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INVERTEBRATE COMMUNITIES OF HIGH MOUNTAIN LAKES (POLISH TATRA MTS.)°

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Summary. The composition of macroinvertebrates was investigated in 11 high mountain lakes situated above the timberline. Qualitative samples were taken in the near shore zone, in the inlets and outlets of streams. The dominant taxa were Chironomidae and Oligochacta, while Plecoptera and Turbellaria dominated in two lakes only. Nematoda were numerous, whereas Trichoptera and Ephemeroptera were very scarce. Taxon richness and diversity of the studied lakes were low – the highest were found in big, deep and non acidified lakes, the lowest ones in small, shallow and slightly acidified ponds.

Key words: benthos, taxon richness and diversity, high mountain lakes, Tatra Mts, acidification

INTRODUCTION

Remote mountain lakes, hardly accessible, with little human activity in their catchment area, are considered as least disturbed freshwater ecosystems in Europe. Although situated far from local sources of pollution, these lakes are threatened by deposition of atmospheric pollutants (acidity and toxic air pollutants) and by climate changes. The high mountain lakes are sensitive to these threats because of their poor buffering capacities of soil and rocks in the watershed to neutralize acidic deposition [Moscllo 1986].

In the framework of the international EMERGE project (2000-2003), which was aimed at generation of the ecological classification system for remote mountain lakes, physical, chemical and biological data from over 350 mountain lakes across Europe were collected. Within that project studied have been also conducted in eleven lakes situated in the Polish Tatra Mountains. The biological samples collected included among others littoral benthos. The sensitivity of invertebrate species to physical and chemical disturbances is frequently used as a tool in monitoring freshwater ecosystems [Fjellheim and Raddum 1990, Fjellheim *et al.* 2000].

This work shows the composition, taxon richness and the diversity of the benthic invertebrates in the Polish Tatra lakes together with their environmental variables.

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STUDY AREA

All the studied lakes (Table 1) are located above the timber line in a range of altitude from 1580 to 1890 m. They are covered with ice from October to June. Five lakes are big and deep: their surface areas range from 6 to 34 ha, while depths from 32 to 79 m, six of them are small (0.04-1.4 ha) and shallow (1-9 m). The lakes shores are rocky with sand and in some lakes with a small amount of organic debris. Ten lakes situated in the High Tatra have a catchment area built of granitic bedrock covered by post glacial rock debris, while the bedrock of Siwy Wyżni pond located in the Western Tatra is built by metamorphic rock. Soils are thin and constitute only a few percent of the whole watershed and bare rocks are an important component of the drainage basin. In most cases the vegetation consists of alpine meadows, with a few exceptions where sparse dwarf pines are present.

METHODS

Invertebrate sampling was performed by the kick method [Frost *et. al.* 1971] in September 2000. Total time for one kick sample is 2 min. Three qualitative samples were taken from each lake: one in the inlet of the stream, one in the littoral zone of the lake, and one in the outlet stream of the lake; when there was no inlet or outlet, additional samples were taken from the littoral zone. All together 33 samples were analysed from 11 littoral zones, 4 from inlets and 8 from outlet streams. The samples were sieved through a net with 250 μm mesh size, preserved in 4% formaldehyde, sorted and identified beneath a binocular in the laboratory. Only Chironomidae, Plecoptera and Trichoptera were determined to the species level (Table 2). Oligochaeta species were studied and used in another publication [Dumnicka and Boggero in press].

RESULTS AND DISCUSSION

The dominant group of the littoral fauna in all the studied lakes was Chironomidae, making up on average 40% of the benthos (Fig. 1A). Other abundant taxa were Oligochaeta (28%) and Nematoda (15%). Turbellaria were found in the littoral of six lakes (1-22%) while Plecoptera in four lakes (1-26%). Trichoptera and Ephemeroptera formed less than 1% in few lakes only.

Littoral fauna of 11 studied high mountain oligotrophic lakes revealed very low diversity (Table 1). The highest value of taxon richness was found mostly in big and deep lakes, with alkalinity value above 25 μeq dm^{-3} and ACN (Acid Neutralising Capacity) value from 29 to 124 μeq dm^{-3}, which indicates their good non-acidified condition [Fott *et al.* 1994]. In the littoral of such lakes *Crenobia alpina* (Turbellaria) and *Diura bicaudata* (Plecoptera) species that are sensitive to acidification were found [Raddum and Fjellheim 2002]. The mean number of taxa was 8.4, while mean Shanon-Wiener diversity index (H') was 2.02 (Table 1).

Small and shallow ponds had lower taxon richness (mean 5.2, H' 1,9) and exhibited various stages of acidification. Three of them: Zmarzły, Długi, and Dwoisty Wschodni ponds located in the same Gąsienicowa Valley, at the decreasing altitude had an incre-

Fig. 1A

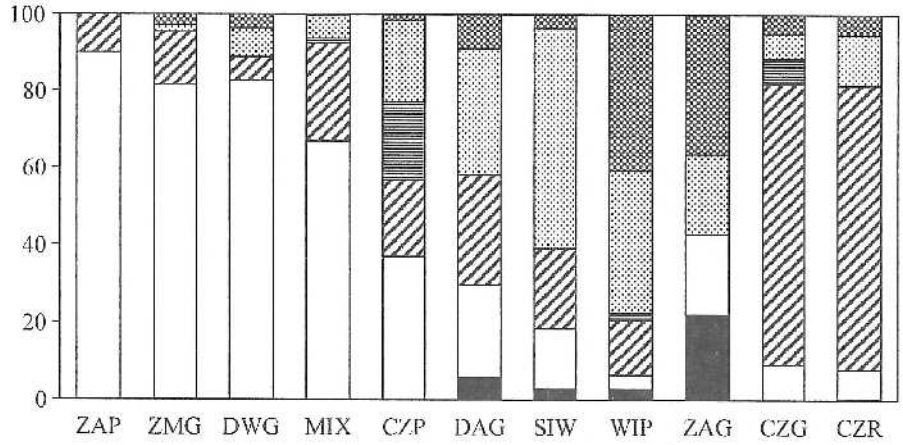

Fig. 1B

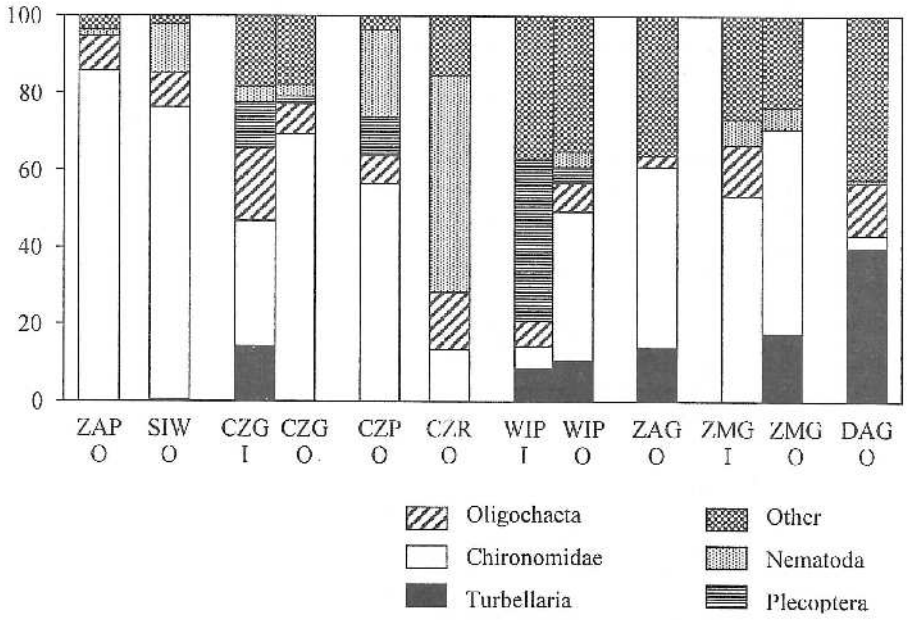

Fig. 1A. Percentage share of macrofauna groups in the littoral of the studied lakes
Rys. 1A. Procentowy udział grup makrofauny w litoralu badanych jeziorFig. 1B. Percentage share of benthos group in the inlets (I) and outlets (O) of the studied lakes
Rys. 1B. Procentowy udział grup bentosu we wpływach (I) i wypływach (O) badanych jezior

Table 1. A summary of environmental variables of the studied lakes; inlet, littoral and outlet fauna taxon richness (TR) and diversity index (H')
Tabela 1. Parametry środowiskowe badanych jezior; ilość taksonów bezkręgowców (TR) i index różnorodności (H') we wpływie, litoralu i wypływie

Lake name Nazwa jeziora	Acronym Akronim	Altitude (m) Wysokość n.p.m.	Area (ha) Pow.	Max depth (m) max. Głębokość	Residence time (year) Czas retencji	Ca (mg dm^{-3})	Alk (μeq dm^{-3})	ANC (μeq dm^{-3})	Inlet TR Wpływ	H'	Littoral TR Litoral	H'	Outlet TR Wypływ	H'
Mnichowy IX	MIX	1871	0.06	2.3	0.029	2.2	0.0	-16	-	-	5	1.43	-	-
Zmarzły Gąsienicowy	ZMG	1787	0.28	3.7	0.0	1.4	12.9	5	2	1.28	4	1.18	4	2.07
Długi Gąsienicowy	DŁG	1784	1.6	10.6	0.1	1.2	22.4	13	2	0.38	5	2.1	-	-
Dwoisty Gąsienicowy Wschodni	DWG	1657	1.4	9.2	0.2	1.8	8.4	20	-	-	8	2	-	-
Zadni Polski	ZAP	1890	6.5	31.6	1.0	1.5	33.0	29	-	-	5	0.81	3	1.16
Zadni Gąsienicowy	ZAG	1852	0.53	8.0	0.1	1.9	36.9	31	-	-	4	1.91	2	1.02
Czarny Gąsienicowy	CZG	1620	17.79	51.0	1.7	2.1	41.5	49	11	3.01	6	2.62	11	2.54
Czarny Polski	CZP	1722	12.7	50.4	4.1	0.7	68.6	59	-	-	15	2.71	10	2.34
Wielki Polski	WIP	1665	34.14	79.3	2.4	1.4	73.4	72	11	2.07	7	1.86	-	-
Czarny pod Rysami	CZR	1580	20.54	76.4	4.1	2.8	137.3	124	-	-	9	2.1	2	1.73
Siwy Wyżni	SIW	1718	0.037	1.0	0.016	3.8	265.9	268	-	-	3	1.55	5	2.19

Table 2. Chironomidae, Plecoptera and Trichoptera species in studied Tatra lakes
Table 2. Gatunki Chironomidae, Plecoptera i Trichoptera w badanych jeziorach tatrzańskich

	Species – Gatunki
Littofal Chironomidae	Corynoneura sp. (ZAP, MIX, DŁG, CZP, WIP, DWG, CZG, CZR), Cricotopus (Isocladius) sp. (ZAP, DŁG, CZP, DWG, CZG, CZR), Eukieferella sp. (ZMG, CZP), Heterotrissocladius marcidus (MIX, ZAG, ZMG, DŁG, CZP, WIP, DWG, CZR), Macropelopia sp. (CZP,CZG), Micropsectra radialis (ZAG, ZMG, DŁG, CZP), M. sp. (CZP, DWG), Microtendipes sp. (CZP), Orthocladiinae (juv.) (ZAG, ZMG, CZP, WIP, DWG, CZG, CZR), Orthocladius (O.) frigidus (CZR), Paratanytarsus sp. (CZP, CZR), Psectrocladius (P.) gr sordidellus (CZP, WIP, DWG), Psectrocladius sp. (CZR), Pseudodiamesa sp. (ZAG, ZMG), Tanytarsus sp. (SIW, CZG), Tvetenia sp. (CZG), Zavrelimyia sp. (DWG), Zalutschia tarica (MIX, DWG).
Chironomidae in inlet or outlet	Chaetocladius sp. (cf. piger) (CZG), Corynoneura sp. (ZAP, CZP, CZG), Cricotopus (Isocladius) sp. (ZAP, ZMG, CZG), Diamesa sp. (gr. zernyi) (ZMG, CZP, CZG), Diamesa gr. latitarsis (CZP), Eukieferella minor (SIW, CZG), E. brevicalcar (CZP, WIP), Heterotrissocladius marcidus (ZAP, CZP), Macropelopia sp. (SIW) Micropsectra radialis (ZAG), Micropsectra sp. (CZP, SIW, WIP), Microtendipes sp. (CZP), Nanocladius sp. (CZP), Orthocladius (O.) frigidus (CZP, CZG), Paratanytarsus austriacus (SIW), Paratanytarsus sp. (CZP), Parorthocladius nudipennis (CZP), Psectrocladius (P.) gr sordidellus (CZR), Rheocrocotopus sp. (WIP, CZG), Tanytarsus sp. (SIW), Tvetenia bavarica (WIP, CZG).
Littoral Plecoptera	Nemura picteti (MIX, CZP, WIP, CZG), Leuctra sp. (CZP), Diura bicaudata (CZP, WIP).
Plecoptera in inlet or outlet	Nemura picteti (CZP, CZG), Leuctra sp. (CZP, WIP), Diura bicaudata (CZP, WIP), Protonemura sp. (WIP).
Littoral Trichoptera	Apatania fimbrata (WIP), Limnephilus coenosus (MIX, SIW, DWG), Rhyacophila philopotamoides (WIP).
Trichoptera in inlet or outlet	Acrophylax zerberus (ZMG, CZP), Apatania fimbrata (CZG), Chaetopteryx villosa (CZP, WIP), Drusus discolor (WIP), Limnephilus coenosus (SIW) Plectrocnemia conspersa (WIP), Rhyacophila fasciata (WIP).

asing ANC value from 5 to 20 μeq dm^{-3}, alkalinity below 25 μeq dm^{-3} and taxon richness from 4 to 8, which corresponded to their intermediate stage of acidification [Galas 2002, Kownacki *et al.* 2002].

The Mnichowy IX pond is naturally slightly acidic (pH 4.83) and its dominant species *Zalutschia tatrica* (Chironomidae) is a glacial relict, typical of acidic tundra lakes [Kownacka and Kownacki 1965].

In Siwy Wyżni pond, the only one located in the Western Tatra on the metamorphic bedrock, three taxa were found exclusively (H` 1,5). The number of the collected specimens in the littoral of this pond was the highest among the remaining studied lakes.

The dominant group of fauna in inlet and outlet streams was Chironomidae (44%, Fig. 1B). Turbellaria, Plecoptera, Nematoda and Oligochaeta percentage share ranged from 10 to 15% of the total stream benthos.

The lowest number of taxa and H` was found in streams, fed by groundwater, flowing into the Zmarzły and Długi lakes (Table 1). Eleven taxa were collected in inlet streams of the big Wielki Polski and Czarny Gąsienicowy lakes. The same number of species was also found in the outlet of Czarny Gąsienicowy and Czarny Polski lakes.

The low number of taxa recorded in ultra-oligotrophic Tatra lakes may partly be due to the low number of samples and partly to harsh abiotic conditions: low temperature, long ice and snow cover and varying water regime. Also the lowest taxa number was stated in lakes with an intermediate stage of acidification. Their ANC values were below 20 μeq dm^{-3}, which is established as a critical value and may have an adverse influence on the lake biocenoses.

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BEZKRĘGOWCE BENTOSOWE JEZIOR WYSOKOGÓRSKICH (TATRY POLSKIE)

Streszczenie. Określono skład bentosu w 11 jeziorach tatrzańskich, położonych w piętrze hal. Próby jakościowe pobierano w części przybrzeżnej jezior, w ich dopływach i wypływach. Dominującymi grupami były Chironomidae i Oligochaeta, a w dwóch jeziorach Turbellaria i Plecoptera. Licznie występowały Nematoda, a Trichoptera i Ephemeroptera były spotykane sporadycznie. Badana fauna była mało zróżnicowana gatunkowo: najwyższe zróżnicowanie stwierdzono w dużych, głębokich i niezakwaszonych jeziorach, a mniejszą liczbę taksonów wykazano w małych, płytkich stawach o różnym stopniu zakwaszenia.

Słowa kluczowe: bentos, zróżnicowanie gatunkowe, różnorodność, jeziora tatrzańskie, zakwaszenie