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PALEOLIMNOLOGICAL STUDIES OF TUNDRA LAKES IN THE PECHORA DELTA (NENETS AUTONOMOUS REGION, RUSSIA)

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ABSTRACT

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. Polar region of the Russia not only play the leading role in world climatic system, but also quickly, with high sensitivity react to climatic changes. Investigation of lake from arctic region has an extreme importance for understanding of the modern environmental processes and their influence on northern ecosystems and biological diversity of these regions. Limnological characteristics and recent environmental history of twelve remote tundra lakes in the Pechora Delta (Nenets Autonomous Region, Russia) were investigated using both limnological and palaeolimnological methods with particular attention to subfossil Cladocera. All the lakes were sallow, alkaline or neutral, with an average pH of 8.2 and characterized by a low mineralization level. In total five cores were obtained in summer 2017, sliced into 1.0 cm-thin samples in the field and further investigated using palaeolimnological methods. Tree cores were freeze-dried and analysed for ^{210}Pb dating. ^{210}Pb results indicate a relatively stable, recent sedimentation rate of about 0.02-0.03 cm/a. The species distribution of Cladocera remains in recent sediment layers was similar to that observed in contemporary water samples. Subfossil Cladocera assemblages are characterized by the dominance of *Chydorus sphaericus* s.l., *Bosmina (Eubosmina) longispina*, *Daphnia pulex* agg. Paleolimnological investigation has shown that the major compositional changes in cladoceran and other paleoindicators are synchronous.

Keywords: subfossil Cladocera, tundra lakes, Pechora delta

INTRODUCTION

Arctic and Subarctic regions have attracted considerable interest of researchers at the recent years. Thought to be that high-latitude regions play a strong role in climatic forcing, and may be particularly sensitive to climate change. Climate change and active development of Far North territories lead to negative consequences like breaking a fragile balance of northern ecosystems, known as systems with a low degree of resistance to anthropogenous influence and extremely slow speed of restoration.

Cladocerans (Cladocera: Branchiopoda: Crustacea) are a key component of aquatic ecosystems, which have been used often in paleoecological reconstructions of climatic and environmental change. Their chitinous exoskeletal components (shell, head shield, postabdomen, postabdominal claws, antennal segments, and mandibles) are usually well

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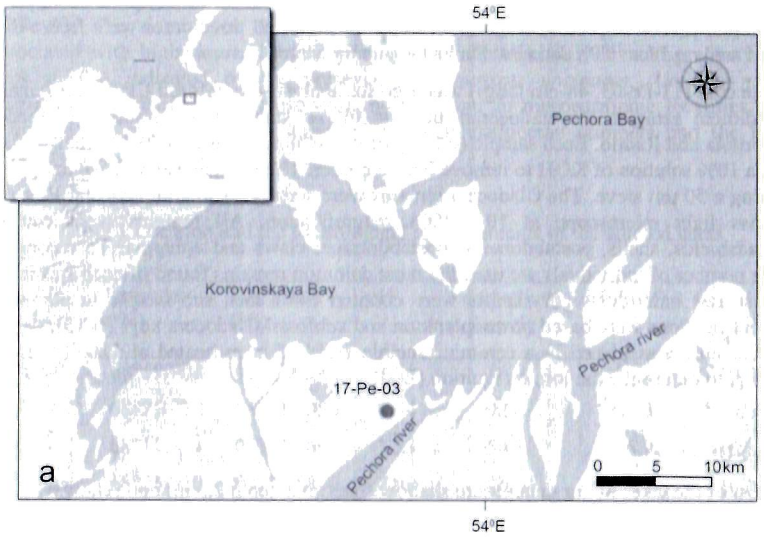
preserved after death in lake sediments. Furthermore, most of them are identifiable to a species level. Ecological information exists for most species, and they are sensitive to changes in climate and environmental variables such trophic state, conductivity, saline transgressions and predation intensity [1-2]. The aim of the present investigation was to examine the taxonomic and ecological diversity of cladoceran microfossil assemblages from lakes in Pechora Delta catchment area (north-east Europe, Russia).

STUDY AREA

The study sites included 12 lakes distributed in the Pechora Delta basin (Fig. 1). The climate of the region is subarctic with long and cold winters, which lasts up to 8 months, and minimum temperatures going below –50°C in January. Summer is short and cool. The warmest month is July [3] with the mean temperatures ranging from 8 to 12°C [4]. The average annual precipitation varies from 370 to 395 mm [4]. Periglacial landscape is dominated by tundra vegetation, deep-reaching frozen ground and widespread lake districts. Study region is underlain by continuous permafrost. Most of lakes are considered to be of oxbow or thermokarst origin. These lakes are small, shallow and characterized by specific thermal and chemical regimes, making them very sensitive to recent climate changes [5]. The period of open water and, respectively, vegetation period for the majority of the water organisms, such as Cladocera, is limited in the Pechora Delta by a short temporary interval of two or three months.

MATERIAL AND METHODS

Limnological characteristics and recent environmental history of twelve remote tundra lakes in the Pechora Delta (Nenets Autonomous Region, Russia) were investigated using both limnological and palaeolimnological methods with particular attention to subfossil Cladocera. The hydrochemical samples for each site were taken from the surface water layer (0.5-1 m) at the centre of each lake. We quantified the pH, water temperature, oxygen concentration and electrical conductivity (EC) using a handheld multi-parameter instrument (WTW 340i) equipped with the appropriate sensors (pH: SenTix 41; Oxygen: CellOx 325; EC and temperature: Tetracon 325). Five sediment cores for palaeoecological studies were collected in late August 2017, using a Uwitec gravity corer from three lakes.



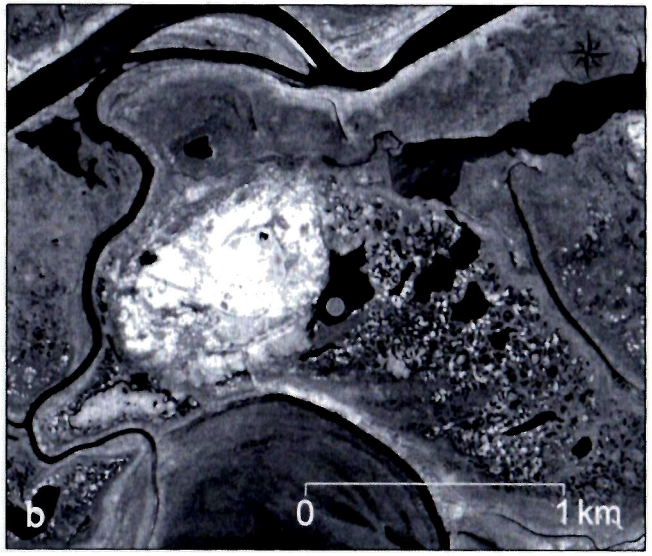


Figure 1. Location (a) and catchment characteristics (b) of studied lake 17-Pe-03

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The sediment cores were sectioned at 1-cm intervals and the subsamplees were placed in small plastic bags for storage in a coldroom. Later, all three cores were freeze-dried and analysed for ^{210}Pb dating at Sankt-Petersburg State University.

One core (11-Pe-03, 48-cm long)) was used for analysis of subfossil Cladocera remains. Sediment samples for cladoceran analysis follow standard techniques described in Korhola and Rautio. Each sample (0,5-1 g of dry sediments) was boiled for half an hour in a 10% solution of KOH to remove humic matter. The residue was washed and sieved using a 50 µm sieve. The Cladocera remains were screened using an Axiostar Plus Carl Zeiss light microscope at 100×-400× magnification. All remains were counted: headshields, shells, postabdomens, postabdominal claws and ephippia. To reconstruct the number of individuals we used the most common remains found of each species. At least 100 individuals per sample were counted from each sub-sample in our study. Identifications were based on zooplankton and subfossil Cladocera keys [6-13]. A 0.5 g subsample was placed in a ceramic crucible and had been heated at 1100°C for two hours to determine the loss on ignition (LOI).

RESULTS

Most of the lakes in our data set are shallow (maximal depth 2.2 m) and relatively small. All the lakes were alkaline or neutral and characterized by a low mineralization level. pH varies from 7.00 to 9.14 (mean value 8.20) (Table 1). The conductivity does not exhibit much variations between the lakes and range from 54.1 to 335.0 µS cm^{-1} (mean value 141.8). Analysis of the ion composition showed that Ca^{2+} and Na^{2+} dominated the cations with HCO_3^- as the primary anion.^{210}Pb results indicate a relatively stable, recent sedimentation rate of about 0.02-0.03 cm/a.

The lake 11-Pe-03 (68°11′30.8″N, 53°47′36.2″E) has thermokarst origin (Fig. 1). The lake is low-conductivity, with pH 7.2 and with prevailing bicarbonate-calcium water composition (Table 2). During our expedition at the end of July the water temperature was 15.0–15.5°C. Mean July temperature 12.9°C [3]. The greatest depth (2.0 m) was recorded in the southern part of the lake, but most of the lake is 1-1.5 m deep (Fig. 1).

The structure of bottom sediments is characterized by an increase in the proportion of organic material (LOI). The LOI varies between 0.9 and 2.9% at the beginning of the stratigraphy and increases constantly to approx. 30.2 -32.8% towards the surface sediment.

The species distribution of Cladocera remains in recent sediment layers was similar to that observed in contemporary water samples. The cladoceran assemblages were quite rich and diverse in all lakes with relatively stable structures. A total of 27 cladoceran taxa, of which 21 are in the family Chydoridae, were identified from the core 17-Pe-03. The most common cladocerans taxa were *Chydorus sphaericus*, *Alona guttata/rectangular, Bosmina (Eubosmina) longispina* (frequency of occurrence 100 %). Bottom part of the core is characterized by the dominance of cold water pelagic taxa *Bosmina (Eubosmina) longispina*, *Chydorus sphaericus* s.l. and small taxa of genius *Alona* (*guttata/rectangula*). A considerable change occurred in the planktonic cladoceran assemblages during the last time. Our record indicates considerable change in Cladocera assemblages. The most common taxa in the top part of core are *Chydorus sphaericus* s.l., *Pleuroxus uncinatus, Alonella nana*, which increased markedly towards

the top. The changes in cladoceran fauna reflected the increase of trophic state of lake 17-Pe-03. The dominance of the cladoceran *Chydorus sphaericus s.l.*, a species associated with high nutrient status, suggests that the lake had elevated productivity. This is also indicated by the presence of *Pleuroxus uncinatus*, *Alonella nana, Disparalona rostrata*, since these taxa mostly occur in mesoeutrophic localities. An eutrophication process is also indicated by high cladoceran numbers and the high organic content of the sediment.

Table 1 Location and the limnological measurements of the studied lakes

Lake No.	Latitude (°N)	Longitude (°E)	pH	Conductivity (µS cm^{-1})	Eh (mV)	O_2 (mg L^{-1})
17-Pe-01	68°19.901	053°38.247	7.86	86.0	-50.5	10.38
17-Pe-02	68°25.722	053°37.955	8.54	92.4	-87.3	10.61
17-Pe-03	68°11.514	053°47.603	7.23	54.1	-15.9	10.09
17-Pe-04	68°25.020	053°38.860	7.98	86.6	-57.2	10.01
17-Pe-05	68°23.233	053°38.009	8.61	87.7	-87.4	10.9
17-Pe-06	68°22.752	053°39.601	7.91	20.7	-52.8	10.31
17-Pe-07	68°25.51.4	053°33.10.8	7.00	33.3	-1.0	10.39
17-Pe-08	68°12.940	053°44.394	8.04	170.4	-56.5	10.36
17-Pe-09	68°19.834	053°38.386	7.26	131.4	-15.5	-
17-Pe-10	68°14.724	053°51.875	7.43	186.6	-23.7	9.78
17-Pe-11	68°14.472	053°52.778	7.75	335.0	-13.8	6.65
17-Pe-12	68°01.026	053°36.697	7.56	142.2	-32.3	-

Table 2 Physical and chemical data from free sampling lakes in the Pechora Delta

Variable	17-Pe-01	17-Pe-02	17-Pe-03
T_{water} (°C)	15.7	15.3	15.4
Water depth (m)	1.5	2.2	2.0
Cl^- (mg L^{-1})	3.79	6.64	14.56
SO_4^{2-} (mg L^{-1})	1.13	1.45	4.45
Ca^{2+} (mg L^{-1})	3.68	9.91	4.75
Mg^{2+} (mg L^{-1})	1.48	1.11	1.83
Na (mg L^{-1})	3.39	5.41	12.90
K^+ (mg L^{-1})	0.32	0.17	0.99

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CONCLUSION

Limnological characteristics and recent environmental history of twelve remote tundra lakes in the Pechora Delta (Nenets Autonomous Region, Russia) were investigated using both limnological and palaeolimnological methods with particular attention to subfossil Cladocera. Cladocera (Crustacea: Branchiopoda) are a key component of aquatic ecosystems. Most of the lakes in our data set are shallow (maximal depth 2.2 m) and relatively small. All the lakes were alkaline or neutral and characterized by a low mineralization level. pH varies from 7.00 to 9.14 (mean value 8.20). Analysis of the ion composition showed that Ca^{2+} and Na^{2+} dominated the cations with HCO_3^- as the primary anion.^{210}Pb results indicate a relatively stable, recent sedimentation rate of about 0.02-0.03 cm/a. The structure of bottom sediments is characterized by an increase in the proportion of organic material (LOI) to approx. 30.2 -32.8% towards the surface sediment. The species distribution of Cladocera remains in recent sediment layers was similar to that observed in contemporary water samples. A total of 27 cladoceran taxa were identified from the core 17-Pe-03. Subfossil Cladocera assemblages are characterized by the dominance of *Chydorus sphaericus* s.l., *Bosmina (Eubosmina) longispina*, *Daphnia pulex* agg. The changes in cladoceran fauna reflected the increase of trophic state of Lake 17-Pe-03. An eutrophication process is also indicated by high cladoceran numbers and the high organic content of the sediment.

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