatica(Mg.) — 1 male: August

Tipulidae

Tipulinae
**Tipula excisa* Schummel — 1 male: July
**T. limbata* Zett. — 1 male: August
**T. melanoceros* Schummel — 1 male: August
**N. tenuipes* (Riedel) — 1 male: August

SCIAROIDEA

Bolitophilidae
Bolitophila cinerea Mg. — 1 male: July
B. modesta Lackshevitz — 1 male: August
B. rossica Landrock — 2 males: August

Keroplatidae
Macrocerinae
**Macrocera parva* Lundström — 1 male: July

Diadocidiidae
Diadocidia ferruginosa (Mg.)— 1 male: August

Mycetophilidae
Mycomyinae
Mycomya affinis Staeger — 1 male: August
M. annulata (Mg.) — 915 males: August
**M. circumdata* (Staeger)— 13 males: August
**M. confusa* Väisänen — 19 males: August
**M. festivalis* Väisänen — 1 male: July-August
**M. heydeni* (Plassmann) — 1 male: August
**M. humida* Garrett — 13 males: August
M. nigricornis (Zett.)— 20 males: August
**M. pseudoapicalis* Landrock — 2 males: July
M. ruficollis (Zett.) — 2 males: July
M. shermani Garrett — 77 males: August
**M. subarctica* Väisänen— 1 male: August
M. trivittata (Zett.) — 4 males: July-August
**M. vittiventris* (Zett.) — 1 male: August

Sciophilinae
**Acnemia falcata* A. Zaitzev — 1 male: August
A. longipes Winn.— 3 males: August
Monoclona braueri (Strobl) — 1 male: July-August
M. rufilatera (Walk.) — 1 male: August
Neuratelia nemoralis (Mg.) — 3 males: July
Phthinia humilis Winn. — 1 male: August
Polylepta borealis Lundström — 6 males: July
**Sciophila exserta* A. Zaitzev — 1 male: July
S. fenestella Curtis — 1 male: August
S. hirta Mg — 2 males: August

Gnoristinae
Acomoptera difficilis (Dz.) — 1 male: July
**Boletina dissipata* Plassmann — 51 males: July-August
B. gripha Dz. — 312 males: July-August
B. moravica Landr. — 1 male: August
B. nigricans Dz. — 130 males: July-August
B. onegensis Polevoi — 63 males: August
**B. pectinungris* Edwards — 1 male: August
**B. rejecta* Edwards — 3 males: August
B. trivittata (Mg.) — 5 males: August
B. villosa Landrock — 5 males: August
Coelosia tenella (Zett.) — 3 males: July-August
C. truncata Lundström — 9 males: July
Dziedzickia marginata (Dz.) — 3 males: August
Palaeodocosia janickii (Dz.) — 1 male: August

Leiinae
Ectrepesthoneura hirta (Winn.) — 9 males: July

E. referta Plassmann — 2 males: July
Leia subfasciata (Mg.) — 3 males: July
**L. winthemi* Lehmann — 3 males: July
Rondaniella dimidiata (Mg.) — 3 males, 1 female: July-August

Mycetophilinae
Mycetophila abiecta (Lastovka)— 3 males: July-August
M. bohemica Lastovka — 1 males: July
M. brevitarsata Lastovka — 2 males: July-August
M. confluens Dz.— 6 males: August
M. dentata Lundström — 1 male: August
M. fungorum De Geer — 28 males, 36 females: July-August
M. hetschkoi Landrock — 1 male: July-August
M. ichneumonea Say — 2 males: August
M. luctuosa Mg. — 2 males: August
M. ocellus Walk. — 1 male: August
M. strigatoides (Landrock) — 3 males: July-August
M. strobli Lastovka — 1 male: August
**Phronia biarquata* Becker — 2 males: August
**P. braueri* Dz. — 2 males: August
P. caliginosa Dz. — 6 males: August
P. cinerascens Winn. — 22 males: July-August
**P. crassitarsus* Hackman — 2 males: August
**P. disgrega*. Dz. — 2 males: August
**P. distincta* Hackman — 2 males: August
P. egregia Dz. — 1 male: August
**P. elegantula* Hackman — 6 males: August
P. flavicollis Winn. — 2 males: July-August
P. forcipata Winn. — 7 males: July-August
**P. gagnei* Chandler — 2 males: August
**P. nigricornis* (Zett.) — 3 males: August
P. nigripalpis Lundström — 119 males: August
**P. obtusa* Winn. — 1 male: July
**P. petulans* Dz. — 1 male: August
**P. portschinskyi* Dz. — 1 male: August
Sceptonia fumipes Edwards — 5 males: July-August
**S. fuscipalpis* Edwards — 1 male: August
**Trichonta delicata* Gagne — 1 male: July
**T. fissicauda* Zett. — 1 male: July
**T. melanura* (Staeger) — 1 male: August
T. venosa (Staeger) — 1 male: July
Z. semifusca (Mg.) — 1 female: August
Allodia pyxidiiformis A. Zaitzev — 2 males: August
**Anatella bremia* Chandler — 1 male: August
Brachypeza bisignata Winn. — 1 male: August
Cordyla brevicornis (Staeger) — 3 males: August
C. fusca Mg. — 2 males: August
**C. insons* Lastovka&Matile — 2 males: July
C. nitidula Edwards — 3 males: August
C. parvipalpis Edwards — 17 males: July-August
C. semiflava (Staeger) — 1 male: August
Exechia lundstroemi Landrock — 1 male: August
E. parva Lundström — 1 male: August

EMPIDOIDEA

Hybotidae

Tachydromiinae

Tachypeza nubila (Mg.) — 1 male: August
T. truncorum (Fall.) — 1 male: August
Platypalpus boreoalpinus Frey — 1 male: July
P. cursitans F. — 9 males, 15 females: July
P. nigritarsis Fall. — 2 males: August
P. stigmatellus Zett. — 2 males, 4 females: July-August

Ocydromiinae

Trichina bilobata Collin — 2 male, 1 female: July-August
Bicellaria nigra (Mg.) — 9 males: July
B. pilosa Lundbeck — 13 males: July-August

Hybotinae

Hybos grossipes (L.) — 2 males: August

Dolichopodidae

Dolichopus nigricornis Mg. — 1 male: July

PALLOPTEROIDEA

Piophilidae

Mycetaulus bipunctatus Fall. — 1 female: August
Amphipogon flavum (Zett). — 1 male: August

OPOMYZOIDEA

Clusiidae

Clusiodes geomyzinus (Fall.) — 1 male: July

Acartophthalmidae

Acartophthalmus nigrinus (Zett.) — 2 males, 1 female: July

SCIOMYZOIDEA

Dryomyzidae

Dryomyza flaveola (F.) — 1 male: July

HELEOMYZOIDEA

Heleomyzidae

Suillia bicolor (Zett.) — 48 males, 45 females: July
S. flavifrons (Zett.) — 1 female: August
S. fuscicornis (Zett.) — 4 males: July-August
S. mikii (Pokorny) — 6 males: July
S. nemorum (Mg.) — 1 female: July
Allophyla atricornis (Mg.) — 13 males, 17 females: July

MUSCOIDEA

Scatophagidae
Scatophaga furcata (Say) — 6 males: July
**S. incola* Becker — 1 male: July
S. suilla (F.) — 14 males: July-August

Muscidae
Alloeostylus diaphanus (Wied.) — 2 females: July-August
Hydrotaea pandellei Stein — 1 male: July

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Ecological characteristics of lake fish parasite fauna formation in the River Kivijoki system

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Abstract

The peculiarities of fish parasite fauna in the lakes Luvajärvi, Kiitehenjärvi and Lake Nuokkijärvi are analysed. Parasites fauna composition is defined mainly by species diversity of final and intermediate hosts. In North Karelia the parasites with strait development cycle are most widespread. Most dominant parasite species with complex development cycle are the ones that have species of zooplancton and benthos as intermediate hosts.

Key words: lake fish parasites, intermediate hosts, development cycle, River Kivijoki system

Introduction

The main goal in modern biology is to develop methods for and approaches to ecological monitoring. It is theoretically and practically important to resolve this problem. In recent year, the eutrophication of water bodies has been markedly accelerated by human activities. Changes in ecosystem are observed, some leading species give way to others, and new trophic chains are formed. Parasitological data reflect clearly and accurately the qualitative and quantitative deterioration of the ecosystem. The results of parasitological investigations provide a comprehensive understanding of the state of a water body and its population by combining such environmental parameters as hydrochemistry (pH, mineralisation), hydrobiology (plankton, benthos), ichtyofauna and aquatic (fish-eating) vertebrates. Therefore, the study of natural biocoenoses unaffected by human economic activities and collection of parasitological data are important in ecological forecasting. The short- and long-term perspectives of system can be outlined by correlating these data with the results obtained by analysing eutrophic water bodies or destroyed ecosystems. The objective of the present paper is to analyse some characteristics of fish parasite fauna formation and to assess the parasitological situation in lakes Luvajärvi, Kiitehenjärvi and Lake Nuokkijärvi.

Materials and methods

Fish from 3 lakes belonging to River Kivijoki system (Luvajärvi, Kiitehenjärvi, Lake Nuokkijärvi) were studied during May - October in 1970s. Fish were taken from sampling sites by gill-net. Altogether 1120 fish specimens from Luvajärvi, Kiitehenjärvi and Lake Nuokkijärvi were studied (Table 1). Collection, fixation and cameral processing of the material were carried out according to Bykhovskaya-Pavlovskaya (1985), modified to include blood samples.

Table 1. Number of fish studied.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977	Total
Salmo salar m. sebago	6	4	2	9	21
Coregonus albula	35	25	11	67	138
Coregonus lavaretus	25	29	6	67	127
Thymallus thymallus	-	-	5	1	6
Esox lucius	25	25	25	31	106
Rutilus rutilus	25	39	25	75	164
Leuciscus leuciscus	25	15	15	15	70
Leuciscus idus	25	15	15	15	70
Phoxinus phoxinus	-	-	11	-	11
Alburnus alburnus	25	15	15	15	70
Abramis brama	7	25	14	26	72
Lota lota	7	8	5	18	38
Perca fluviatilis	25	45	25	66	161
Gymnocephalus cernua	25	20	2	19	66

Results

Salmon (*Salmo salar m. sebago G.*)

Its parasite fauna consists of only 16 species (Table 2). *Capriniana piscium* is the most common protozoon. Small relict crustaceans play an important role in the feeding of Lake Nuokkijärvi salmon and whitefish (*Coregonus lavaretus L.*). They are responsible for the infestation with nematode from the swim bladder of *Cystidicola farionis* (300 individuals per fish are occasionally reported). The main salmon stock is confined to Lake Nuokkijärvi, and there are no independent populations in lakes Luvajärvi and Kiitehenjärvi. Besides, the feeding spectrum of salmon is relatively narrow. All these factors are responsible for the same type of infestation and poor salmon parasite fauna in the above lakes.

Table 2. Salmon parasite fauna. (The first value indicates infection prevalence and the second value indicates the abundance).

SPECIES	Degree of infection
Myxidium sp.	5.5/+
Zschokkella nova	5.5/+
Chloromyxum coregoni	5.5/+
Capriniana piscium	11.2/+
Discocotyle sagittata	71.5/7.7
Triaenophorus nodulosus	5.5/0.05
Eubothrium crassum	100/136
Diphyllobothrium dendriticum	49.5/1.3
Proteocephalus exiguus	16.5/0.23
Crepidostomum farionis	33.0/1.0
Raphidascaris acus	27.5/0.6
Cystidicola farionis	66.0/22.6
Desmidocercella sp.	11.0/2.7
Camallanus lacustris	33.0/0.5
Philonema sibirica	16.5/0.2
Capillaria coregoni	16.5/0.2

Cisco (*Coregonus albula L.*)

Its parasite fauna consists of 19 species (Table 3). The diversity of parasites with a complex development cycle is due to the plankton type of feeding. The cestodes *Proteocephalus exiguus, Triaenophorus crassus* and *Diphyllobothrium ditremum* have been revealed. The cisco, which inhabits the studied lakes, is often infected with *Ichthiocotyllus erraticus, Diplostomum pusillum* and *Raphidascaris acus.* Cisco eating chironomids and gammaruses causes infestation with the nematode *R. acus* in the former case and *Cystidicola farionis* in the latter.

Table 3. Cisco parasite fauna.

SPECIES	Kiitehenjärvi	Kiitehenjärvi	Luvajärvi	Nuokkijärvi
Henneguya zschokkei	8.7	20	9.1	4.5
Tripartiella copiosa	4.0	-	-	-
Capriniana piscium	2.9	16	-	1.5
Discocotyle sagittata	14.5/0.2	28/0.7	27.3/0.5	48/1.4
Triaenophorus crassus	5.8/0.1	36/0.5	45.5/0.8	3.0/0.03
Diphyllobothrium ditremum	52.1/1.1	24/0.4	-	24.0/1.4
Proteocephalus exiguus	92.8/6.8	92/10.1	54.6/4.0	82.5/13.7
Phyllodistomum conostomum	5.8/0.09	16/0.16	-	16.5/0.4
Crepidostomum farionis	-	-	-	1.5/0.01
Ichthiocotyllurus erraticus	37.7/0.9	32/0.5	27.3/0.5	24.0/4.2
Tylodelphus clavata	-	-	-	3.0/0.03
Diplostomum pusillum	-	20/0.5	27.3/0.8	12.0/0.2
Raphidascaris acus	14.5/0.5	68/3.5	18.2/0.4	52.5/2.5
Cystidicola farionis	-	32/0.5	-	1.5/0.01
Desmidocercella sp	-	4/0.04	-	1.5/0.01
Camallanus lacustris	-	20/0.2	-	3.0/0.03
Philonema sibirica	-	-	-	25.5/1.03
Achtheres coregonorum	-	4/0.04	-	1.5/0.01
Ergasilus sieboldi	-	-	-	1.5/0.01

Whitefish (*Coregonus lavaretus L.*)

The River Kivijoki system lakes are inhabited by three ecological forms of whitefish: low-, poly-, and medium-rakered, the latter form being most abundant. Whitefish parasite fauna consists of 26 species (Table 4). Parasites with a complex development cycle related to the benthic organisms such as *Cystidicola farionis* and *R. acus* as well as some species of planktonic origin e.g. *Triaenophorus crassus* and *Proteocephalus exiguus*, are widespread. There are no differences in the whitefish parasite fauna from different lakes, but in Lake Nuokkijärvi whitefish, *C.truncatus* has been revealed.

Table 4. Whitefish parasite fauna.

SPECIES	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Nuokkijärvi 1977
Henneguya zschokkei	4	3.4	4.5
Tripartiella copiosa	-	3.4	-
Apiosoma piscicola	-	3.4	-
Capriniana piscium	12	6.9	1.5
Discocotyle sagittata	-	10.3/0.14	31.5/0.7
Triaenophorus crassus	16/0.5	24.1/2.6	9.0/0.3
Cyathocephalus truncatus	-	-	16.5/0.8
Diphyllobothrium dendriticum	-	-	1.5/0.01
Proteocephalus exiguus	92/7.6	93.1/28.8	93.0/44.0
Phyllodistomum conostomum	-	-	12.0/0.3
Allocreadium isoporum	8/0.08	-	-
Crepidostomum farionis	-	3.4/0.03	-
Ichthiocotyllurus erraticus	92/7.8	68.0/7.5	51.0/3.6
Tetracotyle intermedia	-	24.0/0.38	7.5/0.09
Tylodelphus clavata	52/2.5	37.9/2.97	16.5/0.2
Diplostomum spathaceum	-	-	3.0/0.1
Diplostomum	50/1.7	31.0/4.8	12.0/0.22
Raphidascaris acus	92/9.04	93.0/20.1	60.0/5.1
Phabdochona denudata	-	-	1.5/0.01
Cystidicola farionis	44/2.7	3.4/0.03	36.0/1.2
Desmidocercella sp	-	-	1.5/1.2
Camallanus lacustris	8/0.08	17.0/0.2	4.5/0.1
Philonema sibirica	-	-	4.5/0.1
Capillaria coregoni	4/0.08	68.0/0.8	10.5/0.2
Achtheres coregonorum	44/0.5	27.5/1.1	6.0/0.2
Ergasilus sieboldi	-	-	1.5/0.04

Grayling (*Thymallus thymallus L.*)

Young river grayling was mainly studied in River Kivijoki as well as in the Nageuks (connects lakes Kiitehenjärvi and Lake Nuokkijärvi) and Vonga rapids (connects Luvajärvi and Kiitehenjärvi). The species composition of parasites is relatively poor (5 species). The larvae of *R. acus* are most common.

Pike (*Esox lucius L.*)

In addition to salmon, pike is a major predator in the studied lakes. Active predator feeding is responsible for the species composition of pike parasites which comprises 26 species (Table 5). 11 species of them belong to protozoa. One monogenetic parasite species, 5 cestode species, 3 trematode species, 3 nematode species and 1 crustacean species have been found. *Myxidium lieberkuhni, Chloromyxum esocinum, Myxosoma anurus, Tetraonchus monenteron, Triaenophorus crassus* and *Triaenophorus nodulosus* are abundant. Infestation with other species does not exceed 10%. In spite of substantial differences in the limnological characteristics and typology of water bodies, pike parasite fauna is similar in them. Some differences in infestation intensity and those related to some seasonal feeding characteristics has been observed. It has been found by studying the infestation of pike that fish of the whitefish (cisco) and perch families play a leading role in pike's ration (occurrences of *T. nodulosus*, *T. crassus* and *R. acus*). In all lakes, pike has been found to contain the plerocercoids of *Diphyllobothrium latum*. The intensity and occurrence of this parasite are closely related to the proximity of villages. Maximum values are characteristic of Lake Kiitehenjärvi with the village of Kiitehenjärvi lying on the lake shore, whereas minimum values have been reported for lakes Luvajärvi and Nuokkijärvi with no settlement.

Table 5. Pike parasite fauna.

SPECIES	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Myxidium liberkuhni	88	84	76	69.3
Chloromyxum esocinum	14	65	24	33.0
Myxosoma anurus	12	32	32	59.4
Myxobolus mulleri	-	-	4.0	-
Henneguya lobosa	-	-	-	3.3
H. psorospermica	-	8.0	8.0	6.6
Trichodina nigra	-	-	8.0	16.5
Epistylis lwoffi	-	-	-	3.3
Apiosoma companulata	-	40	36	9.9
A. megamicronucleata	-	8.0	12	9.9
Capriniana piscium	-	-	-	6.6
Tetraonchus monenteron	64/4.96	84/43.9	92/26.5	75.9/32.2
Triaenophorus nodulosus	48/1.96	72/5.2	64/3.0	85.8/12.5
T. crassus	36/4.9	56/5.3	82/16.0	75.9/3.7
Cyathocephalus truncatus	-	-	-	3.3/0.03
Diphyllobothrium latum	64/1.6	40/0.84	4/0.04	13.2/0.16
Proteocephalus sp	-	-	-	3.3/0.1
Sanguinicola sp.	-	-	-	3.3/0.03
Azygia lucii	56/3.01	52/2.2	32/0.6	26.4/0.5
Bunodera luciopecae	-	-	-	3.3/0.1
Raphidascaris acus	16/0.76	64/4.8	75/3.16	82.5/8.5
Haplonema hamulatum	-	8/0.08	-	-
Desmidocercalla numidica	-	4/0.24	-	-
Camallanus lacustris	24/0.88	44/3.3	20/0.36	36.3/1.1
Philometra obturans	8/0.04	20/0.4	48/0.96	26.4/0.5
Argulus foliaceus	-	-	8/0.08	-

Roach (*Rutilus rutilus L.*)

In the lakes studied, the species composition (42 species) and the number of parasites found was remarkably diverse. 14 protozoon species, 10 monogenean parasite species, 4 cestode, 8 trematode, 1 acanthocephalan, 4 nematode and 1 parasitic crustacean species have been revealed (Table 6). Protozoa are represented by *Myxidium rhodei, Zschokkella nova* and *Chloromyxum fluviatile*. The infestation with *Myxidium rhodei* was common.

Monogenean parasites form another large and diverse group of roach parasites. *Dactylogyrus crucifer, D. nanus* and *Paradiplozoon homoin* were the most common, whereas others are scarce. Most roach parasite species are represented by direct life cycle such as Protozoa, Myxosporidia and Crustacea. The low infestation with the cestodes *Proteocephalus torulosus* and *Ligula intestinalis* (maximum value for the former in Luvajärvi is 16 (1-8) 0.24) suggests that roach is an optional plankton-eater under the conditions existing in the River Kivijoki system. Besides, this may be due to some age characteristics of feeding because the average age of the fish studied was 5 years. Infestation with groups that have a complex life cycle such as trematodes and nematodes indicates the bentic feeding pattern of the host. Metacercarians of the genera *Diplostomum* and *Tylodelphys* as well as larvae of the nematode *Raphidascaris acus* are abundant.

Table 6. Roach parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Myxidium pfeifferi	1.3			
M. rhodei	92	100	88	82.4
Zschokkella nova	20	19.8	36	28.3
Chloromyxum fluviatile	23.1	4	33.7	
Ch. legeri	4			
Myxobolus pseudodispar	20	39.6	80	22.1
M. dispar	52	2.6		
M. ellipsoides	3.3			
M. mulleri	32	52	35.1	
M. bramae	6.6	3.9		
M. diversicapsularis	-	3.9		
Apiosoma piscicola	6.6	-	1.3	
Dactylogyrus similis	8/0.41	33.3/2.2	10.8/0.24	
D. fallax	8/0.24	29.7/3.9	14.9/0.49	
D. nanus	12/0.24	36.3/1.8	28/0.56	35.1/1.12
D. minor	12/0.36	6.6/0.17	12/0.36	
D. wunderi	3.3/0.17			
D. zandti	9.9/0.3	4/0.28		
D. crucifer	68/4.68	42.9/8.5	80/19.2	81.1/14.6
D. tuba	4/0.08			
D. suecicus	2.7/0.04			
D. microcantus	2.7/0.05			
D. distinguendus	13.5/0.25			
D. erchardova	5.2/0.24			
D. caballeroi	8/0.24	3.3/0.03	9.4/0.45	
Gyrodactylus sp.	4.1/0.15			
Paradiplozoon homoion	20/0.2	16.5/0.2	28/0.56	24.3/2.8
Caryophyllaeus laticeps	-	10.8/2.1		
Caryophyllaeides fennica	4/0.04	6.6/0.1	8/0.16	25.6/1.7
Ligula intestinalis	4/0.16	3.3/0.03		
Proteocephalus torulosus	6.6/1.97	16/0.24	9.4/4.5	
Rhipidocotyle illense	4/0.2	1.3/0.02		
Phyllodistomum elongatum	3.3/0.03	4/0.03		
Allocreadium isoporum	8/0.24	19.8/1.2	32.4/3.5	
Diplostomum indistinctum	29.7/0.83	20/0.24 -		
D. spathaceum	13.2			
D. pusillum	9.9/0.17	20/0.52	-	
Ichthyocotylurus erraticus	3.3/0.13	1.3/0.04		
Raphidascaris acus	12/1.6	23.1/0.7	32/0.52	20.2/0.6
Capillaria brevispicula	3.3/0.03	4/0.04	2.7/0.02	
Neoechinorhynchus rutili	4/0.08	4/0.04	6.7/0.1	
Ergasilus sieboldi	20/2.68	16.5/1.3	36/1.24	35.1/2.5

Dace (*Leuciscus leuciscus L.*)

Its parasite fauna consists of 21 species (Table 7), half of which are direct-cycle parasites such as Protozoa and monogenetic parasites. Complex-cycle parasites such as nematodes and cestodes (2 species) as well as trematodes (6 species) and Acanthocephala (1 species) were found. *Proteocephalus torulosus, Caryophyllaeides fennica,* and *Allocreadium isoporum* are considered to be abundant. Infestation of fish with the above helminths varies from 10% to 77% depending on the lake.

Table 7. Dace parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Myxidium rhodei	68	46	-	30.8
Chloromyxum legeri	-	6.7	13.7	38.5
Myxobolus musculi	-	13.2	-	30.8
M. mulleri	20	33	-	7.7
M. improvisus	-	6.7	-	30.8
Apiosoma piscicola	-	19.8	-	-
Dactylogyrus cordus	-	13.4/0.4	-	15.4/0.4
D. wunderi	-	6.7/0.07	-	-
Paradiplozoon sp.	12/0.7	-	-	7.7/0.1
Caryophyllaeides fennica	8/0.36	40.2/2.4	6.7/0.1	-
Proteocephalus torulosus	20/0.4	6.7/1.1	53.6/2.7	5.9/3.0
Rhipidocotyle illense	16/4.2	26.8/0.5	33.5/5.7	23.1/2.0
Phyllodistomum sp.	-	6.7/0.3	-	-
Allocreadium isoporum	12/0.12	6.7/0.2	6.7/0.3	38.5/2.0
Ichthyocotylurus erraticus	36/6.2	20.1/0.7	53.6/11.9	7.7/0.1
Tylodelphys clavata	-	6.7/0.07	6.7/0.07	-
Diplostomum indistinctum	16/0.32	40.2/0.7	-	7.7/0.1
Raphidascaris acus	20/1.8	33.5/4.4	53.6/3.1	77/14.1
Desmidocercella sp.	-	-	-	7.7/0.1
Neoechinorhynchus rutili	4/0.04	-	-	-
Ergasilus sieboldi	20/1.4	60.3/6.0	20.1/0.6	30.8/1.0

Ide (*Leuciscus idus L.*)

Ide is a polyphage of carp family with a broad feeding spectrum. Its parasite fauna consists of 31 species (Table 8). Myxosporidia, represented by forms with rapidly and slowly settling spores, provide heavy infestation. Monogenean parasites, mostly specific species, were also responsible for considerable infestation. *Dactylogyrus tuba* and *D. robustus* were most common. It has been shown by analysing other systematic groups that nematodes and trematodes, notably *Raphidascaris acus* and *Allocreadium isoporum,* play the leading role in ide parasite fauna. Cestodes are represented by the tapeworm *Caryophyllaeides fennica* and *Proteocephalus torulosus,* but the occurrence of the latter was more than 45% in all lakes. Ide is slightly infected with trematode larvae the genera *Cotylurus, Tylodelphys* and *Diplostomum.* Ide has come to the north retaining some southern parasites seldom found in Karelia such as the small crustacean *Tracheliastes policolpus,* the nematode *Philometra ovata,* the monogenean parasites of the genus *Dactylogyrus* as well as *Paradiplozoon megan* (Table 8).

Table 8. Ide parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Myxidium rhodei	64	33	20	14.2
Zschokkella nova	48	26.4	39.6	35.5
Chloromyxum fluviatile	-	13.2	19.8	14.2
Myxosoma dujardini	-	-	-	21.3
Myxobolus nemeczeki	-	-	-	7.1
M. macrocapsularis	-	13.2	-	-
M. mulleri	36	13.2	6.7	14.2
M. bramae	-	59.4	26.4	-
Apiosoma piscicola	-	6.6	-	-
Dactylogyrus fallax	12/0.16	6.7/0.13	-	-
D. wunderi	-	6.7/0.47	-	-
D. robustus	4/0.04	6.7/0.07	20/0.4	28.4/1.2
D. tuba	20/1.12	26.8/0.9	40.2/1.0	42.6/3.3
Gyrodactylus sp.	-	6.7/0.07	-	-
Paradiplozoon megan	12/0.32	20.1/2.5	13.4/0.3	7.1/0.5
Caryophyllaeides fennica	40/4.12	13.4/0.13	6.7/0.2	-
Proteocephalus torulosus	72/4.1	60.3/3.7	46.9/5.1	92.3/5.3
Rhipidocotyle illense	-	-	6.7/0.07	7.1/0.07
Phyllodistomum sp.	4/0.24	-	20.1/0.47	14.2/0.9
Allocreadium isoporum	32/6.96	33.0/2.9	33.5/0.9	42.6/2.0
Diplostomum indistinctum	-	40.2/0.8	-	7.1/5.2
Ichthyocotylurus erraticus	-	6.7/0.13	6.7/0.8	-
Raphidascaris acus	32/0.72	53.6/14.0	46.9/2.0	85.2/41.8
Desmidocercella sp.	-	-	-	31.3/0.3
Camallanus lacustris	-	6.7/0.13	-	7.1/0.07
Philometra ovata	-	-	-	7.1/0.07
Capillaria tomentosa	4/0.04	-	6.7/0.07	28.4/1.9
Neoechinorhynchus rutili	12/0.16	26.8/10.6	40.2/3.3	28.4/6.5
Ergasilus sieboldi	8/0.2	20.1/0.2	33.5/0.6	21.7/0.4
Tracheliastes polycolpus	-	33.5/0.7	13.4/0.13	7.1/0.11

Minnow (*Phoxinus phoxinus L.*)

11 individuals caught in the Luva Rapids on the River Kivijoki were examined. Minnow parasite fauna is scanty. The infusoria *Trichodina nigra* and *Apiosoma conica* as well as the monogenean parasite *Gyrodactylus macronichus* were encountered. *Raphidascaris acus* should be mentioned as a complex life cycle parasite.

Bleak (*Alburnus alburnus L.*)

Bleak has closely approached the boundary of its distribution area in the lakes of north-western Karelia. However, the species is fairly abundant, especially in lakes Kiitehenjärvi and Luvajärvi, where it competes both ecologically and trophically with cisco. In the lakes studied, bleak contained 25 parasite species (Table 9). Protozoa such as *Sporozoa, Myxosporidia* and *Trichodina* are represented by 8 species. Seven monogenean species and only one cestode species, *Proteocephalus torulosus,* have been found. Five trematode species, mainly metacercaria, were responsible for heavy infestation. Bleak is not strongly infected with nematodes (3 species), except *Raphidascaris acus, Zschokkella nova, Paradiplozoon alburni* and *Proteocephalus torulosus* are ubiquitous. It can be seen from the Table 9, however, that the bleak parasite fauna of Lake Kiitehenjärvi is very similar to that of Lake Luvajärvi. In Lake Nuokkijärvi, the number of species is much smaller and infection with some helminths is less appreciable. Data on other parasites that migrated northwards such as *Eimeria sp.* (found on gall bladder walls), *Philometra rischta*, and *Sangunicola sp.* are still scanty. It is noteworthy that until recently the latter helminth has been reported only from the Volga basin.

Table 9. Bleak parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Eimeria sp.	-	-	13.4	-
Myxidium rhodei	8.0	-	-	-
Zschokkella nova	16.0	13.4	26.5	46.0
Chloromyxum fluviatile	-	6.7	26.4	33.5
Myxobolus dispar	-	-	-	6.7
M. mulleri	-	13.4	6.7	-
Thelochanellus oculi-leucisci	-	6.3	13.4	26.8
Trichodinella sp.	-	-	6.7	-
Dactylogyrus alatus	12.0/0.84	-	46.9/3.0	-
D. parvus	-	-	-	6.7/0.13
D. fraternus	-	-	26.8/1.7	6.7/0.2
D. minor	-	13.4/0.53	53.6/3.4	6.7/0.07
D. ramulosus	-	-	-	6.7/0.07
D. suecicus	-	-	-	6.7/0.07
Paradiplozoon alburni	4.0/0.04	26.8/0.6	6.7/0.5	26.8/0.4
Proteocephalus torulosus	44.0/0.9	67.0/0.4	40.2/1.9	26.8/0.7
Rhipidocotyle illense	20.0/1.0	40.0/1.6	46.9/2.7	80.0/17.2
Sanguinicola sp.	-	-	-	6.7/0.07
Phyllodistomum sp.	4/0.2	-	-	6.7/0.13
Allocreadium isoporum	40.0/1.1	40.2/0.5	26.8/2.3	33.5/0.4
Diplostomum indistinctum	4.0/0.04	33.5/0.4	-	-
Raphidascaris acus	4.0/0.04	26.8/0.5	40.2/0.87	-
Camallanus lacustris	-	6.7/0.07	-	-
Philometra rischta	4.0/0.08	-	-	-
Ergasilus sieboldi	-	-	6.7/0.07	13.4/0.13

Bream (*Abramis brama L.*)

In lakes Nuokkijärvi and Kiitehenjärvi, the bream parasite fauna consists of 29 species (Table 10). The infection pattern of this typical benthos-eater is generally dependent on ecology and feeding type, as indicated by heavy infection with the helminths *Allocreadium isoporum* and *Raphidascaris acus* as well as two tapeworm species. The myxosporidian *Myxobolus mulleri* (56%) and monogenean parasites of the genus *Dactylogyrus* are widespread, *D. wunderi, D. zandti* and *D. falcatus* (16.9-84.0 %) being most common. The direct-cycle parasite fauna of Lake Nuokkijärvi (Protozoa and monogenean parasites) is more diverse than that of Lake Kiitehenjärvi. The ectoparasite *Gyrodactylus sp.*, seldom found in Lake Kiitehenjärvi, is responsible for heavy infection in Lake Nuokkijärvi. *Trypanosoma sp.* has only been revealed in 3 fish in both lakes (Table 10).

Table 10. Bream parasite fauna.

Species	Kiitehenjärvi 1975	Nuokkijärvi 1977
Trypanosoma sp.	4.0	8.0
Myxidium rhodei	4.0	4.0
Zschokkella nova	-	20.0
Chloromyxum fluviatile	-	12.0
Myxobolus mulleri	16.0	56.0
M. brama	28.0	-
Dactylogyrus fallax	-	4.0/0.04
D. falcatus	16.0/0.28	72.0/17.5
D. wunderi	72.0/7.2	84.0/28.4
D. zandti	32.0/1.6	40.0/9.2
D. crucifer	8.0/0.2	4.0/0.04
Gyrodactylus sp.	4.0/0.76	44.0/11.7
Caryophyllaeus laticeps	-	32.0/1.6
Caryophyllaeides fennica	-	12.0/0.24
Proteocephalus sp.	4.0/0.04	8.0/0.08
Rhipidocotyle illense	8.0/0.3	-
Allocreadium isoporum	92.0/73.6	72.0/41.2
Diplostomum spathaceum	12.0/0.2	-
D. paraspathaceum	20.0/0.44	-
Tylodelphys clavata	-	4.0/0.08
Ichthyocotylurus erraticus	36.0/0.88	-
Neascus brevicaudatus	-	4.0/0.04
Raphidascaris acus	32.0/0.5	48.0/1.96
Desmidocercella sp.	-	8.0/0.16
Camallanus lacustris	-	4.0/0.12
Philometra ovata	-	16.0/0.4
Neoechinorhynchus rutili	12.0/0.12	-
Tracheliastes maculatus	12.0/0.32	4.0/0.04
Piscicola geometra	-	4.0/0.08

Burbot (*Lota lota L.*)

Burbot is the only representative of the cod family from the lakes studied. Its parasite fauna consists of 26 species, including 7 Protozoa, 5 cestode, 6 trematode, and 2 Herudinea species (Table 11). The parasites of different systematic groups differ in occurrence. Heavy infection with the myxosporidian *Myxobolus lotae*, the cestode *Triaenophorus nodulosus* and *Eubothrium rugosum* as well as metacercaria of the trematode *Tylodelphys clavata* was observed. The occurrence of the above parasite species is more than 50% and that of the rest, except Protozoa and the leech *Cystobranchus mammilatus*, is less than 20%. The burbot parasite fauna of Lake Kiitehenjärvi is very similar to that of Lake Nuokkijärvi. Differences in the degree of infection have mainly been observed for nonspecific helminths.

Table 11. Burbot parasite fauna.

Species	Kiitehenjärvi 1974	Nuokkijärvi 1977
Myxidium rhodei	-	5.5
Sphaerospora cristata	20.1	22.0
Chloromyxum mucronatum	16.7	15.5
Ch. dubium	33.5	27.5
Myxobolus lotae	26.8	82.5
Trichodinella lotae	33.5	33.0
Apiosoma megamicronucleata	46.9	55.0
Triaenophorus nodulosus	73.7/35.5	88.0/40.4
Eubothrium rugosum	53.6/3.0	71.5/2.4
Cyathocephalus truncatus	-	5.5/0.06
Diphyllobothrium latum	80.4/2.0	11.0/0.2
Proteocephalus sp.	13.4/0.2	5.5/0.06
Azygia lucii	13.4/0.07	5.5/0.06
Bunodera luciopercae	6.7/0.07	-
Ichthyocotylurus erraticus	6.7/0.2	5.5/0.3
Tylodelphys clavata	93.8/45.7	60.5/2.5
Diplostomum paraspathaceum	-	16.5/0.8
D. pusillum	-	5.5/0.7
Raphidascaris acus	73.7/10.3	11.0/17.8
Ichthyobronema gnedini	67.0/11.5	16.5/2.5
Cottocomephoronema problematica	-	11.2/2.0
Desmidocercella sp.	46.9/3.9	5.5/0.17
Camallanus lacustris	87.1/11.6	16.5/0.61
Capillaria coregoni	20.1/0.73	-
Cystobranchus mammilatus	-	33.0/1.6
Piscicola geometra	-	5.5/0.06

Perch (*Perca fluviatilis L.*)

In the lakes studied, perch has 27 parasite species which belong to 7 systematic groups (Table 12). The most common species are *Trichodina urinaria, Triaenophorus nodulosus, Proteocephalus percae* and *Bunodera luciopercae.* Perch is heavily infected with cestodes, nematodes and some trematodes. These parasites show that it is a zooplankton - and zoobenthos - eater. As perch is confined to the littoral zone, it is infected with quite a number of ectoparasites of the genera *Trichodina* and *Apiosoma* as well as metacercaria, *Diplostomum pusillum, Ichthiocotylurus erraticus* and *Tylodelphys clavata.*

Table 12. Perch parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Luvajärvi 1975	Nuokkijärvi 1977
Zschokkella nova	-	-	4.0	-
Sphaerospora pectinacea	-	-	4.0	-
Henneguya creplini	13.2	4.0	8.0	7.5
Trichodina urinaria	26.8	24.0	4.0	27.0
T. percarum	19.8	4.0	12.0	9.0
Apiosoma companulata	6.7	36.0	16.0	28.5
A. piscicola	-	-	8.0	-
Capriniana piscium	-	-	-	10.5
Dactylogyrus amphibothrium	-	-	-	1.5/0.03
Ancyrocephalus percae	-	4.0/0.04	-	3.0/0.05
Triaenophorus nodilosus	26.8/0.6	12.0/0.4	-	3.0/0.03
Cyathocephalus truncatus	-	4.0/0.04	-	10.5/0.3
Diphyllobothrium latum	13.4/0.2	4.0/0.04	-	3.0/0.03
Ligula intestinalis	6.7/0.04	-	-	-
Proteocephalus percae	33.5/1.2	56.0/2.7	16.0/0.7	13.5/0.3
Azygia lucii	-	8.0/0.1	12.0/0.2	6.0/0.1
Allocreadium isoporum	-	12.0/0.2	-	-
Bunodera luciopercae	72.6/13.2	88.0/12.9	12.3/3.2	40.5/2.2
Ichthyocotylurus erraticus	79.2/14.2	76.0/23.0	80.0/31.6	69.0/5.5
Tylodelphys clavata	100/12.2	92.0/4.8	84.0/6.4	49.5/1.7
Diplostomum pusillum	40.2/7.2	84.0/13.8	70.0/2.9	51.0/3.4
Neascus brevicaudatus	33.5/1.4	40.0/1.2	-	15.0/0.2
Raphidascaris acus	-	8.0/0.08	8.0/0.08	9.0/0.2
Desmidocercella sp.	20.0/0.3	48.0/2.2	12.0/0.12	34.5/1.6
Camallanus lacustris	87.1/10.7	76.0/21.2	88.0/11.2	69.0/6.7
Eustrongylides exisus	-	8.0/0.08	20.0/0.24	1.5/0.3
Achtheres percarum	6.7/0.4	24.0/0.7	48.0/3.3	42.0/2.6

Ruff (*Gymnocephalus cernua L.*)

Ruff is another representative of the perch family in the lakes of the River Kivijoki system. It is seldom encountered, especially in summer. The parasite fauna of ruff generally reflects its habit to live near the bottom. (Table 13). This is indicated by infestation with the nematode *Raphidascaris acus* and the metacercaria *Tylodelphys clavata* and *Diplostomum pusillum*. The representatives of the perch family, even those living in different lakes, are similar in parasite fauna, but differ in infestation intensity which depends on the feeding pattern of ruff.

Table 13. Ruff parasite fauna.

Species	Kiitehenjärvi 1974	Kiitehenjärvi 1975	Nuokkijärvi 1977
1. Henneguya psorospermica	-	10.0	-
2. Trichodinella epizootica	20.0	20.0	47.3
3. Apiosoma piscicola	-	45.0	-
4. Dactylogyrus amphibothrium	44.0/1.16	50.0/5.3	84.8/6.0
5. Triaenophorus nodulosus	24.0/0.45	35.0/1.15	100/4.63
6. Diphyllobothrium latum	-	-	10.0/0.15
7. Proteocephalus sp.	8.0/0.12	5.0/0.05	5.3/0.11
8. Phyllodistomum pseudofolium	4.0/0.04	10.0/0.1	5.3/0.05
9. Azygia lucii	-	35.0/0.55	5.3/0.05
10. Bunodera luciopercae	32.0/2.5	65.0/2.5	37.1/0.6
11. Allocreadium isoporum	32.0/0.76	-	-
12. Ichthyocotylurus erraticus	92.0/114.5	95.0/54.8	90.1/13.8
13. Tylodelphys clavata	75.0/2.5	100/21.1	68.9/3.0
14. Diplostomum indistinctum	-	-	10.6/0.11
15. D. pusillum	92.0/31.2	45.0/11.6	79.5/8.2
16. Neascus brevicaudatus	-	-	5.3/0.37
17. Raphidascaris acus	64.0/3.16	90.0/6.25	95.4/14.1
18. Comephoronema oschmarini	-	10.0/0.15	-
19. Desmidocercella sp.	-	5.0/0.05	-
20. Camallanus lacustris	56.0/5.24	65.0/2.25	-

Ecological characteristics of lake fish parasite fauna

The parasites that occur in fish of the carp family play the most important role under conditions existing in oligotrophic water bodies such as lakes Nuokkijärvi, Kiitehenjärvi and Luvajärvi. These conditioins are also favored by various fish of the salmon and whitefish families as well as their parasites. The bulk of 133 species found in fish from the River Kivijoki system are defined as Myxosporidia (30 species) and monogenetic parasites (32 species), major carp parasites. The heaviest infestation was caused by eurythermic species which represent the genera *Myxidium, Zschokkella* and *Dactylogyrus.* This group of parasites adapt itself to the new living conditions in its own way. Distributed specificity was observed in monogenetic parasites migrating northwards. Parasites are no longer strictly confined to their hosts for some ecological reasons. One major factor is the coincidence of living, growing and spawning sites for many fish of the carp family. Furthermore, in northern lakes thermal regime is responsible for the closeness of the spawning dates of some fish species such as roach, bream and ide. Here, both the spawning period as well as pre- and post-spawning clusters are meant. The above factors are responsible for close interspecific contacts that contribute to parasite exchange. Disturbance of specificity is adaptational because in connection with the small number of its obligate host a parasite uses a related, but more eurybiotic species as a reserve host for self preservation. Roach is a reserve host in the lakes studied. The parasites *Dactylogyrus zandti, D.wunderi, D.tuba* and *D.fallax* found in it support our assumptions and account for the wider occurrence of these helminths in lakes Kiitehenjärvi and Luvajärvi (smaller in area) than in Lake Nuokkijärvi.

Close contacts between some fish of the carp family such as bleak, dace and ide are crucial for maintaining the abundance of many Myxosporidia of the genera *Chloromyxum* and *Myxobolus*. Only 12 complex cycle parasite species are ubiquitous. Their fauna is poorer and infestation is less heavy than in South Karelian fish. This is due to changes in species composition and in the quantity of plankton and benthos (Sokolova et al. 1977). Benthos related species such as trematodes, nematodes and some cestodes are most common. Zooplankton is a less important type of food for the fish living in this lake system than for those inhabiting moderate latitude water bodies. The negligible infestation with trematodes of the genera *Diplostomum* and *Cotylurus* as well as tapeworms of the genera *Ligula* and *Diphyllobothrium* is also due to the small number of definitive hosts such as fish eating birds, in particular seagulls. Only one gull species, sea swallow, nests on the islands located in the lakes of the River Kivijoki system (Danilov et al. 1977). The above factors are responsible for poor parasite fauna and its similarity for the fish species inhabiting entirely different lakes such as Kiitehenjärvi, Luvajärvi and Lake Nuokkijärvi. Similar types of the parasite fauna are more often observed in fish which have a narrow feeding spectrum. Some characteristics depend on a type of feeding in one or another period of time. Burbot's ration is dominated by fish of the whitefish and perch families. However, their different involvement is responsible for differences in the degree of infestation with *Camallanus lacustris* in Lake Nuokkijärvi as well as *Raphidascaris acus*. Infestation of pike with helminths (*Triaenophorus nodulosus, T.crassus, R.acus* and *Azygia lucii*) is due to its predatory type of feeding. The difference in their infestation rates is also due to some ration characteristics in individual water bodies.

Parasitological data show (Table 5) that pike eats more fish of the perch family in Lake Kiitehenjärvi and more fish of the whitefish family (cisco and whitefish) in lakes Nuokkijärvi and Luvajärvi. Lake dependent changes in a type of feeding are observed not only in predators. Infestation of dace with the cestodes *Caryophyllaeides fennica* and *Proteocephalus torulosus* is strictly correlated. The development cycle of the former includes benthic organisms (oligochaetes) and that of the latter includes plankton (Copepoda). Either type of feeding was predominant in dace depending on lake (Table 7).

Generally speaking, the fish parasite fauna studied in the lakes of the River Kivijoki system has characteristics typical of northern water bodies. The fish examined are not heavily infested with parasites of the genera *Diplostomum, Tetracotyle* and *Ligula.* Complex-cycle parasites are dominated by the nematode *Raphidascaris acus* which occurs, sometimes in large numbers, almost in all fish species. This indicates that chironomids (intermediate hosts of a parasite) are most essential in the rations of not only benthos-eaters, but of other fish as well.

The parasites found are typical of northern lake biocoenoses. Parasites of Arctic freshwater lakes, confined to the intermediate relict hosts *Pontoporea affinis* and *Pallasea quadrispinosa*, such as *Cystidicola farionis* and *Cyathocephalus truncatus* have been revealed. The parasite fauna in the lakes of the River Kivijoki system (Malakhova and Ieshko,1977) provides a link for transition from South and Middle Karelian lakes (Shulman et al. 1974) to North, peri-Arctic Karelian water bodies (Rumyantsev et al. 1979). There are some northern species shared with lakes Pyaozero and Topozero, but no Myxosporidia, monogenetic parasites and cestodes of southern origin are observed. Poor acanthocephalan fauna, the absence of *Metechinorhynchus salmonis* and *Echinorhynchus borealis* (despite the existence of all links in their cycle) as well as the occurrence of such parasites as *Sphaerospora pectinacea, Sanguinicola sp.* and *Philonema sibirica* suggest some differences in the fauna of these two closely spaced areas of Karelia.

Conclusion

The faunistic composition of parasites is dependent on a variety of relations in which the main role is played by the specific diversity and number of definitive and intermediate hosts. Simple development cycle species (*Myxosporidia*, monogenetic parasites, *Infusoria*, and *Crustacea*) migrating to the north can survive there. Their existence is maintained by close inter - and intraspecific contacts between their hosts (fish of the carp family provide some examples). The complex cycle parasites, whose development cycle is related to the predominant forms of zooplankton and benthos, have some advantages.

The epizootic state of the water bodies in the River Kivijoki system is good. It should be noted, however, that some dangerous fish parasites such as trematodes of the genera *Tylodelphys* and *Diplostomum* are encountered in the lakes studied. In the near future, lakes Kiitehenjärvi, Luvajärvi, and Nuokkijärvi will be strongly affected by human activities. Their contamination with industrial and domestic sewage will cause changes in the hydrological and hydrochemical regimes of water bodies. Besides, it will increase mineralization and speed up eutrophication. Special attention should be given to the source of diphyllobothriosis the state and size of which are dependent on the observation of sanitary standards and environmentally friendly economic activities.

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Macrobenthos in Lake Kiitehenjärvi

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Abstract

The species composition, abundance, biomass and spatial ecological distribution of macrobenthos in Lake Kiitehenjärvi are discussed. Lake Kiitehenjärvi is the biggest (105.5 km^2) lake in the Kostomuksha Nature Reserve. It is an oligotrophic water body, which has a fairly low production potential (avarage number of benthic invertebrates is 560 ind./m^2 and average biomass 0.6 g/m^2).The species composition of macrozoobenthos is typical of North Karelian lakes with Chironomidae, Oligochaeta and Mollusca predominating. In the past twenty years (1973-1993), the structural parameters and quantitative characteristics of Lake Kiitehenjärvi benthocoenoses, unaffected by large-scale human activities, have not changed considerably.

Key words: macrobenthos, species composition, benthic biocoenoses, Lake Kiitehenjärvi

Introduction

The study of benthic macrofauna started in 1970 as part of a comprehensive hydrobiological investigation of Lake Kiitehenjärvi. The studies continued in more detail in 1972-1973, when intensive exploration of economic resources in Kostomuksha region began and when the matter of water protection became actual. Data on the qualitative composition, structure, quantitative production as well as seasonal and annual dynamics of benthic coenoses were studied. The proportion of benthic invertebrates in the food ration of some fish species was estimated. All parts of the lake were investigated, but more detailed work was done in the northern and central arms and bays along the north and east lakeshores. The Kamalahti Bay was studied most thoroughly because the decision was made to build water intake facilities for Kostomuksha there and because it was necessary to assess water quality (Anon. 1986, Rodkin 1974, Sokolova et al. 1977, Kharkevich 1976). Almost twenty years later, in 1991, when the ecological monitoring of the Kostomuksha area began, studies were resumed to cover mainly the northern part of the lake near the Neitisaari Island, the Kamalahti Bay, the Akonlahti and the Ehrinvaara Bay.

Material and methods

Quantitative macrozoobentos samples were taken by using an Ekman bottom grab (225 cm^2). Lake fauna was studied qualitatively by means of a Drogostaisky dredge and a hand net. Washings-off and collections from substrates were used as well. Samples were washed through a sieve with a mesh size of 0.3 mm, sorted on a white tray and fixed with a 4 % formalin solution. Wet samples were weighed with an accuracy of 0.0005 g. The species were identified using the following literature (Zhadin 1952, Anon 1977, Pankratova 1977, 1983; Chekanovskaya 1962, Chernovsky 1949). 238 samples were collected and analysed in 1970-1973 and 71 samples in 1991-1993.

Results and discussion

The bottom biocoenoses of Lake Kiitehenjärvi consisted of 83 taxa (Appendix). In fact, there are more species in the lake because some large systematic groups such as Nematoda, Hydrachnella, Hemiptera, Coleoptera, Plecoptera etc. were not identified as species and because some biotopes with high diversity potentials were not studied. Chironomidae were the most diverse taxon (over 40 species and larval forms) and predominated in the profundal. In fall and winter, they also prevailed in the littoral. *Tanytarsus sp., Cladotanytarsus sp., Trissocladius zalutchicola and Procladius sp.* were ubiquitous. *Peloscolex ferox, Limnodrilus hoffmeisteri, Stylodrilus heringianus and Stylaria lacustris* were the most common Oligochaeta. Mollusca were dominated by the species of the genera *Euglesa* and *Sphaerium*.

The largerly sandy and rocky littoral zone is small, indistinct and exposed to wind. In sandy shallows, the average number of organisms is no more than 900 ind./m^2, and their average biomass is 1.0 g/m^2. The fauna is dominated by Oligochaeta (*Peloscolex ferox, Limnodrilus hoffmeisteri, Stylodrilus heringianus*), Chironomidae (*Tanytarsus sp., Cladotanytarsus sp., Cryptochironomus sp. and Psectrocladius sp.*) and Mollusca. More abudant and diverse benthos is living on the mud-sandy and coarse detrial bottom of the algae-rich littoral zone (up to 3300 ind./m^2 and 3.5 g/m^2). In plant benthocoenoses, the leading role is played by Oligochaeta (*Stylaria lacustris, Nais simplex and Lumbriculus variegatus*), the phytophilous forms of Chironomidae (*Cricotopus silverstris, C. algarum and Psectrocladius psilopterus*), Ephemeroptera (*Ephemera vulgata, Ephemerella ignita*), *Sialis flavelatera* and some Trichoptera species. Higher aquatic vegetation, especially submerged and floating-leaved plants provide a good habitat for the molluscs *Radix avata, Galba palustris* and *Physa fontinalis*.

Biologically diverse benthic biocoenoses are observed on the silty bottom of the shore slope zone. Chinonomidae form a predominant group represented by eurybiotic species: *Tanytarsus sp., Cladotanytarsus sp., Trissocladius zalutschiocla* and *Procladius sp.*, littoral species: *Psectrocladius sp., Limnochironomus nervosus* and profundal species: *Trissocladius paratatricus, Stictochironomus crassiforceps* and *Paratrichocladius triquetra. Ephemera vulgata* as well as the glacial relicts *Pontoporeia affinis* and *Pallasea quadrispinosa* are valuable food reserves for fish. In summer, the average number of organisms is 1500 ind./m^2 and their biomass is 2.0 g/m^2.

The bottom fauna of the profundal zone deeper than 6 m is poor. It is represented by larvae of Chironomidae, Oligochaeta, Bivalvia and Nematoda. The ecological group of profundal macrobenthos is dominated by Chironomidae such as *Trissocladius paratatricus, Prodiamesa bathyphila, Limnopyes karelica, Tanytarsus sp., Stictochironomus crassiforceps and Procladius sp*. In summer, the average number of chironomidae is no more than 200-300 ind./m^2 and their average biomass is 0.2-0.3 g/m². The Kamalahti Bay benthos, first reported in 1970, is the best studied area. Kamalahti is of oligo-mesotrophic type (Table 1) and dominated by Chironomidae, Bivalvia and large larvae of *Sialis flavelatera* and *Ephemera vulgata*.

Table 1. Numbers (N=ind./m²) and biomass (B=g/m²) of benthic macroinvertebrates in the Kamalahti Bay during different years in summer time.

Taxa	1970*		1972*		1973*		1991		1992		1993	
	N	B	N	B	N	B	N	B	N	B	N	B
Chironomidae	157	0.12	397	0.39	54	0.17	400	0.16	799	0.27	535	0.42
Oligochaeta	40	0.11	737	0.45	38	0.13	61	0.04	44	0.02	89	0.04
Mollusca	53	0.09	150	0.18	14	0.16	113	0.16	444	0.93	244	0.52
Others	17	0.43	71	0.69	14	0.22	39	0.29	-	-	44	0.28
Total	267	0.75	1355	1.71	120	0.68	613	0.65	1287	1.22	912	1.26

* data by V. A. Sokolova

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Appendix

List of Lake Kiitehenjärvi macroinvertebrates.

Nematoda
Oligochaeta
Stylaria lacustris (L.)
Nais simplex Piguet.
Limnodrilus nevaensis Mich.
Ilyodrilus hammoniensis (Mich.)
Peloscolex ferox (Eisen)
Tubificidae sp.
Lumbriculus variegatus (Mull.)
Stylodrilus heringianus Clap.
Hirudinea
Herpobdella octoculata (L.)
Mollusca
Radix ovata Drap.
Galba palustris (Mull.)
Physa fontinalis (L.)
Gyraulus albus (Mull.)
Sphaerium corneum (L.)
Sph. subsolidum Cless.
Sphaerium sp.
Euglesa casertanum (Poli)
Euglesa sp.
Crustacea
Pontoporeia affinis Lind.
Pallasea quadrispinosa G.O. Sars
Hydrachnella
Hemiptera
Coleoptera
Plecoptera
Megaloptera
Sialis flavelatera (L.)
Ephemeroptera
Brachicercus sp.
Ecdyonurus sp.
Arthroplea congener Beng.
Heptagenia fuscogrisea (Ret.)
Ephemera vulgata L.
Trichoptera
Athripsodes cinereus (Curt)
Phryganea bipunctata Rets.
Limnophilus flavicornis Fabr.
Micropterna lateralis Steph.
M. albicans Zett.
Odonata
Lepidoptera
Diptera
Chaoborus cristallinus De Geer.
Bezzia sp.
Cladotanytarsus sp.
Paratanytarsus sp.
Tanytarsus sp.
Micropsectra sp.
Stempellinella minor (Edw.)
Paracladopelma camptolabis Kieff.
Cryptochironomus defectus group
Demicryptochironomus vulneratus Zett.
Cryptocladopelma viridula Fabr.
Harnischia fuscimana kieff.
Chironomus plumosus (L.)
Limnochironomus nervosus (Staeg.)
L. tritomus (Kieff.)
Endochironomus tendens (Staeg.)
Pagastiella orophila (Edw.)
Kribioxenus brayi (Goetg.)
Pentapedilum exectum Kieff.
Polypedilum exectum Kieff.
P. nubeculosum (Mg.)
P. scalaenum (Schr.)
P. bicrenatum Kieff.
Sergentia longiventris Kieff.
Stictochironomus crassiforceps (Kieff.)
Stictochironomus sp.
Protanypus sp.
Prodiamesa batyphila Kieff.
Trissocladius zalutschicola Lipina
T. paratatricus (Tchern.)
Microcricotopus bicolor (Zett.)
Cricotopus algarum Kieff.
C. silvestris (Fabr.)
Paratrichocladius triquetra (Tshern.)
Psectrocladius psilopetrus Kieff.
Ps. dilatatus (Van der Wulp)
Ps. septentrionalis Tshern.
Limnophyes karelicus (Tshern.)
Orthocladiinae sp.
Procladius choreus Mg.
P. ferrugineus Kieff.
Ablabesmyia sp.
Tanypodinae sp.

The state of forest ecosystems in the Kostomuksha Nature Reserve

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Abstract

The condition of forests was studied in the Kostomuksha Nature Reserve. Fourteen sample plots were laid out in 1992-1993. The loss of needles in pine forests was 12-25% and up to 40% in some trees. The percentage of changes in needle colour was about the same. The average discoloration was 2-25% and up to 70% in some trees. In spruce stands defoliation was 6-8% and discoloration 11-13%. In some spruce trees maximum defoliation and discoloration were no more than 20%. The crowns of all the pine stands were injured by *Tomicus pineperda*. All the stands studied have 1st to 2nd class degree of damage and are thus at the initial stage of degradation. The metal and sulphur content of indicator plants did not exceed the average values of the region. Signs of pollution were discovered within the impact zone around the ore-dressing mill (10-15 km).

Key words: Boreal coniferous forest, integrated monitoring, pollution, defoliation

Introduction

The forests of the Kostomuksha Nature Reserve retain features typical of virgin boreal forests. The predominance of coniferous coenoses, small areas occupied by young trees and the complex age structure of stands are characteristic. The forested part of the nature reserve is dominated by pine. Severe climate and poor soils are responsible for low forest productivity. The landforms and soil hydrology of the study area are favourable for a variety of forest types: 13 types were revealed in pine forests, 9 types in spruce stands and 8 types in birch forests. Phytocoenotically, a green-moss group of forest types, represented by crowberry-blueberry and crowberry-lingonberry associations, was predominant.

Mature and overmature forests cover over 50% of the forested area. The trees, in particular pine, differ in age. Trees ranging from 80 to 360 years are observed in the stand, but two to tree generations are normally identified. The first generation is represented by trees older than 150 years. Trees of the second generation are younger, more abundant and grow well. They account for about 30% of the wood stock. The young generation, called undergrowth, gradually spreads beneath the old forest canopy. Spruce undergrowth, also seen under the pine canopy, predominates in species composition. The high age of the trees and forest fires are responsible for a variety of wood damage. About 40% of noncoeval pine stands are injured. Trunk rot, dry rot and gray rot are the most common types of injury. In stands older than 200 years over 50% of trunks are affected by rot. In spruce forests, the difference in age is even more pronounced, but unlike pine stands, their generations are arranged as vertical storeys. Spruce trees, normally confined to wet forest types, are badly injured. A great number of decaying and damaged trees contribute to the abundance of insect pests in phytocoenoses. The latter affects the photosynthetic apparatus of trees under certain conditions.

The assimilation apparatus is also influenced by air pollution. Changes in needle color and the loss of needles in the crown depend on many factors such as position of a tree in the canopy, climate conditions in previous years etc. Defoliation and discoloration are, however, fairly stable among trees of high growth classes when the needles are fully formed.

Material and methods

The study was carried out in 65-140-year-old pine and spruce stands which were unaffected or only slightly affected by human activities. Setting of sample plots and all the measurements were made according to general requirements and criteria of forest inventory and monitoring (UN/ELE, 1986). To characterize the investigated area more thorouhgly, fourteen sample plots were chosen within the territory of Kostomuksha Nature Reserve (Table 1). Some sample plots are used for integrated monitoring (Nos. 1, 2, 8, 13, 14). The areas of sample plots (0.1-0.4 ha) depended on size and density of forest stands (min. 1 ha, 200 stocks/ha). Coordinates of each plot were recorded.

Table 1. Characteristics of the stands studied in the Kostomuksha Nature Reserve.

No	Age	Composition	Forest type	Qual. class	Height average m	Relative density	stock m^3/ha	Distance from mill, km
1	110	10pine	MT	III	20.0	0.9	297	27
2	110	7P3Spr	MT	IV	17.1	0.7	208	27
3	105	10P	VT	V	15.6	0.7	172	30
4	110	10P	VT	IV	19.0	0.65	170	27
5	100	8P1S1B	MT	IV	22.3	1.0	360	21
6	125	10P+Bir.	CT	Va	13.0	0.4	124	26
7	125	10P+B	VT	IV	19.8	0.86	265	35
8	90	9P1Spr.	MT	III	19.9	0.8	269	28
9	80	10P+S	MT	III	16.8	0.8	227	27
10	100	9P1Bir.	VT	III	19.8	0.7	250	16
11	85	10P+B	MT	IV	15.8	0.8	209	23
12	140	9P1B+S	VT	IV	21.6	0.8	300	5
13	65	10S+B	MT	IV	11.9	1.2	205	27
14	110	7S2P1B	MT	IV	17.3	0.8	348	27

Our monitoring survey was based on visual assessment of tree crown conditions (damage caused by air pollution and insect pests). On each sample plot at least 20 sample trees (predominant, dominant and co-dominant) were selected . Defoliation and discoloration, cone yield and damages by insect pests were assessed (UN/ELE, 1986).

Results and discussion

The nature reserve is located near the Kostomuksha ore-dressing mill, the biggest air polluting source in Karelia. However, the zone can be extended in cases of emergency when large amounts of emissions are discharged into the atmosphere. The loss of needles (defoliation) in pine forests was 12-25% and up to 40% in some trees. The percentage of changes in needle colour was about the same. The average discoloration was 2-25% and up to 70% in some trees. In spruce stands defoliation was 6-8% and discoloration 11-13%. In some spruce trees maximum defoliation and discoloration were no more than 20% (Table 2).

Table 2. Forest condition in the Kostomuksha Nature Reserve.

N	Distance form the mill, km	Age of need-les	Defoliation, %		Discoloration, %		Insect pests *	Cone yield	Damage degree
			Av.	Range	Av.	Range			
1	27	3-4	12	5-25	15	0-40	+	poor	1
2	27	3-4	18	5-40	24	10-40	+	poor	2
3	30	2-3	21	15-30	3	0-5	+	poor	2
4	27	2-4	25	5-40	25	5-70	+	poor	2
5	21	2-4	15	5-20	2	0-5	+	medium	1
6	26	2-3	16	5-25	3	0-5	+	poor	2
7	35	3-4	18	5-30	7	0-25	+	poor	2
8	28	2-4	21	5-40	12	5-50	+	poor	2
9	27	3-4	14	5-25	4	0-5	+	poor	2
13	27	6-7	6	0-20	11	0-20	-	medium	1
14	27	6-7	8	0-20	13	5-25	-	medium	1

*All pine stands were injuried by *Tomicus piniperda.*

No distinct relation between the state of the assimilation apparatus and distance from the mill was revealed in 1993, because strongly defoliated pine trees were found near the mill and at the opposite end of the nature reserve. The crowns of all the pine stands investigated were injured by *Tomicus piniperda.* In some stands traces of injuries made by *Neodiprion sertifer* a few years ago are observed. It can be seen in table 2, that insect pests are responsible for the heavy loss of needles. The greater number of *Tomicus piniperda* and consequently, greater needle consumption may be due to the weakening of wood coenoses by air pollution. All the stands studied have 1st to 2nd class degree of damage and are, therefore, at the initial stage of degradation. It should be noted, however, that the number of *Tomicus piniperda* can be expected to increase periodically due to the predominance of overmature trees and a large number of injuries. The causes of injuries could be elucidated by studying the insects of the nature reserve in detail and by correlating the results obtained with data from other regions. The degree of degradation was indicated by the number of dead standing trees. The percentage of such trees varied from 1 to 21%, depending on the age of stands and the predominant species; 7.2% in pine stands and 1% in spruce forest.

The highest percentage of dead trees (21%) was observed in a pine stand, where most of the dead trees were old. The proportion of dead trees was thus normal in terms of environmental conditions, age and geographical latitude. So far, no relationship between the number of dead trees and the distance from the mill has been found. This is supported by the fact that the pollutants, discharged by the mill, have had no apparent negative effect on the state of the upper tree storeys. One of the methods used for primary diagnostics of degradation in wood phytocoenoses is to determine the amount of chemical elements, primarily heavy metals and sulphur, in indicator plants. The application of the moss technique as a means of surveying atmospheric heavy metal deposition was developed in late 1960s (Rühling & Tyler 1968; Tyler 1970). The best results were obtained by studying the green mosses *Hylocomium splendens* and *Pleurozium schreberi*. In addition to those, we used *Hypogymnia physodes* and *Cladonia silvatica*.

Samples, collected on the ground trials, were analysed using atomic absorption spectrophotometer AS-115 and commonly used method for analysing various elements (UN/ELE 1986). The results of our analyses are presented in tables 3 and 4.

Table 3. Average content of chemical elements in indicator plants sampled in the Kostomuksha Nature Reserve.

Plant	Element Fe	(mg /kg, ovendry weight) Zn	Cu	Pb	Cd	S
Hypogymnia phys.	663	35	3.8	4.7	0.26	503
Hylocomium splen	594	40	4.4	4.4	0.27	660
Cladonia silvatica	544	20.5	2.3	3.6	0.27	293

It can be seen by comparing mean values, obtained from different indicators, that their metal content has the same pattern. Terrestrial lichens accumulate less metals and much less sulphur , but *Cladonia silvatica* can well be used for diagnostics when the above elements are abundant in phytocoenoses. Small variations in *Zn, Cu, Pb, Cd* and *S* content are observed in all groups of indicator plants both inside and outside the impact zone. Variation in *Fe* content is more explicit even away from Kostomuksha ore-dressing mill. It is difficult to assess the influence of the mill in our trial grounds because they are all outside the impact zone (16-35 km from the mill). In this connection, the studies conducted by Finnish researchers (Muhos forest station) on sample plots laid out by the gradient, Russian-Finnish boundary - Kostomuksha ore-dressing mill,are demonstrative.

Table 4. Metal and sulphur content of *Hypogymnia physodes* samples taken in trial grounds (Muhos 1994).

No. of sample plot	Distance from the mill, km	Element (mg/kg ovendry weight) Fe	Zn	Cu	Pb	Cd	S
1	5	5700	80	4.0	6.5	0.27	1100
2	16	1000	28	3.9	6.4	0.38	850
3	23	600	28	4.1	7.0	0.31	840
4	27	300	33	4.0	6.6	0.31	830

Fe content increases sharply from 300 to 5700 mg/kg (ovendry weight) towards the mill. Zn and S content is observed to rise 2.5 and 1.25 times, respectively, only near the mill. It has been shown by comparing the metal and sulphur content of the samples taken near Kostomuksha and in other cleanest parts of Karelia, such as the Kivach Nature Reserve and the Paanajärvi National Park, that the average quantities of some elements, most harmful for human health and plants (Pb,Cd), are similar in all the areas studied and in nearest territory of Finland (Folkeson 1981; Pakarinen 1981; Niskavaara & Airas 1991). The Zn content is also about the same. The amount of sulphur is observed to increase towards big industrial enterprises such as the Kondopoga pulp-paper mill and the Kostomuksha ore-dressing mill.

The Cu content varies over a wide range, maximum concentrations being reported from North Karelia. The Cd content varies greatly as well, maximum values being recorded near the Kostomuksha mill. The metal and S content of the samples taken in the Kostomuksha Nature Reserve does not exceed the mean values calculated for Karelia. So far, the pollutants discharged by the Kostomuksha ore-dressing mill have only affected the phytocoenoses within the impact zone (10-15 km).

The validity of our data is supported by some Finnish studies. The results obtained in the Oulanka National Park, in the Lake Kiitehenjärvi area near the state border and in the Kostomuksha area are similar to our results (Rühling et al. 1987; Kubin 1990). This work was a prelimienary investigation of forest conditions in Karelia. The sample plot net on the territory of Kostomuksha Nature Reserve will be extended in 1995-1996 . The data obtained will also be supplemented with new data from sample plots of local monitoring in the vicinity of the ore-dressing mill and adjacent areas.

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Assessment of forest decline around Kostomuksha ore-dressing mill using satellite images

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Abstract

The results from remote sensing-aided forest monitoring in the vicinity of sulphur dioxide and heavy metal emission sources are presented in this report. An attempt was made to reveal the damage area, using multispectral satellite data (Russian scanner MSU-E). Spectral vegetation index, the ratio of the digital number (relative reflectance on the ground surface) of near infrared to red channels has been applied as parameter for image classification, which decreased with the increase of defoliaton degree of the stands. The results indicate that multispectral satellite data can reveal damaged areas in pine forests in the early stage of degradation, before the appearance of clear signs of damage. After ten years when the ore-dressing mill started operating, the damaged area has become slightly larger than the impact zone, where the largest amounts of the dust fall and the increased sulphur dioxide concentrations in the air are observed.

Key words: Satellite sensing, forest decline, air pollution, Kostomuksha ore-dressing mill

Introduction

Kostomuksha ore-dressing mill was put into operation in the northwestern part of Karelia in 1982. Before the appearance of the mill, forests in the area were in more or less virgin state. In 1986, the Forest Research Institute (Karelian Research Centre) began the ground monitoring of the forest around the mill. The pollution impact on the environment near powerful sources of emissions is so strong, varied and spatially heterogeneous that conventional ground observations are not sufficient. Remote sensing methods are needed. Due to spectral properties of tree canopy, one of the most effective techniques for surveying forest damage is to use satellite scanner data. In this study an attempt was made to reveal the damage zone around the emission source using ground observations and remote sensing data.

The mill discharges annually about 60 000 tons of sulphur dioxide to the atmosphere, more than 2 000 tons of nitrogen oxides and about 5 000 tons of dust with high content of heavy metals (mostly Fe, and also Ni, Cr, Cu). According to the volumes of emissions, the main pollutants in the study area should be sulphur dioxide and heavy metals containing dust.

The estimation of the air pollution in the area is based on the results of the air analyses which were made by mill environment pollution control laboratory during the period 1987-1990. The measurements have been carried out by a mobile unit in the current wind direction, so it is difficult to define actual mean pollutant concentration in the air. We can only approximately outline the most harmful zone by the maximum levels of gas contamination. In the distance less than 10-12 km from emission source, the levels of sulphur dioxide concentration more than ten times higher, exceed the critical threshold for pine (0.015-0.02 mg/m3).

Data obtained by bulk deposition and soil survey suggest that the main volume of the dust falls in 8-10 km zone from the source of emission. Heavy metals are observed to accumulate in the soil, but their concentration even in the upper soil horizons is much lower than in industrial regions of Europe and America and is not alarming. Sulphur deposition and acid rain lead to the soil acidification, but within the impact zone alkaline dust neutralizes this influence (Lazareva et al. 1993).

This suggests that the main pollutant at present is sulphur dioxide. Indirect effect (from the soil) is not significant. Levels of increased sulphur dioxide concentration in the air and dust contamination depict the limits of impact zone; approximately 10-12 km from the source of emission.

Study area and methods

Ground observation

Permanent sample plots were established in 1986-1987. The gradient approach has been applied in the study, the direction of the gradient line was chosen according to the predominant wind direction. Gradient-type studies require minimum variation in site characteristics to reveal pollution effect (Reed et al. 1988). All sample plots were located in mature Scots pine (*Pinus sylvestris*) dominated stands of myrtillus type; the most wide-spread forest type in this region. The size of the sample plot was 40 x 60 m.

Mean sample plots characteristics:

Stand age	110-140 years
Total timber volume	240-270 m^3/ha
Mean height	19-22 m
Mean dbh	22-28 cm
Basal area	22-30 m^2/ha
Proportion of the pine	0.8-1.0
Density	400-600 stems/ha
Exposition	towards emission source

One of the earliest symptoms of tree damage by air-born pollutants is the loss of needles. It makes the canopy sparse, hence the state of each individual tree in the sample plot was defined by visually estimated defoliation degree – the main method that has been applied in a number of European countries for monitoring the vitality of forests (Anon. 1986), using the following classification (Table 1).

Table 1. Defoliation degrees of the tree.

Defoliation class	Needle loss,%	Degree of defoliation
0	up to 10	none
1	>10-25	slight
2	>25-60	moderate
3	>60	severe
4	100	dead tree

This classification reflects the experience gathered in Central Europe in the years 1980-1989. Conifers regulate the amount of foliage according to weather conditions, and loss of foliage of up to 25% is not necessarily a sign of deteriorating vitality. Trees having lost more than 60% of foliage could remain alive for a variable time but generally did not enter the class 2.

The state of the whole stand was defined by calculated defoliation index (DI). It represents the mean weighted defoliation class of dominant and co-dominant trees in the sample plot. Suppressed trees were excluded from the calculation to avoid the influence of competition between the trees. Also the trees with clear signs of wounds and disease were excluded. Basal area of the stem of the tree at breast height (1.3 m) was used as the weighting factor since it is relatively closely related to the tree crown area (Assman 1970).

Satellite data

The information of the Russian scanner MSU-E was used in the study. The scanner has 3 spectral bands; green (G), red (R) and near infrared (NIR), that correspond approximately to the Landsat-TM Bands 2, 3 and 4. Pixel size is 45 x 34 m. The image 45 km x 55 km (1000 pixels x 1600 lines) was obtained at 11:44 (Moscow time) on 6 June 1992. In-house software running on a PS/2 computer was used for processing and analysing scanner data. Due to absence of digital terrain model and GPS the localization of the sample plots has been made visually.

Results

Estimation of defoliation in the sample plots was conducted in 1987, 1989 and 1991, in late August. In 1987 the state of the stands was about the same along the gradient line, regardless of the distance to the mill, and DI was 0.2-0.3, suggesting the predominance of undamaged (zero defoliation class) trees. In 1989 there was slight deterioration in northeast direction. In 1991 the state of the ground sample plots within impact zone deteriorated sharply, where DI was over 1.1-1.2, and 0.6-0.8 elsewhere.

Long-term observations indicated a large annual variation in the needle fall in pine stands (Jukola-Sulonen et al. 1990). Also deterioration in remote plots could be attributed to general deterioration in air quality in Northern Europe caused by long-range transport of air pollutants. Natural variation in different sites is too great while the network of sample plots is rather sparse, and defoliation index DI in the sample plots varies considerably. Thus it is impossible to estimate the damage using ground observation alone. Due to this reason, in 1992 an attempt was made to reveal the damage area, using multispectral satellite data and DI in the sample plots as the ground data.

Defoliation decreases needle mass and increases the roughness of the canopy surface. The decrease in the assimilating biomass tends to increase the visible light reflectance and to decrease the reflectance in the NIR range (Gates 1970). Roughness increases the amount shadowing and decreases the reflectance, but shadowing has less meaning in the visible light range than in the NIR range due to the greater scattering of the shorter wavelengths (Häme 1991). In damaged needles the proportion of chlorophylls decreases and it increases red light reflectance. Thus, if two stands have the similar tree species, age and density, the more damaged stand should have lower reflectance in the NIR part of the spectrum and the higher in the red one.

A type of spectral vegetation index, NIR/R channel ratio, (VI in this study) and intensity (digital number) of red channel was used as a parameter for the image classification and for distinguishing pine forests from other types of land surface.

Defoliation changes the spectral characteristics of the canopy and, on the other hand, defoliation index of the stand. This makes it possible to use the correlation between these parameters for detecting the forest damage. The relationship between spectral vegetation index (VI) and defoliation index (DI) observed in the field in 1991 was approximated by the following equation,

$$VI = -0.2702 \times DI + 1.8662 \quad (1)$$

where the correlation coefficient (r) is 0.742.

No correlation is observed between the state of the stands and intensity in the visible spectral range (red and green channels). This suggests that the decline in chlorophyll concentration, shown by chemical analyses of the needles (Lazareva et al 1993), is too small to be apparent on the stand level and, therefore, does not affect the reflection coefficients in this range.

Based on the results of ground observation, stands with DI over 1.2 (VI lower than 1.56) were considered to be damaged. The results of computer processing of the scanner image according to this classification (Fig. 1) indicate the spot of the "damaged" pixels around the point in which the pipes of the mill are located. The shape of the damaged area corresponds to prevailing wind direction. The largest density of damaged stands is observed near quarry, the source of dust emissions.

Field checking of the classification performance showed that in some "damaged" pixels could actually be, for example, sparse stands without high defoliation. Nevertheless, the area with high density of the "damaged" pixels reliably depicts the forest decline zone.

Conclusion

The results indicate that multispectral satellite images could deliver the information concerning damaged zones and to some extent the damage degree in boreal pine forests in the early stage of degradation, before the appearance of clear signs of damage, such as needle discoloration and extremely high defoliation. Such information could be useful for regional monitoring, to define the current status and the trends in forest ecosystem response to pollutant exposure and for the local authorities when planning environmental protection measures, city development, localization of new residential and recreational zones etc.

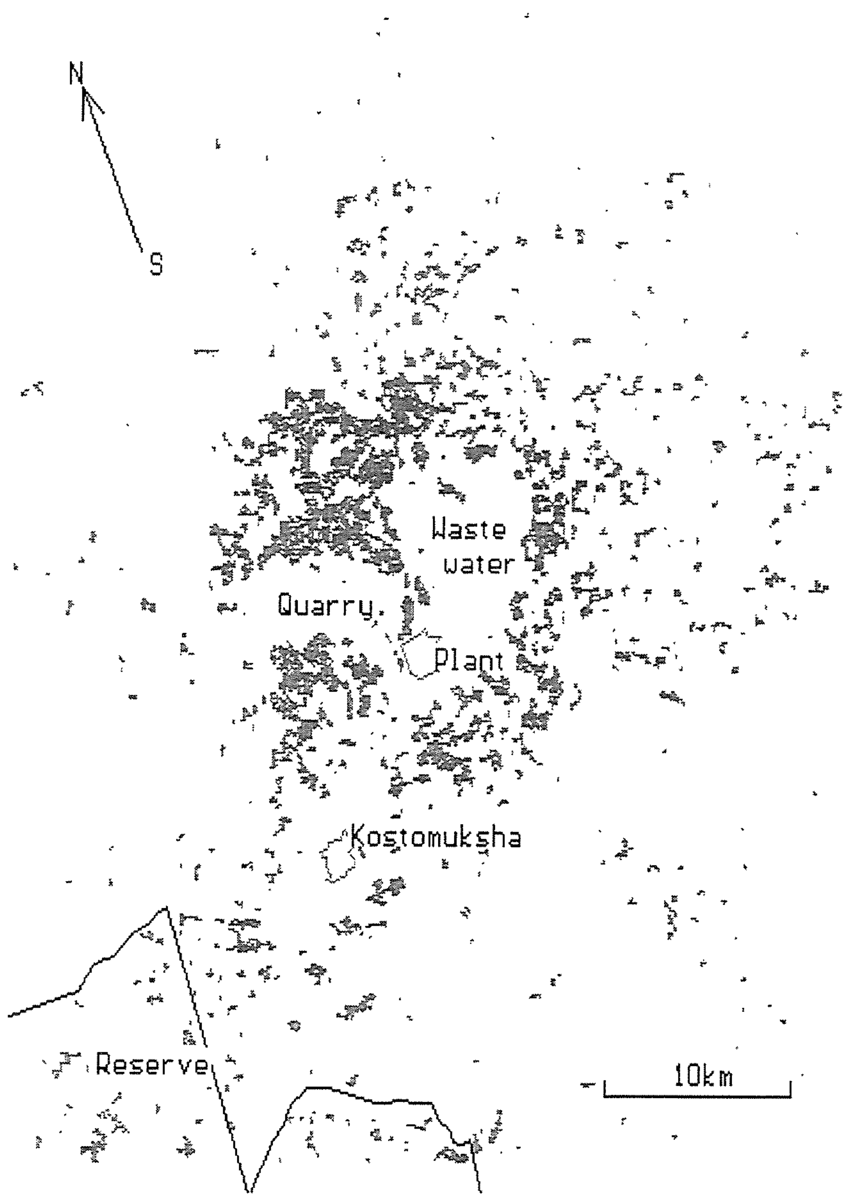

Fig. 1. Classified satellite image. Black points represents the stands with defoliation index over 1.2.

Channel ratio near infrared to red proved to be a sensitive indicator for detecting forest damage in the zones of industrial air pollution. This agrees with the results obtained by many researchers, e.g. Nakane and Kimura (1992) with another pine species (*Pinus densiflora*). The defoliation index (mean weighted defoliation degree) of the sample plot could be useful as ground data because it correlates with spectral index derived from scanner data.

The data obtained during the monitoring period (1987-1993) demonstrate the permanent deterioration of forest state throughout the study area, but in the vicinity of the mill, emissions are the primary cause of forest decline. After ten years of the mill operating, the limits of the damaged area are slightly larger than the impact zone, where the largest amounts of the dust fall and the increased sulphur dioxide concentrations in the air are observed.

The boundary of the damage zone extends southeast near the Kostomuksha Nature Reserve. The forests of the region are low-productive and compositionally simple. Therefore, they are less resistant and respond faster to harmful emissions. The northeast part of reserve is likely to be damaged as well, unless measures are taken to sharply decrease the amount of pollutants discharged by the mill.

Considering the apparent impact of sulphur dioxide and the ongoing accumulation of sulphur in biocoenoses (Lazareva et al, 1993), it is necessary to continue ground and satellite forest monitoring to control this process and to elucidate further trends in the development of the ecological situation.

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Heavy metal concentration in the bank vole (*Clethrionomys glareolus* Schreb.) and in the common shrew (*Sorex araneus* L.) liver and kidneys in the Friendship Park and in the Oulanka National Park

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Abstract

The heavy metal concentration in the kidneys and the liver of the bank vole (*Clethrionomys glareolus* Schreb.) and the common shrew (*Sorex araneus* L.) are studied from the individuals snap-trapped mainly in spruce forests in 1992 at three parts (Juortanansalonsalo, Iso-Palonen and Elimyssalosalo) of the Finnish side of the Friendship Park (ca. 64°N, 30°E) and in the surroundings of the Oulanka Biological Station (ca. 66°N, 30°E) by using DCP-AES and ETAAS equipments. The trapping sites are arranged in ascending order according to the concentrations of Pb, Cu and Cd in both the species, with the range of the mean values in ppm, into the following table.

	Clethrionomys glareolus (no. of ind. = 79)	ppm	**Sorex araneus** (no. of ind. = 80)	ppm
Pb	Iso-Palonen < Juortana < Oulanka < Elimys	0.28-0.48	Oulanka < Iso-Palonen < Juortana < Elimys	0.32-0.87
Cu	Oulanka < Elimys < Juortana < Iso-Palonen	16.6-19.2	Oulanka < Elimys < Juortana < Iso-Palonen	27.3-29.5
Cd	Oulanka < Elimys < Juortana < Iso-Palonen	0.17-1.45	Oulanka < Juortana < Elimys < Iso-Palonen	0.95-3.42

Key words: Small mammals, heavy metals, Friendship Park

Introduction

The small mammals, voles and shrews, form one group which has been studied among others in the Friendship Park. This group is formed by species which are using either plant (green parts of plants, berries and seeds, lichens) or animal based ingredients (mainly invertebrates) - or both - as their food, and are relatively place-fixed having rather restricted moving area. They also form a part in the food chain between plants or invertebrates and bigger vertebrates, birds and mammals. They act as an intermediate factor between those on age scale, too. Thus they can be imagined to indicate, in addition to the differences of heavy metal concentrations between separate areas, also the changes on time axis and the possibilities of the transfer of different metals in the food chain (Hunter & Johnson 1982, Hunter et al. 1987a, 1987b, 1987c).

The concentrating of heavy metals into separate organs of small mammals has been during last two decades eagerly studied on geographically wide area from various points of view (Fischer 1975, Getz et al. 1977, Johnson & Roberts 1978, Paukert & Obrusnik 1986, Pankakoski et al. 1989). In most cases the main interest has been laid on the pollution caused either by traffic along road sides or by different industrial enterprises (a.o. Jeffries & French 1972, Buchauer 1973, Quarles et al. 1974, Goldsmith & Scanlon 1977, Albase & Cottenie 1985, Beyer et al. 1985, Scanlon 1987, Kirjalainen 1991, Pankakoski et al. 1992, 1993).

The aim of this study has been to investigate the heavy metal concentration of the two small mammal species in three parts of the Finnish side of the Friendship Park and to compare them with each others and with the concentration met in the same species in another location, Oulanka National Park, situated ca. 200 km north of the Friendship Park, and to find a comparition level for them for possible use to come.

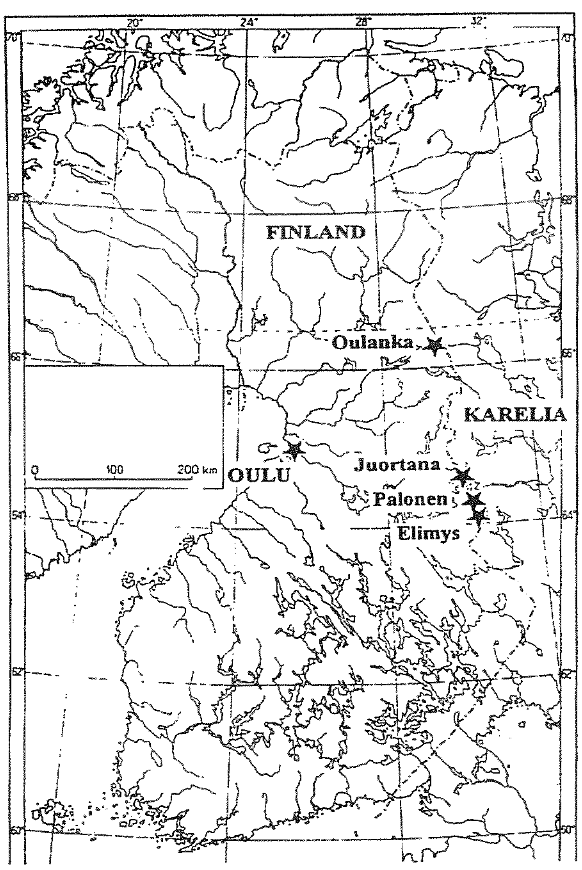

Fig. 1. Oulu and the study areas (trapping sites) along the Finnish-Karelian borderline are shown by asterisks.

Material and methods

The basic inventory of small mammals in the Finnish side of the Friendship Park was started in 1990. In all, 29 constant trapping lines were constructed in three parts of the Park, to Juortanansalonsalo, Iso-Palonen and Elimyssalosalo (Fig. 1.) into different habitats. The small mammals have since then been snap-trapped twice a year, in early and late summer. All the lines have been situated near roads, neither nearer than 30 meters nor further off than 1.5 km from the roads. The roads are small local or forest roads on which the traffic density is very low or on which there is no daily traffic at all (Tie- ja vesirakennuslaitos, 1985). From the 1239 small mammals trapped during 1990-1993, individuals of the most numerous rodent, bank vole (*Clethrionomys glareolus* Schreb.) and of the insectivore, common shrew (*Sorex araneus* L.) were selected to be used in heavy metal analyzes. Because of the statistical treatments, equivalent number of individuals of both the species were included into the material. When picking up bank voles, the age and sex of the individuals were taken into account but in the case of the common shrew, the sex was notified only (Table 1.), because the number of old (= overwintered) shrews in the catches was very small due to the timing of the trapping period (August-September). In the spring catches the number of individuals was generally insufficient and in addition to that there was no comparative material available for that period. The comparative material consisted of individuals of the same species caught from the area of the Oulanka Biological Station during corresponding time. The individuals taken into the analyzes were selected according to the same criteria as in the case of the Friendship Park.

The small mammal individuals used in the analyzes were each packed into an air-tight polyethene bag and stored in deep freeze (-18°C) prior to the treatments. They were measured and weighed at the Zoological Museum of the University of Oulu before dissection. Dissection was operated with sterile single-use plastic gloves and instruments in order to minimize the contamination risk. The liver and kidneys of each individual were put into a pair of Petri dishes and freeze-dried (Flexi-Dry™ MP*) in -70°C, 6 days for bank voles and 4 days for common shrews. After the freeze-drying the samples were moved into the Department of Chemistry for the heavy metal analyzes. The analyzed samples consisted of the liver and kidneys of each individual, because the kidneys alone are too small by their mass for reliable analyzes (Pankakoski et al. 1992). Samples were decomposed with nitric acid and hydrogen peroxide using microwave digestion technique. The concentrations of lead (Pb), copper (Cu), cadmium (Cd) and nickel (Ni) were determined from each sample by d.c. plasma-atomic emission (DCP-AES) and electrothermal atomic absorption (ETAAS) spectrometry. These equipments have been used also when determining the heavy metal concentration in earth-worms (Pulliainen et al. 1986, Perämäki et al. 1992) and in small mammals (Kirjalainen 1991) and they also are commonly used in pollution studies in general (Jeffries & French 1972, Schlesinger & Potter 1974, Johnson & Roberts 1978, Yassoglou et al. 1987 and Pankakoski et al. 1989). The total amount of samples was 159 (and it was restricted by the number of comparable individuals and the amount of money available).

The results of the heavy metal determinations have been statistically analysed using microcomputer (programgroup SPSS-WIN). The comparitions have been mainly executed by non-parametric Wilcoxon´s Test based on the median of a sample, because of the relatively wide variation in the analyzing values between the individuals. When testing the concentrations of heavy metals in bank voles according to the trapping sites, the values for separate age- and sex groups were pooled. The same method was used in the point of the common shrew in respect to the sexes, too. The pooling was made possible by the fact that the main explanation for the differences in the concentration values was formed by the trapping area

(Analysis of Variance). The concentration level of nickel in general appeared to be very low even in respect to the analyzing capability of the equipments used and that is why it has been left out of the material here. The results are shown (Table 2.) as dry-weight values (mg/g = ppm).

Table 1. Number of the individuals used in the heavy metal analyzes.

Locality	Sex	Age	Clethrionomys glareolus	Sorex araneus
Oulanka	Males	Ad.	5	
ca. 260 m asl.		Juv.	5	9
	Females	Ad.	5	
		Juv.	4	11
			19	20
Juortanansalo	Males	Ad.	5	
ca. 220 m asl.		Juv.	5	10
	Females	Ad.	5	
		Juv.	5	10
			20	20
Iso-Palonen	Males	Ad.	5	
ca. 220 m asl.		Juv.	5	10
	Females	Ad.	5	
		Juv.	5	10
			20	20
Elimyssalo	Males	Ad.	5	
ca. 240 m asl.		Juv.	5	10
	Females	Ad.	5	
		Juv.	5	10
			20	20
Total		159	79	80

Results

Lead (Pb)

The concentration of lead in the whole material varied between 0.22 ppm (Iso-Palonen, bank vole males juv.) and 0.93 ppm (Elimyssalo, common shrew females), being on average 0.45 ppm. Generally speaking its concentration was higher in the common shrew than in the bank vole, except in Oulanka where the situation was reversed (on highly significant level) (Table 2.). The concentration level in the bank vole females has been slightly higher than in the males, as in the case of the old versus young individuals, but the difference is not significant in either cases ($P>0.05$). The common shrew shows corresponding result (juveniles only).

There are clear differences in lead concentration between the areas. The concentration of lead in both species increases in the order: Iso-Palonen-Juortanansalo-Elimyssalo. Oulanka falls between Juortanansalo and Elimyssalo in the case of bank vole and before Iso-Palonen in the case of common shrew.

Copper (Cu)

The concentration of copper varied correspondingly between 14.0 ppm (Oulanka, bank vole males, juv.) and 30.4 ppm (Iso-Palonen, common shrew males), the mean being 21.4 ppm. The mean for the whole material is raised by the high level of the common shrews. The concentration of copper in the common shrew (variation of mean values 27.1-30.4 ppm) is significantly higher than that in the bank vole (variation of mean values 14.0-22.0 ppm). The difference between sexes is not significant. Neither is there difference between the bank vole females and males, but the higher concentration level in young individuals, when compared to the old ones is statistically significant. The areal order according to the copper values in both species is ascendingly as follows:Oulanka-Elimyssalo-Juortanansalo-Iso-Palonen (Tables 2, 3 and 4).

Cadmium (Cd)

The limits for the cadmium concentration are 0.15 ppm (Oulanka, bank vole males and females) and 3.43 ppm (Iso-Palonen, common shrew females). The concentration in the common shrews is, on the average, threefold to that in the bank voles. There is no difference between the sexes in either of the species. Instead, the cadmium concentration in old bank vole individuals is ca. threefold higher than in young individuals.The difference is statistically very significant ($P<0.01$). The concentration level in the bank vole increases in the following order: Oulanka-Elimyssalo-Juortanansalo-Iso-Palonen. In the common shrew the order is: Oulanka-Juortanansalo-Elimyssalo-Iso-Palonen, correspondingly, (Tables 2, 3 and 4). The concentration of cadmium in the Friendship Park is up to 15-fold (Iso-Palonen) in the bank vole and over threefold in the common shrew (also at Iso-Palonen) when compared to the corresponding values at Oulanka.

Table 2. The heavy metal concentration (mean ± S.E. ppm, [median in brackets]) in the bank vole (*Clethrionomys glareolus* Schreb.) and the common shrew (*Sorex araneus* L.).

Clethrionomys glareolus

Locality	Sex	Age	Pb		Cu		Cd	
Oulanka	Males	Juv.	0.41 ± 0.09		16.2 ± 0.917		0.15 ± 0.0	
		Ad.	0.40 ± 0.063		15.2 ± 0.583		0.16 ± 0.01	
	Females	Juv.	0.43 ± 0.1		22.0 ± 3.189		0.15 ± 0.0	
		Ad.	0.47 ± 0.142		14.0 ± 1.14		0.21 ± 0.046	
Juortanansalo	Males	Juv.	0.34 ± 0.086		19.0 ± 1.414		0.54 ± 0.266	
		Ad.	0.39 ± 0.081		16.4 ± 0.98		1.11 ± 0.396	
	Females	Juv.	0.38 ± 0.105		18.0 ± 0.548		0.49 ± 0.125	
		Ad.	0.40 ± 0.085		17.6 ± 0.927		1.52 ± 0.575	
Iso-Palonen	Males	Juv.	0.22 ± 0.01		20.0 ± 0.775		0.71 ± 0.131	
		Ad.	0.33 ± 0.105		19.5 ± 0.646		2.55 ± 1.035	
	Females	Juv.	0.25 ± 0.039		18.8 ± 0.735		0.80 ± 0.144	
		Ad.	0.34 ± 0.087		18.4 ± 0.748		1.76 ± 0.512	
Elimyssalo	Males	Juv.	0.54 ± 0.077		16.6 ± 0.872		0.20 ± 0.037	
		Ad.	0.37 ± 0.103		15.8 ± 0.49		1.33 ± 0.64	
	Females	Juv.	0.43 ± 0.12		18.8 ± 2.905		0.26 ± 0.075	
		Ad.	0.56 ± 0.111		16.8 ± 0.663		1.37 ± 0.757	
Total material	Males		0.38 ± 0.03	[0.32]	17.3 ± 0.399	[17]	0.84 ± 0.192	[0.28]
	Females		0.41 ± 0.036	[0.30]	18.0 ± 0.598	[17]	0.84 ± 0.161	[0.53]
		Juv.	0.37 ± 0.032	[0.30]	18.6 ± 0.581	[18]	0.42 ± 0.055	[0.23]
		Ad.	0.41 ± 0.034	[0.32]	16.6 ± 0.368	[17]	1.25 ± 0.223	[0.55]
Oulanka			0.43 ± 0.048	[0.36]	16.6 ± 0.986	[16]	0.17 ± 0.013	[0.15]
Juortanansalo			0.38 ± 0.042	[0.30]	17.8 ± 0.512	[17.5]	0.91 ± 0.196	[0.64]
Iso-Palonen			0.28 ± 0.035	[0.22]	19.2 ± 0.369	[19]	1.45 ± 0.320	[0.87]
Elimyssalo			0.48 ± 0.051	[0.44]	17.0 ± 0.746	[17]	0.79 ± 0.262	[0.23]

Sorex araneus

Locality	Sex	Age	Pb		Cu		Cd	
Oulanka	Males	Juv.	0.32 ± 0.084		27.1 ± 0.914		0.98 ± 0.208	
	Females	"	0.32 ± 0.045		27.5 ± 0.697		0.93 ± 0.195	
Juortanansalo	Males	"	0.62 ± 0.184		30.2 ± 0.499		2.19 ± 0.271	
	Females	"	0.52 ± 0.116		28.0 ± 0.803		2.37 ± 0.349	
Iso-Palonen	Males	"	0.50 ± 0.144		30.4 ± 0.777		3.41 ± 0.419	
	Females	"	0.55 ± 0.1		28.6 ± 1.301		3.43 ± 0.697	
Elimyssalo	Males	"	0.82 ± 0.164		28.5 ± 1.098		2.90 ± 0.388	
	Females	"	0.93 ± 0.192		29.0 ± 0.699		2.96 ± 0.465	
Total material	Males	(Juv.	0.56 ± 0.078	[0.40]	29.1 ± 0.458	[30]	2.40 ± 0.218	[2.23]
	Females	only)	0.57 ± 0.068	[0.45]	28.2 ± 0.441	[29]	2.38 ± 0.266	[2.03]
			0.57 ± 0.051	[0.44]	28.7 ± 0.32	[29]	2.39 ± 0.172	[2.08]
Oulanka			0.32 ± 0.044	[0.20]	27.3 ± 0.539	[27]	0.95 ± 0.139	[0.73]
Juortanansalo			0.57 ± 0.16	[0.36]	29.1 ± 0.523	[30]	2.28 ± 0.216	[2.15]
Iso-Palonen			0.53 ± 0.085	[0.43]	29.5 ± 0.766	[30]	3.42 ± 0.396	[3.09]
Elimyssalo			0.87 ± 0.124	[0.75]	28.8 ± 0.636	[29]	2.93 ± 0.295	[2.76]

Table 3. Differences in the heavy metal concentration between separate locations (Wilcoxon's 2-sample test) on both species. The significance levels shown are as follows: ns = nonsignificant ($P>0.05$). * = significant ($P<0.05$), ** = very significant ($P<0.01$) and *** = highly significant ($P<0.001$).

	Pb			Cu			Cd		
	Juortanan-salo	Iso-Pal.	Elimyssalo	Juortanan-salo	Iso-Pal.	Elimyssalo	Juortanan-salo	Iso-Pal.	Elimyssalo
Clethrionomys glareolus									
Oulanka	0.876 ns	2.808**	0.508 ns	2.029*	3.523***	0.770 ns	4.282***	5.348***	3.048**
Juortanansalo	-	2.169*	1.402 ns	-	2.180*	1.790 ns	-	1.786 ns	1.609 ns
Iso-Palonen	-	-	2.987**	-	-	3.781***	-	-	3.337***
Sorex araneus									
Oulanka	1.272 ns	1.858 ns	3.711***	2.345*	2.162*	1.879 ns	4.329***	4.855***	4.883***
Juortanansalo	-	0.112 ns	1.968 ns	-	0.517 ns	0.300 ns	-	2.232*	1.542 ns
Iso-Palonen	-	-	2.267*	-	-	0.788 ns	-	-	0.798 ns

Table 4. The heavy metal concentrations in the bank vole (*Clethrionomys glareolus*) and the common shrew (*Sorex araneus*) in ascending order according to the locations.

	Clethrionomys glareolus	Sorex araneus
Pb	Iso-Palonen<Juortana<Oulanka<Elimys	Oulanka<Iso-Palonen<Juortana<Elimys
Cu	Oulanka<Elimys<Juortana<Iso-Palonen	Oulanka<Elimys<Juortana<Iso-Palonen
Cd	Oulanka<Elimys<Juortana<Iso-Palonen	Oulanka<Juortana<Elimys<Iso-Palonen

The general trend between the locations seems to be so, that the heavy metal concentrations at Oulanka are lower than those in the Friendship Park. In the separate parts of the Friendship Park highest values are met at Iso-Palonen and the lowest ones at Elimyssalo - lead forming an exception so that its highest values in both species are met at Elimyssalo.

Summary and discussion

The heavy metal concentrations in the kidneys and liver of the bank vole (*Clethrionomys glareolus* Schreb.) and the common shrew (*Sorex araneus* L.) were studied from the individuals snap-trapped in 1992 at three parts, Juortanansalo, Iso-Palonen and Elimyssalo, of the Finnish side of the Friendship Park (ca. 64°N, 30°E) and in the surroundings of the Oulanka Biological Station (ca. 66°N, 30°E). The kidneys and the liver of each individual were put together to form a sample from which the concentration of lead (Pb), copper (Cu), cadmium (Cd) and nickel (Ni) was analyzed with DCP-AES and ETAAS equipments (Department of Chemistry, University of Oulu). The total amount of samples was 159. Nickel was left out because of its very low level in the samples.

It was found out, that small mammals are generally speaking good bioindicators of heavy metals. There, however, are differences among them for instance so, that insectivores (a.o. common shrew, mole) represent the best and those species which eat mainly seeds (a.o. mice) the worst indicators, those eating also green parts of plants (a.o. field vole) falling in between them (Pankakoski 1989, Pankakoski et al. 1993).

The study areas (the trapping sites of the small mammals) were located in the immediate vicinity of the border zone between Finland and Karelian Republic (Russia) in coniferous zone. The distance from the nearest large industrial enterprice (Kostomuksha mining combinate) is 40-60 km into westerly/south-westerly direction to the Friendship Park and ca. 200 km into northwesterly direction to Oulanka. The main wind directions both at Kostomuksha and at the trapping sites are northeasterly in summer and southwesterly in winter times (Suomen Kartasto 1987, Atlas Karelskoi ASSR 1989), though the direction deviation between northeasterly/easterly and southwesterly/westerly winds is more even in summer than in winter. As a yearly average, the main sector for the wind directions is approximately from south to west.

There are no remarkable industrial enterprices in the town Kuhmo, which could cause mentionable pollution downflow in the area (Manninen & Huttunen 1989). The main air pollution is caused by energy production and traffic and thus consist mainly of oxides of sulphur and nitrogen, perhaps also including some amounts of lead and nickel (Aunela & Larjava 1990). The traffic density on the local and forest roads in the immediate vicinity of the trapping fields is very low and thus it cannot be thought to play any remarkable role for the results. The traffic density and the closeness of a road are usually found to correlate positively with kadmium and lead concentrations in small mammals (Quarles et al. 1974, Getz et al. 1977, Goldsmith & Scanlon 1977, Kirjalainen 1991).

When observing the heavy metal concentrations in the both species, one can notice, that the concentrations in the common shrew are higher than those in the bank vole (mean ppm: Pb = 0.57/0.39[0.37], Cu = 28.7/17.6[18.6] and Cd = 2.39/0.84[0.42] correspondingly [values for young bank voles in brackets]). The results are parallel to those got in other studies in Finland (Pankakoski 1989, Pankakoski et al. 1989) and the only exception in the areal results is caused by lead at Oulanka and even that is statistically insignificant ($t = 1.674^{NS}$).

In the different parts of the study area there are differences in the concentrations of the heavy metals in the common shrew so, that they are lower (measured as medians as well as means of the values) at Oulanka than at the Friendship Park. Lead forms an exception at Elimyssalo, as mentioned before. The results of the bank vole are parallel. The concentration of copper and cadmium were highest at Iso-Palonen in both species (for details see Tables 2 and 3). If the results are compared to those got from the vicinity of Helsinki, Capital of Finland, (Pankakoski 1989, Pankakoski et al. 1989) one can notice, that the better indicator species - the common shrew - shows in the Friendship Park concentration at its highest just 1/10 of the lowest concentration values of lead at the surroundings of Helsinki (med. 0.43/4.15 Iso-Palonen/Espoo), the concentration of copper is ca. 6 measuring units higher (med. 30/24.1 respectively) and of cadmium about the equal (med. 3.09/2.69 Iso-Palonen/Tikkurila).

The other indicator - bank vole - shows higher lead values in the Friendship Park than the lowest values around Helsinki, but just about 1/10 of the highest values there. Anyhow, the values are very low. The copper concentration is around the same size class (med. Iso-Palonen 19, Tikkurila 19.54 and Espoo 17.64). The concentration of cadmium is, as median, higher in the Friendship Park (0.23-0.87) than in the surroundings of Helsinki (0.00-0.29).

It is obvious, that part of the heavy metals in the study area results from airborne pollution (long-distance pollutants) brought by the southerly/southwesterly winds. However, it seems to be justified to assume, that especially the southern part of the whole study area - ie. the Friendship Park - gets more heavy metal downflow than the northernmost part of it - Oulanka - and that the surplus originates from the mining combinate of Kostomuksha and that the part of the Friendship Park (Iso-Palonen), nearest to the combinate, is beginning to reach the level which is more common for an industrialized, densely inhabited centre than for a natural forest. This is especially true in the case of copper and cadmium, the concentrations of which (a.o.) in mosses have been noticed to correlate negatively in respect to the distance from the combinate (see Virkanen et al. 1994) in the surrounding area.

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Heavy metals in moths of Elimyssalo Nature Reserve, Friendship Park

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Seven moth species were collected in the connection of a larger Lepidoptera inventory in 1991 in the area of the Nature Reserve Friendship for heavy metal analyses. Six metals; Cd, Cu, Fe, Mn, Ni and Zn were analysed using a Varian techtron 1200 atomic absorbtion spectrophotometer. *Hepialus fusconebulosus* which is living as larva on underground plant parts showed highest values. Cd, Cu and Zn contents in moths were higher than in mosses used as reference. Especially Mn and Cd contents in moths were higher than the values found in other connections from southern Finland. This was interpreted to be due to the emissions of Kostamus combinate.

Key words: Moth species, heavy metal content, food plants, Elimyssalo, Kuhmo

Introduction

Heavy metal load which is carried by dry and wet depositions can be measured from the mosses, because they take their nutrition from air and impurities are thus gathered upon their leaves (Virkanen et al. 1994, Kubin & Lippo 1996). The larvae of Lepidoptera as herbivorous insects, can easily accumulate metals, when they eat contaminated plants (Virkanen et al. 1994). On the other hand their larvae can get rid of unnecessary metals with the aid of faeces up to some extent (Pihlajamäki et al. 1989), but when the contents increase one can find residues also in adults. By choosing species which use different food plants as larvae, one can get better understanding from deposits coming to a certain district (Rantataro et al. 1990). In the vicinity of emission sources decrease in size of all instars of moths has been noticed (Heliövaara et al. 1989).

The aim of this study was to map the heavy metal load of moths in the area of Elimyssalo, Kuhmo, eastern Finland.

Methods

Samples and analyses

The study area is one of the Finnish subareas of the the Nature Reserve Friendship. The moth samples, representing seven different species (Table 1), were collected from the area of Elimyssalo, Kuhmo (64°10'N; 30°28'E) in a moth inventory (Leinonen 1992) with light traps and bait traps. The samples were kept in freezer until analysing. The sampling took place between 12.05. - 13.08. 1991. Total number of individuals analysed was 432, out of which 11 % were females. For reference material 230 samples of mosses (*Hylocomium splendens*) were collected from Kuhmo and analysed.

The heavy metal analyses were done at the end of 1991 and in the beginning of 1992. The heavy metal content of bait fluid was also analysed. Samples were first dried in freezer and finally at 40°C. Bait fluid was dried by evaporating it in a beaker. Dried moths and bait fluid were then weighed into teflon tubes and 15 ml concentrated nitrogen acid was added. Samples were wetburned in CEM-microwave in order to free metals from sample material. Zero and reference samples were also used. Burned samples were filtered through a Whatman 40-filter into 50 ml bottles, whereto the samples were diluted by ionefree and distilled water. The metal contents were then identified using a Varian techtron 1200 atomicbsorbtion spectrophotometer. Possible deviations from zero were taken away and the reference samples were compared to the their real contents. For further information concerning material and methods see Leinonen (1993) and Virkanen et al. (1994).

Results and discussion

Altogether six different heavy metals were inspected from seven different moth species. *Hylocomium splendens* was used as reference. The studied metals were cadmium, copper, iron, manganese, nickel and zinc (Table 1). The metal contents of bait fluid were clearly smaller than those measured from the moths. Because we do not know how much bait fluid occurred inside and on the insects, it is hard to estimate the contamination influenced by it. Anyway we suppose that it does not play any remarkable role in the results.

The contents of different metals varied from species to species (Table 1). In the case of four metals the highest values were recognised from *Hepialus fusconebulosus*, which had clearly higher contents of Fe, Mn and Zn than other species. This may be connected to the fact that the larva of this species is living on underground plant parts (Seppänen 1970). The lower values of Mn in *Ocropacha duplaris* and *Eulithis populata* are difficult to explain. The larvae of *O. duplaris* and *Orthosia gothica* after Seppänen (1970) use leaves of deciduous trees as their food plants, while the others are mainly living on *Vaccinium* shrubs, so it is not so easy to find any connection between the food plants and metal contents.

Table 1. Heavy metal contents of certain moths (Lepidoptera). A= Present study at Elimyssalo, eastern central Finland in 1991. B= After Pihlajamäki et al. 1989, Nuorteva et al. 1992, in Southern Finland. n=not determined

A. Metal content ppm (æg/g dry)

Spesies	Cd	Cu	Fe	Mn	Ni	Zn
Ochropacha duplaris	0.51	13	67	12	3	107
Eulitis populata	0.28	16	59	14	2	174
Orthosia gothica	0.19	15	63	95	–	212
Diarsia mendica	0.41	19	83	58	11	183
Xestia rhaetica	0.41	16	63	147	3	190
Xestia speciosa	0.30	20	75	99	3	151
Hepialus fusconebulosus	0.73	15	132	155	5	220
mean level	0.40	16	77	83	4	177
bait fluid	–	–	18	10	0.4	5.5
mosses mean	0.26	4	172	371	4	25
B.						
Dendrolimus pini	0.04	16	39	7	n	74
Thera obeliscata	0.11	16	12	22	n	223
Bupalus piniarius	0.00	10	59	24	n	211
Laothoe populi	0.17	15	74	3	n	274
Sphinx pinastri	0.09	16	86	4	n	172
mean level	0.10	15	54	12	n	160
Pinus sylvestris	0.22	2	95	180	n	53

When we compare the contents in moths and mosses, we can notice how the nickel contents were fairly similar. Cd, Cu and Zn contents were clearly higher in moths than in mosses. Fe and Mn, on the contrary, occurred in greater quantities in mosses. It is known that the shoots of *Pleurozium schreberi* are effective to absorb Mn (Virkanen et al. 1994).

The level of Cd and Cu of mosses in the present case seem to represent quite normal level but that of Ni is a little bit high when compared to common background values (Kubin & Lippo 1996). The values of Fe and Zn of the mosses are on the same level as found in lichens by Kubin (1990), while that of Mn seems to be exceptionally high, which may be due to Kostamus combinate. In mosses a decrease in growth has been observed and there exists a negative correlation between the distance from the combinate of Kostamus and heavy metals. This seems to indicate that the origin of Cd, Cu and Mn is at Kostamus (Virkanen et al. 1994). Measures (Poikolainen 1994) from the bark of pine (*Pinus sylvestris*) also show how the amounts of especially Fe and Ni are increasing close to Kostamus.

The heavy metal contents in moths are somewhat higher than the so called background value would presume. A clear exception can be registered in the case of Zn and Cu, where especially the amount of Zn exceeds the background level many times. Cu is an important metal in the blood of insects as is well known and it naturally explains the rised values. If we compare our figures to those observed in southern Finland and from different moth species (Pihlajamäki et al. 1989, Table 1), we can notice that the average values in the present case are on both sides of those.

Two striking exceptions are, however, to be seen. Mn-contents are eight time and Cd-content four time bigger here at Elimyssalo than in southern Finland. This seems to indicate, that these metal contents originate from Kostamus.

When we look at the heavy metal contents of different species counted on individual level, we see that the highest total accumulation is in *Xestia rhaetica* (7.876 μg/ind.) (Table 2). It is hard to find any clear reason for this. *X. rhaetica* has a two-year life cycle; it hibernates twice as larva (Mikkola et al. 1977). *X. speciosa,* which has the second highest value, has a same kind of a lifecycle. More observations are needed to conclude if this reflects the fact that these species are not so capable to exclude metals by faeces or if this results from their two-year life-cycle.

Table 2. Heavy metal contents in different (μg/ind.)

Species	Metal content (μg/ind.)						
	Cd	Cu	Fe	Mn	Ni	Zn	Total
Xestia speciosa	0.004	0.281	1.052	1.390	0.042	2.121	4.890
Xestia rhaetica	0.008	0.354	1.173	2.738	0.056	3.358	7.867
Ochropacha duplaris	0.006	0.142	0.733	0.131	0.033	1.171	2.216
Eulithis populata	0.001	0.072	0.265	0.063	0.009	0.783	1.193
Hepialus fusconebulosus	0.003	0.067	0.592	0.695	0.022	0.988	2.367
Orthosia gothica	0.002	0.167	0.700	1.054	0.000	2.354	4.277
Diarsia mendica	0.004	0.202	0.882	0.616	0.117	1.946	3.767

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Abstract	This publication contains the proceedings of a Finnish-Russian seminar held in Kuhmo, Finland 2. - 5.5.1994. In the seminar, the results of the ecological research in the Nature Reserve Friendship up to 1993 were presented. Part of the research was conducted in connection with the establishment of the town and iron mine of Kostomuksha in the 1970s. The nature conservation research co-operation in general started in 1990, but joint studies on wild forest reindeer have been conducted since the mid-1970s. This volume contains 30 articles of Finnish and Russian specialists, dealing with the fauna and flora of various groups, vegetation, landscapes, geology, climate and natural history of the nature reserve and adjacent areas. Attention has also been paid to the environmental efects of Kostomuksha iron mine and refinery.	
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Julkaisun nimi	Suomalais-venäläisen Ystävyyden luonnonsuojelualueen ekosysteemit, eläimistö ja kasvisto	
Julkaisun osat/ muut saman projektin tuottamat julkaisut		
Tiivistelmä	Julkaisu perustuu Kuhmossa 2. - 5.5. 1994 pidettyyn suomalais-venäläiseen seminaariin, jossa esiteltiin Ystävyyden luonnonsuojelualueen ekologisen tutkimuksen tuloksia. Osa tutkimuksista oli tehty Kostamuksen kaupungin ja rautakaivoksen perustamisen yhteydessä 1970-luvulla. Laaja luonnonsuojeluekologinen tutkimusyhteistyö alkoi vuonna 1990, mutta yhteistutkimuksia metsäpeurasta on tehty 1970-luvun puolivälistä alkaen. Tämä julkaisu sisältää 30 suomalaisten ja venäläisten asiantuntijoiden artikkelia, joissa käsitellään lajistoa eri eläin- ja kasviryhmissä, kasvillisuutta, alue-ekologiaa, geologiaa, ilmastoa ja luonnon historiaa Ystävyyden luonnonsuojelualueen eri osissa sekä niiden ympäristössä. Myös Kostamuksen rautakaivoksen ja -rikastamon ympäristövaikutuksia on tutkittu.	
Asiasanat	luonnon monimuotoisuus, metsät, suot, vesistöt, boreaaliset kasvillisuusvyöhykkeet	
Julkaisusarjan nimi ja numero	Suomen ympäristö 124	
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Rahoittaja/ toimeksiantaja	Ympäristöministeriö	
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Presentationsblad

Utgivare	Finlands miljöcentral	Datum September 1997
Författare	Tapio Lindholm, Raimo Heikkilä & Marjo Heikkilä (red.)	
Publikationens titel	Ekosystem, fauna och flora i det finskt-ryska naturskyddsområdet Vänskap	
Publikationens delar/ andra publikationer inom samma projekt		
Sammandrag	Publikationen är baserad på ett finskt-ryskt seminarium i Kuhmo 2. - 5.5. 1994. I seminariet presenterades resultat av ekologisk forskning i naturskyddsområdet Vänskap. En del av undersökningarna hade gjorts på sjuttiotalet i samband med planeringen av Kostamus stad och järngruva. Det omfattande naturskyddsekologiska forskningssamarbetet startades år 1990, men gemensamma undersökningar av skogsrenen hade gjorts från mitten av sjuttiotalet. Denna publikation innehåller 30 artiklar av finska och ryska specialister. Artiklarna innehåller information om fauna och flora i många djur- och växtgrupper, vegetation, landskapsekologi, geologi, klimat och naturhistoria i olika delar av naturskyddsområdet Vänskap och deras omgivningar. Också miljöeffekterna av järngruvan och järnkombinatet i Kostamus har undersökts.	
Nyckelord	biodiversitet, skogar, myrar, sjöar, boreala vegetationszonen	
Publikationsserie och nummer	Suomen ympäristö 124	
Publikationens tema	Natur och naturtillgångar	
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Название публикации

Экосистемы, фауна и флора российско-финляндского заповедника "Дружба"

Томы публикации

Резюме

Настоящая публикация основывается на материалах семинара, организованном в г. Кухмо со 2 по 5 мая 1994 г. В семинаре были представлены результаты экологических исследований в заповеднике "Дружба". Некоторые исследования были сделаны в 1970-х годах в связи с оснаванием г. Костомукша и горно-обоготительного комбината. Широкое эколого-исследовательское сотрудничество по охране природы началось в 1990 году, хотя общие исследования о лесном северном олене сделали уже в первой половине 1970-х годов. Настоящая публикация состоит из 30 докладов финских и русских специалистов. В докладах обсуждаются фауна и флора разных групп, растительность, ландшафтная экология, геология, климат и естественная история в разных частях заповедника "Дружба" и в их окружающей среде. Кроме этого, исследовали также влияние горно-обоготительного комбината на окружающую среду.

Ключевые слова

биоразнообразие, леса, болота, озеры, бореальная зона

Прочие сведения

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NATURE AND NATURAL RESOURCES

Ecosystems, fauna and flora of the Finnish-Russian Nature Reserve Friendship

The Nature Reserve "Friendship" was established in nearby territories of Russia and Finland in 1990 on the basis of a contract signed by the presidents of both countries, Michail Gorbachew and Mauno Koivisto. It consists of Kostomuksha strict nature reserve (zapovednik) on the Russian side, covering 47 500 hectares, and five nature reserves on the Finnish side, Ulvinsalo, Elimyssalo, Lentua, Iso-Palonen - Maariansärkät and Juortanansalo, covering altogether 22 000 hectares. The nature reserves consist of primaeval boreal coniferous forests (western taiga), small aapamires and humic lakes.

The Finnish-Russian research cooperation in the Nature Reserve "Friendship" is based on research programmes ratified by the ministries of environment of Finland and Russia for two year periods. The main aims of the research are to study the importance of nature reserves of different sizes and types in protecting the biodiversity of boreal nature. Comparative studies on the different sides of the boundary are important, because there is a great difference in land use history in Russia and Finland along the boundary, which has been in the same place for 400 years. On the Russian side there are still very large primaeval areas, while in Finland the intensive land use has caused a high degree of fragmentation in the nature.

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