New data on the zooplankton of watercourses of the National Park "Krasnoyarsk Stolby"

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Based on natural materials collected by the authors in 2020-2022, data on zooplankton in the watercourses of the "Krasnoyarsk Stolby" National Park are summarized. A list of 85 species is given: 38 species and subspecies of rotifers, 26 species of cladocerans, 11 species of cyclops, and 10 species of harpacticidae. For the first time, 24 species of rotifers, 10 species of cladocerans, 14 species of copepods were discovered or identified to species.

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Introduction

"Krasnoyarsk Stolby" is a national park in the Krasnoyarsk Territory on the northwestern spurs of the Eastern Sayan, bordering on the Central Siberian Plateau. The natural boundaries of the protected area are the right tributaries of the Yenisei: in the northeast - the Bazaiha river, in the south and southwest - the Mana and Bol'shaya Slizneva rivers.

The territory of the reserve has a well-developed hydrographic network with a total length of more than 300 km, which is grouped into four different drainage basins – basin of Mana river, basin of Bazaha river, basin of Bol'shaya Slizneva river and the Yenisei itself. All rivers and streams have a typical mountain character.

The first hydrobiological and ichthyological studies of reservoirs in protected areas, including the study of the species composition of zooplankton, were carried out in the period from 1956 to 1960 by Yu. I. Zapekina-Dulkeit and G. D. Dulkeit (Zapekina-Dulkeit and Dulkeit G.D. 1961). The Mana River and its basin were studied in some detail in the period from 1966 to 1970, including 20 zooplankton samples were taken, the determination of which was carried out by T.V. Chervinskaya (Zapekina-Dulkeit 1972). In a later period, no more work was carried out on the study of zooplankton directly on the territory of the national park “Krasnoyarsk Stolby”. Monitoring of the mouth zones of the Mana and Bazaikha rivers, which are subject to significant anthropogenic impact, does not give an idea of the plankton structure of watercourses in the protected area itself (Lukashina et al. 2021).

The purpose of this work is to inventory the species composition of zooplankton inhabiting the water bodies of the “Krasnoyarsk Stolby” National Park.

Materials and methods

In the summer period (July-August) 2020-2022, the employees of the Novosibirsk branch of the Institute of Water and Environmental Problems of the Siberian Branch of the Russian Academy of Sciences conducted reconnaissance hydrobiological studies of a number of watercourses draining the territory of the “Krasnoyarsk Stolby” National Park.

Investigated watercourses:

- Rivers of Yenisei basin: Bol'shaya Slizneva river, Laletina stream;

- River of Mana basin: river Mana at the sites of the Berly and Kandalak cordons, Snezhnaya stream, Lomovaya stream, Berly stream, Krivopohval'nyj stream, Knyazeva stream, Hajdynka stream, Vynosnaya stream, Maslyanka stream, floodplain lake near the mouth of the Maslyanka stream, Malyj Indej stream, Srednij Indej stream, Bol'shoj Indej stream, Sarala stream, Kandalak oxbow;

- Bazaiha river basin: river Bazaiha at the sites of the Dolgusha and Synzhul cordons and within the city of Krasnoyarsk in the mouth zone, the river Kaltat, Synzhul stream, Bol'shoj Inzhul stream, Vesyolyj stream (Fig. 1).

Zooplankton were collected by filtering 100 liters of water through an Apstein net with a mesh size of 65 µm. Samples were fixed with 4% formalin (Guidelines... 1982; Guidelines... 1992). To determine the taxonomic composition and count the number of zooplankton, the samples were analyzed in the Bogorov chamber (Guidelines... 1992). A total of 60 zooplankton samples were taken.

During the research, the following were measured: depth, transparency, water temperature, concentration of oxygen dissolved in water, pH, mineralization (according to NaCl), content of organic substances (according to BOD_5). The concentration of oxygen dissolved in water, the percentage of water saturation with oxygen, and the water temperature were measured using a Mark-302M oximeter. Water mineralization and pH were measured using an ANION 4120 portable ion-selective instrument.

The Shannon index values were calculated taking into consideration both the parameters of number and biomass (Shitikov et al. 2005), since this version of the calculations "harmoniously combines both factors of abundance" (Rozenberg 2010).

Figure 1. *Map-scheme of the location of observation sites in the territory of the Krasnoyarsk Stolby National Park.*

Redundancy analysis (RDA) was performed using a covariance method to determine the relative importance of environmental factors in explaining the variability in the numbers of individual zooplankton species in the Past v.4.08 (Hammer et al. 2001). The data set for analysis contained the measured physicochemical parameters of the water and the species richness of zooplankton.

Since redundancy analysis works better when the variables are distributed close to normal, the data is Hellinger-transformed (logarithm log(x+1)) to give equal weight to all variables (TerBraak 1995; Ramette 2007; Zuur et al. 2010).

Results and discussion

The studied watercourses are important both in terms of hydrological regime and hydrochemical parameters (Table 1).

The water temperature in the studied watercourses ranged from 7.0 to 24.1 °C. the coldest were spring-fed streams. Larger rivers (Mana, Bazaiha, Kaltat) in the summer low water have a higher temperature value, especially in the mouth zone of observation, where the speeds are manifested by respiratory diseases. The highest temperatures are observed in the floodplain and oxbow lake.

According to the pH level, the water of almost all the studied watercourses is neutral or slightly acidic, with the exception of the Bazaiha river, in which the pH level is consistently more alkaline, and Veseliy stream, which is a tributary of the Bazaiha river (Table 1).

According to the level of water mineralization, all surveyed watercourses belong to hypohaline fresh waters.

The concentration of dissolved oxygen in water in all watercourses is high (from 7.1 to 13.59 mg/l), which corresponds to the ecological optimum. According to the degree of saturation of water with oxygen, all water bodies belong to the classes of extremely pure and pure waters (Oksiyuk et al. 1993).

The content of freshly formed organic substances in water (by BOD_5), according to the complex hydrochemical classification (Oksiyuk et al. 1993), in most of the studied watercourses corresponds to the class of extremely pure and pure waters. The prolonged rain flood of 2020 had a great impact on the content of organic substances in the water, which were washed away from the catchment area and moved at high speed in the water stream without having time to be utilized. Accordingly, by the BOD_5 value, the water of all the studied watercourses in 2020 belonged to the class of moderately polluted waters.

All studied watercourses are characterized by a relatively high flow velocity, rocky soils, a large number of flooded tree trunks and shrubs in the channel.

At the time of the study, 85 species were identified in zooplankton in the watercourses of the Krasnoyarskiye Stolby National Park: 38 species and subspecies of rotifers, 26 species of cladocerans, 11 species of cyclops, and 10 species of harpacticidae (Table 2).

Watercourse	Date	Coordinates	Depth, m	Water temperature, °C	pH	Mineralization, ppm	O2, mg/l	O2, %	BOD5	Bottom sediments
Bol’shaya Slizneva river	23.07.20	55°57'05" N 92°36'57"E	0.30	7.9	7.68	151.2	12.95	101.9	4.23	boulders, pebbles
Kaltat river	23.07.20	55°56'32" N 92°50'22"E	0.30	10.2	6.83	145.60	12.73	112.80	3.81	boulders, pebbles
Laletina stream	23.07.20	55°57'04" N92°44'44"E	0.15	9.5	7.18	106.70	12.88	109.90	3.98	stony-pebble
Bazaiha river at the site of the Dolgusha cordon	09.08.22	55°49’04” N 93°05’37” E	0.40	18.4	8.3	204.7	7.5	88.4	0.2	boulders, pebbles
Bazaiha river at the site of the Inzhul cordons	10.08.22	55°50’00” N 93°02’29” E	0.15	17.4	8.4	182.7	10	104.5	0.3	boulders, pebbles
Bazaiha river at the site of the Synzhul cordons	24.07.20	55°54'42" N92°53'13"E	0.50	11.9	8.55	181.50	12.95	120.80	4.23	pebble sand

Bazaiha river in the mouth zone	24.07.20	55°58'18" N 92°47'23"E	0.4	14.2	8.32	168.80	12.44	119.50	4.50	sand and pebble with silt
Bazaiha river in the mouth zone	10.08.22	55°58’18” N 92°47’22” E	0.5	24.1	8.4	166.7	8.4	100.4	4.4	pebble sand
Synzhul stream	24.07.20	55°54'39" N92°53’05"E	0.20	7.0	8.50	154.50	13.59	111.60	4.91	stony-pebble
Kaltat river	16.08.21	55°56’31” N 92°50’07”E	0.20	10.2	6.6	47.0	-	-	-	boulders, pebbles
Bol’shaya Slizneva river	16.08.21	55°57’07” N 92°36’59”E	0.40	11.4	6.93	135	-	-	-	boulders, pebbles
Laletina stream	16.08.21	55°57’02” N92°44’40”E	0.10	10.8	6.89	119	-	-	-	stony-pebble
Berly stream	17.08.21	55°43’32” N93°01’10”E	0.10	10.8	6.79	152	11.2	101.1	2.31	stony-pebble
Snezhnaya stream	17.08.21	55°43’17” N93°90’13”E	0.35	12	6.82	111	11.1	101.1	-	stony-pebble
Lomovaya stream	17.08.21	55°43'56" N93° 01'27"E	0.15	11.9	-	-	10.96	101.1	-	boulders, pebbles
Knyazeva stream	17.08.21	55°42’21” N92°51’38”E	0.10	13.8	6.72	87	10.48	100.2	-	boulders, pebbles
Mana river at the site of the Berly cordon	17.08.21	55°42’37” N92°57’25”E	1.00	17.9	7.2	108	10.93	115.2	-	pebble sand
Mana river at the site of the Kandalak cordon	19.08.21	55°47'34" N92°41'59"E	0.50	16.5	7.15	106	9.88	100.7	2.48	pebble sand
Krivopohval’nyj stream	18.08.21	55°43'45" N92°55'13"E	0.20	11.1	6.7	82	11.39	103.3	-	boulders, pebbles
Hajdynka stream	18.08.21	55°43’46” N92°53’55” E	0.20	11.8	6.41	55	11.23	102.7	-	rocky
Vynosnaya stream	18.08.21	55°43'44" N92°52'41"E	0.20	10.9	6.72	152	11.22	99.5	-	rocky
Maslyanka stream	18.08.21	55°43’59” N92°47’43” E	0.10	8.1	6.98	175	10.87	91.1	2.76	rocky
Floodplain lake near the mouth of the Maslyanka stream	18.08.21	55°44’06” N92°46’51” E	0.50	22.1	6.72	95	7.4	88.7	2.36	muddy silt
Srednij Indej	19.08.21	55°45’24” N92°46’4	0.40	11.3	6.75	53	11.28	103	-	pebble sand

stream		1” E								
Malyj Indej stream	19.08.21	55°45’23” N92°46’4 1” E	0.20	8.8	6.68	71	8.98	77.1	-	pebble sand
Bol’shoj Indej stream	19.08.21	55°46'02" N92°46'4 1"E	0.40	9.5	6.72	105	11.76	102.5	3.68	boulders, pebbles
Sarala stream	19.08.21	55°46’30” N92°44’3 8” E	0.15	10.2	7.00	143	11.47	102.6	-	boulders, pebbles
Kandalak oxbow	19.08.21	55°46’24” N92°43’4 6” E	0.15	18.1	7.13	108	9.34	101.1	-	silty sand
Kaltat river	08.08.22	55°56’31” N 92°50’07” E	0.20	17.0	7.7	72.7	7.1	79.1	0.5	boulders, pebbles
Vesyolyj stream	09.08.22	55°48’49” N 93°05’21” E	0.2	12.9	8.1	218.7	8.5	100.3	0.5	stony-pebble
Bol’shoj Inzhul stream	08.08.22	55°50’07” N 93°02’37” E	0.2	11.4	7.7	186.7	9.1	83.7	0.2	stony-pebble

Table 1. *Localization of sampling sites and some physicochemical characteristics of the watercourses of the “Krasnoyarsk Stolby” National Park*

Taxa	Synzhul stream	Bazaiha river	Bol’shaya Slizneva river	Kaltat river	Laletina stream	Mana river	Berly stream	Knyazeva stream	Vynosnaya stream	Maslyanka stream	Hajdynka stream	Malyj Indej stream	Srednij Indej stream	Floodplain lake near the Maslyanka stream	Kandalak oxbow	Bol’shoj Inzhul stream	Vesyolyj stream
Phylum: Rotifera Cuvier, 1817																	
Asplanchna herricki de Guerne, 1888*														+			
Asplanchna priod Gosse, 1850														+			
Brach	+	+	+	+													

ionus angularis Gosse, 1851*																		
Brachionus angularis bidens Plate, 1886*					+													
Brachionus bennini Leissling, 1924*												+						
Brachionus calyciflorus var. d Gosse, 1851*			+															
Brachionus leydigii Cohn, 1862*			+															
Cephalodella forficula (Ehrenberg, 1830)				+											+			
Colurella obtuse (Gosse, 1886)*					+													
Conochilus unicornis Rousselet, 1892**														+				

Euchlanis deflexa Gosse, 1851*				+	+										+		
Euchlanis dilatata Ehrenberg, 1832															+		
Euchlanis dilatata luck Hauer, 1930*		+				+									+		
Euchlanis incise Carlin, 1939*			+														
Euchlanis lyra Hudson, 1886		+				+											
Euchlanis meneta Myers, 1930*		+												+			
Euchlanis pyriformis Gosse, 1851*														+			
Euchlanis triquetra Ehrenberg, 1838															+		
						+											

Filinia longiseta (Ehrenberg, 1834)																	
Keratella cochlearis (Gosse, 1851)*						+								+			
Keratella quadrata (Müller, 1786)	+	+	+	+		+		+									
Lecane flexilis (Gosse, 1886)*	+																
Lecane luna (Müller, 1776)*						+											
Lepadella acuminata (Ehrenberg, 1834)		+		+									+				
Mytilina mucronata spinigera (Ehrenberg, 1830)*														+			
Mytilina ventrali														+			

s (Ehrenberg, 1832)																	
Notholca acuminata (Ehrenberg, 1832)		+				+											
Notommata aurita (Müller, 1786)*		+															
Plationus patulus (Müller, 1786)														+			
Polyarthra euryptera Wierzejski, 1891*														+			
Polyarthra minor Voigt, 1904*														+			
Polyarthra vulgaris Carlin, 1943*														+			
Pompholyx sulcata Hudson, 1885*		+															
Rotar		+	+														

ia rotatoria (Pallas, 1766)*																	
Synchaeta pecti Ehrenberg, 1832														+			
Synchaeta tremula (Müller, 1786)*		+												+			
Testudinella patina (Hermann, 1783)		+												+	+		
Trichotria similis (Stenroos, 1898)*	+														+		
Subphylum: Crustacea Brünnich, 1772																	
Suborder: Cladocera Latreille, 1829																	
Acroperus harpae (Baird, 1834)															+		
Alona												+					

costata Sars, 1862*																	
Alona guttata Sars, 1862*															+		
Alona intermedia Sars, 1862*															+		
Alona quadrangularis O. F. Müller, 1776														+			
Alonella excisa (Fischer, 1854)														+			
Alonella (Baird, 1850)*														+	+		
Alonella exigua (Lilljeborg, 1853)						+											
Biapertura affinis (Leydig, 1860)*															+		
Bosmina (Eubosmina) coregoni Baird, 1857						+								+			

Ceriodaphnia quadrangula (O.F. Müller, 1785)														+	+			
Ceriodaphnia pulchella Sars, 1862						+								+	+			
Chydorus sphaericus (O.F. Müller, 1776)		+												+	+			
Daphnia (Daphnia) Leydig, 1860														+				
Disparalona rostrata (Koch, 1841)*															+			
Eurycercus lamellatus (O.F. Müller, 1776)															+			
Graptoleberis testudinaria (Fisch														+	+			

er, 1851)																	
Lathonura rectirostris (O.F. Müller, 1785)*														+	+		
Megafenestra aurita (Fischer, 1849)*														+			
Peracantha truncata (O. F. Müller, 1785)															+		
Pleuroxus aduncus (Jurine, 1820)**															+		
Pleuroxus trigonellus (O. F. Müller, 1776)**														+			
Scapholeberis mucronata O. F. Müller, 1776		+													+		
Simocephalus exspinosus (DeGeer, 1778)*														+			
															+		

Simocephalus vetulus (O. F. Müller, 1776)																	
Sida crystallina (O. F. Müller, 1776)*															+		
Subclass: Copepoda Milne-Edwards, 1840																	
Order: CyclopoidaBurmeister, 1834																	
Acanthocyclops vernalis (Fischer, 1853)	+														+		
Acanthocyclops v (Jurine, 1820)		+				+											
Cyclops strenuus strenuus Fischer, 1851						+											
Eucyclops macruroides (Lilljeborg,															+		

1901)																	
Eucyclops serrulatus var. proximus (Lilljeborg, 1901)**															+		
Macrocyclops albidus (Jurine, 1820)														+	+		
Macrocyclops fuscus (Jurine, 1820)														+	+		
Mesocyclops leuckarti (Claus, 1857)*	+		+			+				+			+	+	+		+
Paracyclops affinis (Sars G.O., 1863)*								+									
Paracyclops fimbriatus (Fischer, 1853)*	+		+	+		+		+				+			+		
Thermocyclops oithonoides (Sars G.O.,														+			

1863)*																	
Order: Harpacticoida Sars, 1903																	
Attheyella crassa Sars G.O., 1863*	+	+						+		+							
Bryocamptus vejdovskyi (Mrázek, 1893)*					+		+		+			+					
Canthocamptus staphylinus (Jurine, 1820)*						+											
Epactophanes richardi richardi Mrázek, 1893*																+	
Maraenobiotus insignipes (Lilljeborg, 1902)*	+			+				+		+	+		+	+	+		
Moraria brevipes Sars G.O., 1863*	+																
Nannopus														+			

palustris Brady, 1880*																	
Nitokra hibernica (Brady, 1880)*	+						+							+	+		
Pesceus schmeili sch (Mrázek, 1893)*								+						+			
Phyllognathopus paludosus Mrázek, 1893*	+			+						+							

Table 2. *Species composition of zooplankton in the watercourses of the "Krasnoyarsk Stolby" National Park.* Note: * – the species was recorded for the first time for the watercourses of the "Krasnoyarsk Stolby" National Park; ** – the species definition has been clarified (previously only the genus was indicated).

Bol'shaya Slizneva river

In a section 1500 m above the mouth, the number of zooplankton in 2020 during the rainy flood was 200 ind./m^3 with a biomass of 3.3 mg/m^3. The Shannon-Weaver species diversity index was 1.18 bit. In this area, a biocenosis was observed, the basis of which was eurybiont forms of copepods and rotifers. Species of *Euchlanis incisa* and *Rotaria rotatoria* noted in the main river channel, which are not typical for river ecosystems, got into the main stream from small swampy backwaters and oxbow lakes. In 2021, in the same area, the abundance of zooplankton was 100 ind./m^3 with a biomass of 0.6 mg/m^3. The basis of the biocenosis was also formed by eurybiont forms of copepods and rotifers. The Shannon-Weaver species diversity index was 1.05 bit.

Kaltat river

In 2020 in the area 1500 m above the mouth the number of zooplankton was 200 ind./m^3 with a biomass of 3.0 mg/m^3. Juvenile stages of copepods, rotifers and harpacticides have been found. In 2021, in the same area, the abundance of zooplankton was 60 ind./m^3 with a biomass of 0.9 mg/m^3. The community also includes juvenile stages of copepods, rotifers, and harpacticides. Among the Cyclopoida, only the nektobenthic *Paracyclops fimbriatus* was noted. The Shannon-Weaver species diversity index in both 2020 and 2021 was 1.05 bit. The basis of the biocenosis was eurybiont forms of rotifers.

Bazaiha river

In the area 16.5 km upstream of the mouth in 2020, the abundance of zooplankton was 140 ind./m^3 with a biomass of 1.75 mg/m^3. Rotifers and juvenile stages of copepods dominated. The Shannon-Weaver species diversity index was 1.25 bits. In the area 1 km upstream of the mouth, the number of zooplankton was 200 ind./m^3, the biomass was 2.17 mg/m^3. 6 species of rotifers and juveniles of cyclops and harpacticids were found. Rotifers dominated in numbers. The Shannon-Weaver species diversity index was 1.06 bit.

In 2022, sections of the river were surveyed in the areas of the Dolgusha and Inzhul cordons (Fig. 1). At the site near the Dolgusha cordon, the abundance of zooplankton was 40 ind./m^3 with a biomass of 0.76 mg/m^3. Zooplankton was represented only by nektobenthic Harpacticoida. At the site near the cordon Inzhul, the abundance of zooplankton was 140 ind./m^3 with a biomass of 0.66 mg/m^3. Zooplankton was represented by nektobenthic Harpacticoida and rotifers (Table 2).

In the estuary zone of the Bazaikha river in 2020 and 2022, the numerical indicators and species diversity of zooplankton differed slightly from those in the overlying sections of the river, however, the species composition of zooplankton was fundamentally different. The copepods *Acanthocyclops vernalis*, *Mesocyclops leuckarti*, *Paracyclops fimbriatus* and the eurybiont rotifer *Keratella quadrata* were noted in the zooplankton composition. The Shannon-Weaver species diversity index was 1.54 bits. In the river, a biocenosis was observed, the basis of which are eurybiont forms of rotifers.

Synzhul stream

In the area 500 m above the mouth, the number of zooplankton was 100 ind./m^3 with a biomass of 1.71 mg/m^3. 2 species of rotifers, 1 species of harpacticides and cyclops nauplii were found. The Shannon-Weaver species diversity index was 1.65 bit.

Laletina stream

In the area 2200 m above the mouth in 2020, during the rainy flood, the number of zooplankton was 85 ind./m^3 with a biomass of 0.98 mg/m^3. 3 species of rotifers and 1 species of harpacticides were found. The Shannon-Weaver species diversity index was 1.43 bit. In 2021, the abundance of zooplankton was 25 ind./m^3 with a biomass of 0.24 mg/m^3. Only 1 species of harpacticides has been found.

Berly stream

The number of zooplankton was 75 ind./m^3 with a biomass of 1.67 mg/m^3. Only 2 types of harpacticides have been found (Table 2).

Knyazeva stream

Among other small streams, it differs by a higher abundance (350 ind./m^3) and biomass (5.6 mg/m^3) of zooplankton. Numerical indicators exceed those even in the main channel of the Mana river. However, rotifers have been recorded singly, and nektobenthic crustaceans form the basis of the community. The Shannon-Weaver species diversity index was 1.70 bits.

Vynosnaya stream

The number of zooplankton was 25 ind./m^3 with a biomass of 0.24 mg/m^3. 1 species of harpacticides was found (Table 2).

Maslyanka stream

The number of zooplankton was 75 ind./m^3, biomass - 1.46 mg/m^3. Plankton is mainly represented by nektobenthic crustaceans. The Shannon-Weaver species diversity index was 1.68 bit.

Hajdynka stream

Lots of suspended matter. Only copepodites *Maraenobiotus insignipes* were noted in the sample. Number 25 ind./m^3, biomass - 0.43 mg/m^3.

Malyj Indej stream

The number of zooplankton is 100 ind./m^3, biomass is 1.03 mg/m^3. The basis of the community was *Bryocamptus vejdovskyi* and *Paracyclops fimbriatus* (Table 2). The Shannon-Weaver species diversity index was 1.21 bits.

Srednij Indej stream

The number of zooplankton is 850 ind./m^3, biomass is 6.80 mg/m^3. It is impossible to single out dominants, since all the noted species were encountered singly.

Bol’shoj Indej stream

The number of zooplankton is 25 ind./m^3, biomass is 0.08 mg/m^3. In the plankton nauplii of harpacticids of stages I-III were singled out. It was not possible to carry out the definition of organisms to the species. Very likely that the development of plankton is hindered by high current velocities, at which nektobenthos is not retained even on moss overgrowth of stones.

Kandalak oxbow

A floodplain water body with a high species diversity of crustaceans (Table 2). The samples contained 5 species of Rorifera, 15 species of Cladocera, and 8 species of Copepoda (including 2 species of Harpacticoida). The number of zooplankton was 59925 ind./m^3 with a biomass of 2295.0 mg/m^3. Large phytophilic crustaceans predominated. Of the species rarely found in Siberia, we note the rotifer *Trichotria similis*. The Shannon-Weaver species diversity index was 2.41 bit.

Floodplain lake near the mouth of the Maslyanka stream

A floodplain water body with a high species diversity of zooplankton, especially phytophilic rotifers (Table 2). The samples contained 14 Rotifera species, 11 Cladocera species, and 7 Copepoda species (including 4 Harpacticoida species). The number of zooplankton was 560430 ind./m^3 with a biomass of 2702.1 mg/m^3. Phytophilic forms of rotifers and crustaceans predominated. Of the species quite rare in Siberia, we note *Lathonura (Moina) rectirostris* and *Megafenestra aurita*. The Shannon-Weaver species diversity index was 2.33 bit.

Mana river

At the site near the Berly cordon, the abundance of zooplankton was 110 ind./m^3 with a biomass of 0.83 mg/m^3. Rotifers, nauplii and copepodites of Cyclopes and Harpacticoida have been found. The Shannon-Weaver species diversity index was 1.44 bit. In this area, there is a biocenosis based on nektobenthic forms of copepods, primarily harpacticides.

At the site near the Kandalak cordon, the number of zooplankton was 150 ind./m^3, biomass was 1.79 mg/m^3 due to the presence in the samples of phytophilic forms of cladocerans confined to macrophyte thickets, which form extensive "meadows" in this area. The Shannon-Weaver species diversity index was 1.46 bits.

Bol’shoj Inzhul stream

In the area above the mouth, the number of zooplankton was 40 ind./m^3 with a biomass of 0.54 mg/m^3. Only harpacticides were found (Table 2).

Vesyolyj stream

In the area above the mouth, the number of zooplankton was 60 ind./m^3 with a biomass of 0.70 mg/m^3. Only 1 species of copepods was found (Table 2).

Streams Snezhnaya, Krivopohval'nyj, Sarala

There is a large amount of suspended matter in the streams. The presence of zooplankton was not detected.

Influence of ecological factors on zooplankton communities

The distribution patterns of species in watercourses were analyzed depending on a number of environmental factors: temperature (T), dissolved oxygen concentration (O_2), current velocity, watercourse depth, salinity, pH, and BOD_5 (Fig. 2). The ordination results showed that the eigenvalues of the first and second RDA axis accounted for 42.36% of the data variation. The full model using all seven factors significantly explained the same 42.36% of the total variance in the zooplankton species structure, that is, in fact, the first axis turned out to be the most significant in explaining the variance (Table 3).

Canonical axis	% of variance explained	Cumulative % of variance explained
1	42,2000	42,20
2	0,1576	42,36
3	3,70×10–4	42,36
4	1,33×10–5	42,36
5	8,33×10–6	42,36
6	6,46×10–6	42,36
7	3,13×10–6	42,36

Table 3. *Percentage contribution of the explained variance in the abundance of individual zooplankton species depending on environmental factors*

The first component can be interpreted in terms of factor loads primarily as a combined effect of temperature (positive correlation) and flow velocity (negative correlation) (Table 4). The projections of the vectors of dissolved oxygen concentrations, pH, BOD_5, and salinity on are practically collinear and unidirectional with the flow velocity vector. This fact is explained by the peculiarities of small mountain streams: high flow rates contribute to the saturation of water with oxygen; a faster flow carries more organic matter from the catchment, which does not have time to be utilized in the watercourse; high speeds do not contribute to the accumulation of organic matter and the development of phytoplankton, which, as a result of metabolism, can shift pH to the acid. Some increase in salinity with increasing flow velocity may be a consequence of the composition of the underlying rocks and requires a separate study.

Explanatory	Axis 1	Axis 2
Depth	0,185	-0,027
T	0,408	0,002
pH	-0,175	0,003
Salinity	-0,155	-0,003
O2	-0,377	0,003
BOD5	-0,066	0,003
Flow rate	-0,385	-0,020

Table 4. *The result of the analysis of the contribution of factor loadings to the principal components*

All detected species were included in the analysis, including eurybiont species with wide ecological lability and narrow stenobionts, which were noted singly. Most of the species were concentrated at the point of origin (Fig. 2). However, a distinct trend in the distribution of zooplankton species along the Y axis can be traced. Moreover, these are representatives of both rotifers, cladocerans, and typically planktonic and nektobenthic copepods. Along the depth and temperature vectors, as expected, there are species that were found only in floodplain water bodies.

That is, the number of species is affected by temperature (positively) and the flow velocity and its accompanying factors (negatively) with approximately the same force (Fig. 2).

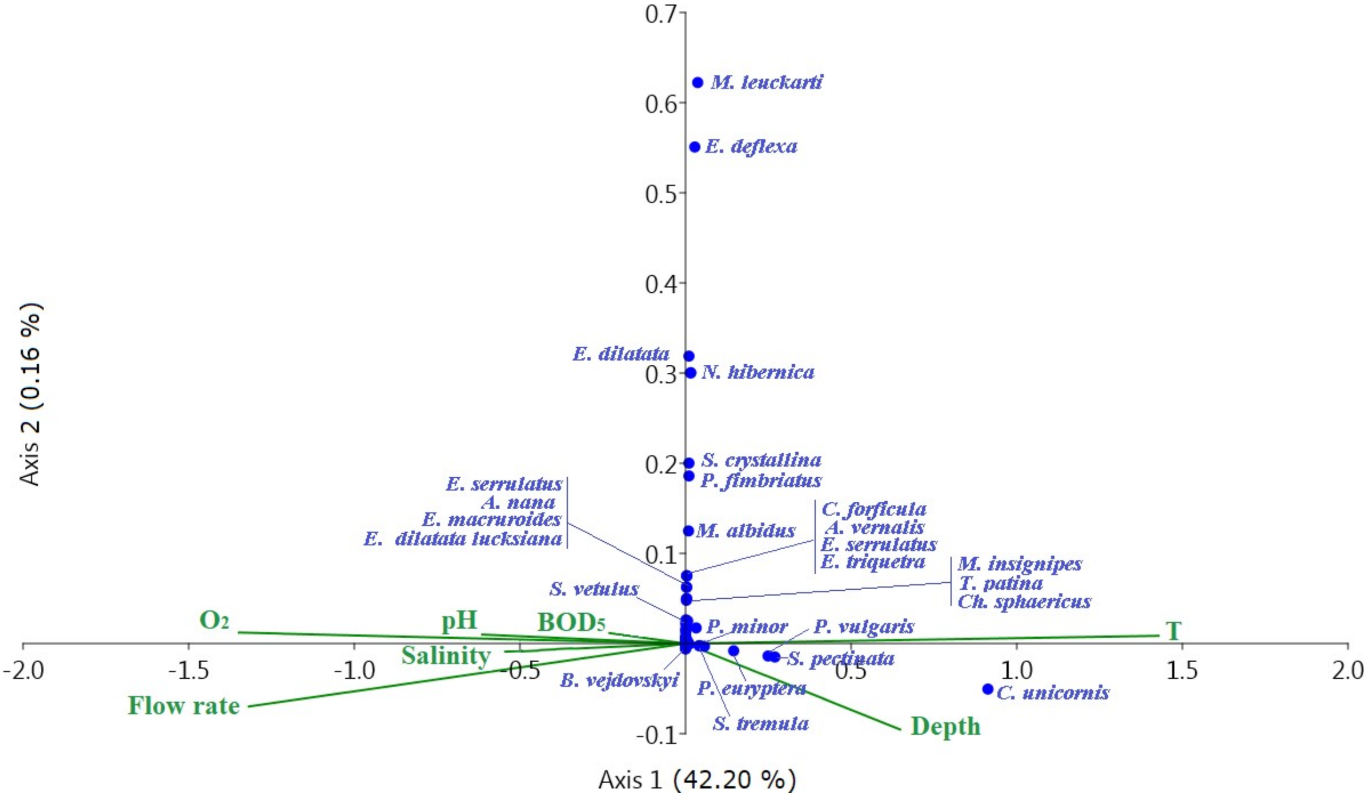

Figure 2. *Ordination of abundance (RDA) of zooplankton species in the space of environmental factors (p < 0.05).*

Discussion

Quantitatively, the zooplankton of watercourses is, as expected, very scarce. High flow rates do not promote the development of crustaceans, but at the same time are favorable for the development of rheophilic rotifers. In addition, the samples contained a significant number of nektobenthic forms, which were often washed away from the substrate by the stream. The greatest species diversity of zooplankton, as expected, is found in floodplain water bodies, backwaters and oxbow lakes.

Compared to species lists published earlier (Zapekina-Dulkeit and Dulkeit, 1961; Zapekina-Dulkeit, 1972), we did not find *Daphnia longispina* O.F. Müller, 1785, *Alona (Coronatella) rectangula* G.O. Sars, 1862, *Leydigia leydigi* (Schödler, 1863), *Alonopsis elongata* (Sars 1861), *Brachionus capsuliflorus* Pallas, 1766, *Eucyclops macruroides* var. *denticulatus* (Graeter, 1903), *Philodina* sp., *Platiyas quadricornis* (Ehrenberg 1832), *Mesocyclops crassus* (Fischer, 1853), *Macrocyclops distinctus* Richard, 1887, recorded in small numbers in collections from floodplain reservoirs of the Mana River. Also, no *Eudiaptomus vulgaris* (Schmeil, 1896) was found, which was recorded for the oxbow lake of the Bazaikha River. The parasitic *Tracheliastes sachalinensis* Markevich, 1936 was not found either, because fish were not examined for parasites.

Also, in our collections, species indicated for the lower reaches of the Mana River (outside the territory of the National Park) were not found: *Bosmina longirostris* (O. F. Müller, 1785), *Cyclops vicinus vicinus* Uljanin, 1875, *Diacyclops languidus languidus* (Sars G.O., 1863), *Trichotria truncata* (Whitelegge, 1889) and for the lower reaches of the Bazaikha River: *Ectocyclops phaleratus* (Koch, 1838), *Eucyclops macrurus* (Sars G.O., 1863) (Lukashina et al. 2021). These species are confined to low river speeds and to zones with higher trophic level.

Our research allowed us to expand our knowledge of the zooplankton in the watercourses of the “Krasnoyarsk Stolby” National Park. For the first time, 24 species of rotifers, 10 species of cladocerans, 14 species of copepods were discovered or identified to species.

The least studied order of the copepod subclass is the harpacticoids. Harpacticoida species have not yet been identified in the waterways of the National Park. A total of 10 species have been recorded. It should be noted that different species were found in different streams, which most likely indicates high species diversity of these crayfish, and at the same time, an insufficient study of the population of rivers and streams to analyze species similarity. The most common were *Maraenobiotus insignipes*, *Bryocamptus vejdovskyi*, *Attheyella crassa* and *Nitokra hibernica* (Table 2).

A feature of the Harpacticoid fauna of the watercourses of the “Krasnoyarsk Stolby” National Park is a high diversity of families - four, which is not typical for freshwater fauna. Usually regional lists of the group include only one family: Canthocamptidae. The same features of the species diversity of the nektobenthic fauna of crustaceans are indicated for the watercourses of the Putoran Plateau (Chertoprud et al. 2022).

In oligotrophic mountain streams, the structure of zooplankton is determined primarily by hydrophysical factors: temperature and flow velocity. Hydrochemical indicators are not limiting, since they do not exceed critical values.

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