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Kryon – communities of high mountain streams

Kryon – zoocenozy wysokogórskich potoków

SUMMARY

High mountain streams, flowing above the upper forest line, arise from the meltwater of glaciers, permanent snow fields and high mountain lake-outlet streams and temporary springs

Larvae of *Diamesa* (Chironomidae, Diptera), mainly *Diamesa steinboecki* group*, Diamesa latitarsi* group dominate among macroinvertebrates developing in these streams. Other fauna groups, like Ephemeroptera do not occur or are represented by single individuals of Trichoptera and Plecoptera. Biodiversity is here very small, 2–10 taxons, density very low, below 1500 individuals/m^2. In lower parts of these streams macroinvertebrate communities differentiate depending on hydrological conditions. In high mountain lake-outlet streams Simuliidae (Diptera) dominates. Inflow strong springs to high mountain stream (in the Tatra Mts. at the upper forest boundary) changing the composition, structure, and abundance of community and mayflies *Baetis* and *Rhithrogena,* and Orthocladiinae (Chironomidae) dominate. It should be mentioned, however, that streams flowing out of springs are sometimes met also at high altitude up to 3000 m a.s.l. Their fauna differs from that of high mountain streams. Larvae of *Diamesa latitarsis* group dominate here as well, but there are also numerous larvae of Orthocladiinae and some Trichoptera and Plecoptera but Ephemeroptera do not occur. Biodiversity is here much higher (15–30 taxons) and density above 2500 individuals/m^2.

Dissimilarity of macroinvertebrates in high mountain streams led to their separation from classical zone system of running waters *crenon→rhithron→ potamon* and to formation of new zone *kryon*.

STRESZCZENIE

Potoki wysokogórskie płynące powyżej górnej granicy lasu powstają z lodowców, płatów wiecznego śniegu, jezior wysokogórskich lub okresowych drobnych wycieków. Badania prowadzono w potokach Tatr i porównawczo w górach Szwedzkiej Laponii, Alpach i Kaukazie. Rozwijające się w tych potokach zespoły makrobezkręgowców charakteryzują się dominacją larw z rodzaju Diamesa (Chironomidae, Diptera), głównie *Diamesa steinboecki*, *Diamesa* gr. *latitarsis*. Pozostałe grupy fauny nie występują, np. jętki (Ephemeroptera), lub są reprezentowane przez pojedyncze osobniki chruścików (Trichoptera), widelnic (Plecoptera). Bioróżnorodność jest tu bardzo mała, 2–10 taksonów, zagęszczenie niskie, nieprzekraczające 1500 osobników/m^2. W dolnych odcinkach tych potoków zoocenozy się różnicują w zależności od warunków hydrologicznych. W potokach płynących poniżej jezior wysokogórskich dominują Simuliidae (Diptera). Często na pewnej wysokości (w Tatrach przy górnej granicy lasu) do potoku dopływają źródła i począwszy od tego momentu, zmienia się struktura, skład i liczebność zespołu. Dominują tu jętki z rodzaju *Baetis* i *Rhithrogena* oraz *Orthocladiinae* (Chironomidae). Należy jednak nadmienić, że również powyżej górnej granicy, na dużych wysokościach (do 3000 m n.p.m.), spotyka się potoki biorące początek ze źródeł. Ich fauna różni się zarówno od omawianych potoków wysokogórskich, jak i źródliskowych. Nadal dominują larwy *Diamesa* gr. *latitarsis*, ale spotyka się również bardzo liczne larwy Orthocladiine z rodzajów *Orthocladius* (*Euorthocladius*), *Tvetenia* oraz widelnice i chruściki, brak natomiast jętek. Znacznie wyższa jest tu bioróżnorodność (15–30 taksonów) i zagęszczenie (powyżej 2500 osobników/m^2).

Odmienność zespołów makrobezkręgowców w potokach wysokogórskich spowodowała wydzielenie ich z klasycznego strefowego podziału wód płynących *crenon→rhithron→potamon* i stworzenie nowego zespołu *kryon*.

Key words: high mountain, stream, kryon, zonation, macroinvertebrate, communities

INTRODUCTION

Longitudinal changes in ecological conditions from the headwaters to the mouth of the river system are profound, especially over large elevation gradients, as are the attendant changes in the structural and functional attributes of lotic macroinvertebrate communities. Illies (1961) and Illies, Botosaneanu (1963) proposed a world-wide classification system for lotic waters and introduced the terms *crenon* (spring source), *rhithron* (torrent and mountain river) and *potamon* (large river) to divide lotic system into three major zones, each with additional subdivision. Most river systems originate as springs. But in mountains with maximum elevations exceeding the permanent snowline, yet an additional zone must be added. Streams arising from the meltwater of glaciers, permanent snow fields and high mountain lake-outlet and temporary springs form a distinct macroinvertebrate communities, the *kryon* (Steffan 1971, Kownacka, Kownacki 1972).

Studies on the fauna of high mountain streams were initiated by Steinböck (1934) and Thienemann (1936) in the Alps seventy years ago. However, information on high mountain stream and its macroinvertebrate communities are still incomplete.

The aim of this work was to present a zonal distribution of the macroinvertebrate communities in the different types of the high mountain streams and the influence of hydrological, physical and hydrochemical factors upon the composition and numbers of the invertebrates.

STUDY AREA AND METHODS

The study was carried out mainly in the High Tatra Mts (I) on the Mnichowy Potok and Sucha Woda streams (the Tatra National Park, Poland) and comparatively in the Swedish Lappland (II) on the Kaskasatjåkka, Tarfalajåkka and Ladtjojåkka streams near Kebnekaise mountain (about 140 km beyond the Arctic Circle), in the Alps (III) on the Rio Plima and its tributaries Rio Madricio and Rio Gioveretto, (the Parco Nacionale della Stelvio, South Tirol, Italy) and in the Caucasus (IV) on the Upper Terek River (the South Ossetia, Georgia) in the glacial, spring-fed and lake-outlet streams.

(I) The Mnichowy stream is the outlet of the Zadni Mnichowy Stawek pool, originating from the meltwater of permanent snow fields, and situated at an altitude of 2075 to 1840 m. a.s.l. The length of this stream is 550 m., with mean channel slope of 427‰. Temperature of water is very low (1–4.5°C) and the water is transparent.

Investigation was carried out in the outlet from Zmarzły Staw Gąsienicowy Lake (1851 m a. s. l.), the Czarny Potok stream which is the outlet of Czarny Staw Gąsienicowy Lake (1619 m a. s. l.), the Sucha Woda stream and the Cicha Woda (Cichowiańska Woda) stream which inflow to the Poroniec stream at an altitude of 770 m a. s. l. The total length of this streams is 15.5 km, with mean channel slope of 68‰. The water was transparent.

(II) Investigation was carried out in glacier stream Kaskasatjakka which flows from under the Kaskasatglaciären (1340 m. a.s.l.), the Tarfalajåkka stream which is outlet of the Tarfalkasjön lake (1168 m. a.s.l.), and lower reach of the Ladtjojåkkaj river (500–560 m. a.s.l.). On altitude 1020 m. the Tarfalajåkka stream flows across a small pool and on 1000 m joins with glacial stream flowing out of the Storglaciären. The Ladtjojåkka river flows across Ladtjojaure Lake. In the glacier stream water was turbid, and in the outlet of lakes and the Ladtjojåkka river water was transparent. The total length of Tarfalajåkka stream is 9.5 km, with mean channel slope of 82‰ and length of investigation reach of the Ladtjojåkka river was 13.5 km long with slope 4.4‰.

(III) The Rio Plima river, the right tributary of the Fiume Adige river, flows across a Val Martello valley. It arises from Vederetta Lunga glacier at 2700 m a.s.l. and flows across cobbles – pebbles postglacial terraces covered with rock rubble. At the altitude of 2300 m a.s.l. it flows into deep canyon, which ends at 1900 m. Then it flows across forest valley. At the altitude of 1850 m a great dam reservoir Lago Gioveretto was built. Down from the village Martel (1000–1200 m.) the stream flows across forest areas or fields, meadows and orchards. Along this reach the water level is much lower because the water is used for watering orchards. After 26.5 km, at the altitude of 660 m a.s.l. the stream flows into Fiume Adige. The average channel slope is here 82.3‰.

Rio Gioveretto, the right tributary of Rio Plima, arises from Vederetta dello Gioveretto glacier at the altitude of 2750 m a.s.l. First it flows along postglacial valley covered with boulders, then it flows steeply down the moraine slope into the next terrace covered with rubbles and stones, sometimes with high mountain meadows. Below 2200 m a.s.l. it flows across the thick spruce and larch forest. Then at the altitude of 1850 m a.s.l. it flows into Lago Gioveretto reservoir. The length of this stream is 3 km, with mean channel slope 300‰.

Rio Madriccio, the left tributary of Rio Plima, arises from melting snow patches and springs flowing from under a moraine, then it flows steeply down the glacial valley in a river bed cut into moraine layers covered with big rock blocks. Starting from 2200 m a. s. l. it falls in cascades steeply down across spruce and larch forest, sometimes across meadows. It flows into Rio Plima at 2000 m a.s.l.. The length of this stream is 5 km, with mean channel slope 170‰.

(IV) Observations of the fauna distribution was carried out along the course of the Upper Terek river and its glacial tributary Suatisi. The Suatisi stream arises from glacier at 2800 m a.s.l. and joins Terek river at 2550 m. a.s.l. The length of this stream is about 2 km, with mean channel slope

125‰. The length of the investigated reach (on altitude 1800–2250 m. a.s.l.) of the Terek River is 33 km and mean chanel slope 13.6 ‰. In both streams water was turbid.

Samples of invertebrates were collected with hand net 22.5 x 22.5 cm, covered with gauze 0.3 mm in mesh diameter. The material obtained was calculated per 1 m^2 of stony bottom. Result is presented as percentage domination. On the basis of values of dominance 3 groups were distinguished: dominant taxa >10%, subdominant 1–9.9 % and adominant <1 %. In the table only dominant taxa are presented.

RESULTS

(I) The Tatra streams

In the upper part (1950–2070 m a.s.l.) of the Mnichowy stream the macroinvertebrate community was similar to that in the glacial streams. The species *Diamesa steinboecki*, *D. nowickiana* and *D. latitarsis* were dominating (Tab. 1). In the lower part (1900 m a.s.l.) of this stream, apart from species of the genus *Diamesa*, *Parorthocladius nudipennis* was dominating and some specimens of Diptera from families of Simuliidae (*Prosimulium* sp.), Blephariceriade, Tipulidae and Plecoptera (*Leuctra* sp), Trichoptera (*Drusus monticola*), Turbelaria (*Planaria alpina*) were found. Ephemeroptera was absent.

The fauna in the Sucha Woda stream was represented mainly by insects larvae, especially of Chironomidae (Diptera) (Tab. 2). Above 1550 m. the dominant taxa were *Diamesa latitarsis* group and in outlet of the Czarny Staw lake also Simuliidae – *Prosimulium*. At the altitude 1550–1000 m. *Eukiefferiella minor* and *Parorthocladius nudipennis* (Chironomidae), as well as *Baetis alpinus* and *Rhithrogena loyolaea* (Ephemeropptera) predominate. Below 1000 m the dominant taxa were larvae *Orthocladius* (Euorthocladius) rivicola group and Simuliidae. In reach of the Sucha Woda stream which dry up temporarily (about 1000 m), immediately on the resumption of flow, juvenile larvae *Eukiefferiella cyanea* and *Diam*esa sp., appear in masses, but from July until the end of the period of flow, nymphs of mayflies *Baetis alpinus* group were the first dominant. In autumn larvae of *Diamesa latitarsis* were an important faunistic element.

(II) The Swedish Lapland streams

In the glacial stream Kaskasatjåkka (Tab. 3), at the foot of the glacier, only single larvae of *Diamesa latitarsis* group and juvenile stage *Diamesa* were found. Below the Lake Tarfalasjön community was completely reconstructed. The first dominant were larvae *Pseudodiamesa* sp., the second *Diamesa ursus*; an important subdominant were larvae *Orthocladius (E.) rivicola* group., whereas larvae of *Diamesa latitarsis* group were scarce. At the next site community changed again. The first dominant were larvae of *Orthocladius (E.) rivicola* group, the second *Diamesa* sp. I, quite numerous were Simuliidae – *Prosimulium ursinum*. The tributary of big, turbid, stream from Storglaciären rapidly changed compo-

Table 1. Characteristics of the Mnichowy stream and altitudinal zonation of macroinvertebrate communities (bold figure – dominant 10–100%, + adominant >1%, A – alpine zone)

Sites	1	2	3	4	5
Altitudae (m a.s.l.)	2075	2060	2025	1890	1850
Zone	A	A	A	A	A
Water temperature ^{0}C	1.1–3.5	4.5	3.7–4.0	3.0–4.5	2.5–6.5
pH	6.2				6.2
Diamesa steinboecki	**25**	**15**	**27**	**29**	+
Diamesa latitarsis	**11**	**27**	**18**	**31**	**22**
Diamesa nowickiana	**23**	**21**	**32**	3.2	
Diamesa sp. (gr. *zernyi*)	**17**	4.5	5.2	6.2	4.7
Pseudokiefferiella parva	9.7	**19**	**14**	1.6	1.0
Parorthocladius nudipennis				+	**31**

Table 2. Characteristics of the Sucha Woda stream and altitudinal zonation of macroinvertebrate communities, (bold figure – dominant 10–100%, + adominant >1%, A – alpine zone, D – dwarf pine zone F – forest zone)

	ZP*	Czarny Potok			Sucha Woda				Cicha
Sites	1	2**	3***	4	5	6	7****	8	9
Altitudae (m a.s.l.)	1850	1600	1500				1000		780
Zone	A	D	D	F	F	F	F	F	F
Water temperature ^{0}C	0.9–6.9	4.5–12.3	2.4–9.4	1.0–9,1	1.4–7.9	0.4–5.3	0.5–9.4	1.2–10	0.2–13
pH	6.3–6,4	6.0–6.5	6.2–6.5	6.3–6.6	6.4–7.0	6.6–7.4	6.9–7.4	7.4–8.3	7.0–8.5
Conductivity µS in 18^0	17	18–22	23–96	21–26	31–69			69–185	118–215
Calcium Ca mg/dm^3	2.4–4.4	2.6–4.3	2.9–4.9	3.3–5.0	5.7–8.6			13–33	20–41
O_2 %	79–81	83–85	82–86	82–86	84–88	84–89		89–92	79=94
Diamesa latitarsis gr.[1]	**48**	**12**	+	+	1.5	4.5	3.6	+	+
Protonemura sp.	**10**	+	3.0	3.1	1.4	1.2	+	+	1.0
Prosimulium sp.	8.7	**27**	+	1.0	1.8	5.6	9.6	**12**	**15**
Eukiefferiella minor	1.5	4.8	**27**	**10**	1.3	3.6	+	4.5	3.2
Diamesa spp. (juv.)	1.4	+	+	+	3.8	3.2	**12**	4.0	2.9
Tvetenia bavarica gr.[2]	+	**15**	3.8	8.9	1.7	1.8	2.3	3.1	4.0
Nais variabilis	+	**14**	+	+	+	2.0	+		+
Baetis alpinus gr.[3]		+	**17**	9.5	**13**	**10**	**23**	3.4	3.1
Parorthocladius nudipennis	3.1	+	**13**	**12**	**30**	**16**	1.4	2.0	1.4
Orthocladius (*E.*) gr. *rivicola*	+	+	+	1.1	2.2	9.5	5.3	**27**	**31**
Eukiefferiella cyanea						+	**28**	+	+
Mean density ind./m^2 (in thousand)	0.7	**2.1**	**16.7**	11.0	7.7	12.0	**7.5**	12.7	13.5

*ZP – the Zmarzły Potok stream below Zmarzły Staw Lake; ** below Czarny Staw Lake; *** below the inflow the strong springs; **** reach of stream which dry up temporarily
1 – imago *D. latitarsis* and *D. laticauda*; 2 – on sites 1–7 only *E. bavarica*; 3 – on sites 1–6 only *B. alpinus*, on sites 7–9 *B. alpinus* and *B. melanonyx*

Table 3. Altitudinal zonation of macroinvertebrate communities in the Tarfalajåkka and the Ladtjojåkka streams (bold figure – dominant 10–100%, + adominant >1%, T – alpine tundra, FT – forest-tundra)

	Kaskasatjåkka				Tarfalajåkka							Ladtjojåkka	
Sites	1	2	3	4	5*	6	7	8**	9	10	11	12	13 ***
Altitudae (m a.s.l.)	1340	1340	1280	1190	1170	1140	1100	1040	900	700	580	520	510
Zone	T	T	T	T	T	T	T	T	T	FT	FT	FT	FT
Water temperature °C	0.5	0.8	1-3.5	3.5	4.5	1	3.3	3.8	5.2	6.0	6.2		
Diamesa sp. II (gr. *latitarsis)*[1]	**100**	**85**	**33**	**11**		9.3	1.6	**21**	**51**	**41**	**43**	1.2	
Diamesa spp. (juv.)		**12**	**26**	**20**	**12**	6.7	**24**	**35**	**14**	**16**	**13**	**14**	+
Diamesa sp. I (gr. *latitarsis)*			**41**	**47**	4.8	**22**	7.0	8.4	3.5	**26**	**21**	**26**	
Diamesa ursus			7.3	6.4	**13**	**10**	**32**	**11**	+	2.6	3.7		
Pseudodiamesa sp.					**28**	+							
Orthocladius (*E.*) gr. *rivicola*					6.9	**27**	4,7	+	+	+	5.0	5.6	
Diamesa bertrami											+	**39**	2,6
Simuliidae													**37**
Cricotopus sp.													**19**
Density ind./m² (in thousand)	0.1	0.4	0.9	2.7	3.6	5.7	30.7	5.2	21.6	**15.4**	**8.0**	**12.1**	**4.5**

[1] Imago of *Diamesa* genus (o – present)

Diamesa lindrothi			o		o			o	o	o	o		
Diamesa saetheri							o	o	o	o	o		
Diamesa bertrami										o	o		

• below Lake Tarfalasjön; ** below the inflow of the glacial stream Storjakka, ***below Lake Ladtjojaure sition and structure of community. Larvae *Diamesa ursus*, *Diamesa* sp. II and juvenile stages of *Diamesa* were dominating. On the consecutive sites 9 to 11 *Diamesa* sp. I, *Diamesa* sp. Ii i *Diamesa* spp. (juv.) were still dominating in the community, but its diversity was bigger and larvae of Orthocladiinae, Simuliidae and other Diptera appeared. However, there were no representatives of other fauna groups.

Above Ladtjojaure Lake the Ladtjojåkka river fauna was similar to that found in Tarfalaj**å**kka stream. Chironomidae from genus Diamesa were dominating. For the first time the single individuals of Ephemeroptera, Plecoptera and Trichoptera were found. Below Ladtjojaure Lake the fauna was completely different. Simuliidae from genus Gnus were dominating. The important components of the fauna were Ephemeroptera, Plecoptera, Trichoptera, Hydracarina, Ostracoda, whereas representatives of taxons dominating so far, like genus Diamesa, appeared, if any, only as sigle individuals.

(III) The Alps streams

An analysis of the fauna's distribution along Rio Plima (Tab. 4) yielded that only single larvae of the genus *Diamesa* (*D. steinboecki*, *D.* sp. II (gr. *latitarsis*), *D.* sp. (gr. *zernyi*)) were found at the foot of the glacier. The same community, although consisting of a greater number of specimens, has been observed at the distance 200 m. from the glacier. At the stretch from site 3 (300 m from the glacier) to site 6 the larvae of *Diamesa steinboecki* were the first dominant. No

Table 4. Characteristics of the Rio Plima river and altitudinal zonation of macroinvertebrate communities (bold figure – dominant 10–100%, + adominant >1%, A – alpine zone, F – forest zone)

Sites	1	2	3	4	5	6	7	8*	9	10	11
Altitudae (m a.s.l.)	2700	2665	2600	2500	2300	2250	1900	1500	1250	950	670
Zone	A	A	A	A	A	A	F	F	F	F	
Water temperature °C	0.4	3.0	4.5	4.7	7.5	6.0	4.9	11.1	10.8	11.8	17.9
pH	8.0	7.6	7.4	7.2	7.0	6.8	6.8	7.1	7.1	7.1	7.4
CO_2 mg/dm^3	0	0	0	0.4	0.6	1.0	1.3	1.4	1.5	1.5	1.2
Alkalinity mval/dm^3	0.47	0.55	0.55	0.55	0.56	0.46	0.46	0.43	0.48	0.58	0.85
O_2 mg/dm^3	10.6	10.2	9.9	10.2	9.6	9.6	10.5	8.2	9.2	9.0	8.2
O_2 %	75.7	78.2	78.9	81.8	82.7	79.6	84.6	77.0	85.8	85.9	87.7
B.O.D. s mg O_2/dm^3	1.60	1.90	0.85	1.40	1.30	0.65	0.90	1.90	1.30	2.20	1.90
Diamesa sp. (gr. *zernyi*)	**53**	**33**	**20**	7.4	9.7	7.0	3.9			+	+
Diamesa steinboecki	**26**	**24**	**64**	**84**	**34**	**34**	1.2				
Diamesa sp. *II* (gr. *latitarsis)*	**13**	**18**		2.0	5.9	1.9	8.7	+			
Diamesa spp. (juv.)		**20**	**16**	5.4	8.4	5.8	5.1	+			
Taeniopterygidae (juv.)					**11**	6.7	+			+	
Orthocladius (*E.*) gr. *rivicola*					7.5	1.9	**20**	3.9	2.3	**44**	**13**
Diamesa sp. *I (*gr. *latitarsis*						**23**	**20**			+	+
Simulium argenteostriatum								**58**	**40**	3.4	+
Odagmia monticola							+		+	**12**	**66**
Prosimulium sp.		+			+			**17**	+		
Density ind./m^2 (in thousand)	0.5	1.2	2.7	1.6	1.9	0.6	8.3	3.1	2.7	2.3	8.3

* below Lago Gioveretto reservoir

fauna groups other than Chironomidae and single larvae of Diptera were found until site 4. Ephemeroptera (*Baetis alpinus*), Plecoptera and Trichoptera appear at site 5 downstream. The macroinvertebrate community of site 7 (1900 m a.s.l.) is different, the larvae of *Orthocladius* (*Euorthocladius*) gr. *rivicola* were first dominant and taxa diversity much increased at this station. Below the reservoir Gioveretto, Simuliidae (*Simulium argenteostriatum* and *Odagmia monticola*) were dominating.

In the glacial stream Rio Gioveretto (Tab. 5), at the foot of the glacier, only single larvae of *Diamesa steinboecki* and juvenile stage Diamesa were found. A similar community occurred at 300 m. from the glacier, but there its density was higher.. In the middle course of the stream, above the upper forest boundary, *Diamesa* larvae were dominant and also important was *Orthocladius* (*E.*) gr. *rivicola*. At this site single specimens of Ephemeroptera, Plecoptera and Trichoptera were found. The mayfly *Baetis alpinus* dominated at the lower course of the stream in the forest zone.

The communities of the spring-fed Rio Madricio were much different (Tab. 5). Already at the spring (station 1), apart from the larvae of the genus *Diamesa*, fairly numerous were the representatives of other groups; Plecoptera (*Protonemura* sp.), Trichoptera (*Drusus* sp.) and Ephemeroptera (*Rhithrogena*). Downstream from station 2, apart from larvae of *Orthocladius* (*E.*) *rivicola* group and *Diamesa*, the whole stream was also dominated by other taxa. Simuliidae (*Prosimulium* sp.) were important dominant at station 5 and 6.

(IV) The Caucasus streams

In the stream, just below the glacier, no representatives of the fauna were reported, though numerous imago *Diamesa* and stoneflies *Protonemura alticola*

Tab. 5. Altitudinal zonation of macroinvertebrate communities in the glacial stream Rio Gioveretto and spring stream Rio Madricio (symbols as in Tab. 4)

	Rio Gioveretto					Rio Madriccio					
Sites	1	2	3	4	5	1	2	3	4	5	6
Altitudae (m a.s.l.)	2700	2650	2200	2100	1900	2850	2700	2600	2300	2200	2000
Zone	A	A	A	F	F	A	A	A	A	F	F
Water temperature °C		6.1		7.2		3.7					
pH				7.1		6.0					
Diamesa steinboecki	**88**	**90**	+				**14**				
Diamesa spp. (juv.)	**11**	7.6	4.0	5.9	2.0	**34**	8,4	10	13	14	12
Diamesa sp. *I (*gr. latitarsis)		+	**53**	**21**		**14**	**12**	**23**	**23**	**15**	6.5
Diamesa sp. *II* (gr. latitarsis*)*			**23**	2.0	3.0		8.4	2.2	5.2	**14**	**16**
Baetis alpinus			+	**22**	**41**				1.3	3.6	3.5
Orthocladius (*E.*) gr. *rivicola*			8.2	7.2	7.9	2.0	**25**	**32**	**21**	3.5	**18**
Prosimulium sp.			+	2.3	2.0		15	+	5.2	**28**	**12**
Tvetenia sp.			+	6.9	3.0	**20**	+	3.0	4.3	2.3	12
Protonemura sp.		1,7	+			**12**			+	1.0	+
Drusus sp.			+	2.3	+	**10**		6.6			
Taeniopterygidae (juv.)				2.3		1.6	+	**10**	4.6	2.6	+
Density ind./m^2 (in thousand)	0.2	1.5	8.0	2.0	0.5	3.0	5.0	4.0	12.0	4.7	5.3

Tab. 6. Altitudinal zonation of macroinvertebrate communities in the Upper Terek River and its glacial tributories Suatisi (sites 1, 2, 3) (A – alpine zone, P – mountain pasture)

Sites	1	2	3	4	5	6	7	8
Altitudae (m a.s.l.)	2800	2800	2750	2500	2200	2100	2100	1700
Zone	A	A	A	P	P	P	P	P
Diamesa spp. (juv.)		**29**	**12**	?	+	+	+	+
Diamesa sp. (gr. *latitarsis)*		**16**	**48**	?	?	?	+	+
Diamesa spp.		**23**	+	**15**	?	+	+	+
Protonemura sp.			**18**	+	?	?	+	+
Orthocladius (*E.*) gr. *rivicola*			+	**23**	**49**	?	**?**	+
Eukiefferiella cyanea				+	**20**	**78**	**81**	**75**
Density ind./m² (in thousand)	0	1.2	8.7	6.0	8.7	9.2	7.7	4.7

were seen flying above the stream (Tab. 6). But already 50 m below the glacier very young larvae *Diamesa* were encountered. At a distance of 500 m from the glacier a community consisting mainly of *Diamesa* larvae was found. They were hard to identify but on the basis of collected imago at least three species were found: *Diamesa caucasica, D. tskhomelidzei, D. sakartvella*. Other species, *Orthocladius* (*E.*) gr. *rivicola* dominated in the Terek river at the altitude 2200–2500 m. In the lower part of the Terek river (1700–2200 m) mainly the community consisting of larvae *Eukiefferiella cyanea* was found.

RESULTS AND DISCUSSION

Zone of high mountain streams has very characteristic macroinvertebrates communities, which are met in all high mountains and subarctic streams of northern hemisphere (Bretschko 1969, Brodsky 1980, Gay 1982, Kownacka, Kownacki 1972, Kownacki 1991, Maiolini, Lencioni 2001, Robinson at al. 2001, Saether 1968, Steffan 1971, Snook, Milner 2001, Ward 1992, 1994). Examination of the glacial brooks in northern Scandinavia, Steffan (1971) introduced the terms *kryal* for biotop and *kryon* for biocenosis. *Kryal* was divided into two zones: the upper *metakryal*, with community *metakryon* dominated by *Diamesa,* (mainly *Diamesa steinboecki* group (sensu Kownacki (1978) and *Diamesa latitarsi* group) and the lower zone *hypokryal* with community *hypokryon* inhabited by *Prosimulium* (Simuliidae) in addition to *Diamesa*. In both zones Ephemeroptera are absent or very rare. Similar biocenosis were found in streams arising from the permanent snow fields, high mountain lake-outlet stream and temporary springs in high elevations (Kownacka, Kownacki 1972). *Metakryon* community is common in all investigated streams but *hypokryon* is not universal and found only in high mountain lake-outlet stream. *Hypokryon* were found in the outlet of Czarny Staw lake (the Tatra Mts) and in Tarfalajåkka below Lake Tarfalasjön (Scandinavia). In the Alps glacial streams the Rio Plima and Gioveretto *me-*

takryon passes into *rhithron* community. Simuliidae appear in great number only in Rio Plima below Lago Gioveretto reservoir. In the Caucasus *metakryon* was found in the Suatisi stream. In the lower part of the Terek river (1700–2200 m) mainly the community consisting of larvae *Eukiefferiella cyanea* was found. This species was characteristic also in the reach of Sucha Woda stream which dries up temporarily at the altitude of about 1000 m and develops immediately on the resumption of flow (Kownacki 1985). Quite different are macroinvertebrate com-

Table 7. Macroinvertebrate communities in the Olczyskie Wywierzysko spring in seasonal cycle

Month	June	July	Aug.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Water temperature °C	4.1	4.5	4.8	4.5	4.4	4.4	4.0	4.3	3.8	4.0	3.9
Parorthocladius nudipennis	15	21	51	14	2	+	2	+	+	+	+
Diamesa sp. (gr. *zernyi*)	7	28	3	5	+						
Baetis alpinus	9	4	+	12	61	69	79	59	53	67	69
Diamesa sp. (juv.)	11	11	16	11	+	+		+			+
Protonemura spp.	11	+	+	+	+	11	8	24	25	20	6
Paratrichocladius skirvithensis	13	+	+	+	+	+	1	+	1	+	
Orthocladiinae (juv.)	11	3	4	9	2	+	1	+	+	+	+
Diamesa sp. (gr. *latitarsis*)	8	2	5	14	+	+	+	+	+		+
Orthocladius (*Euorthocladius*) sp.	2	1	+	10	+						
Eukiefferiella minor	3	+	6	3	20	14	1	11	12	4	12
Density ind./m^2 (in thousand)	22	17	25	7	142	87	52	47	52	42	15

Tab. 8. Abiotic factors affecting macroinvertebrate communities in rhitral and kryal zone

	Rhitral	*Kryal*
Feed	spring	glacier, snow, high mountain lakes, periodic spring
Flow	annual	periodic
Water level fluctuation	moderate seasonal and low daily	high seasonal and daily
Temperature	winter<4°C<summer	0.5°C →5.5°C
Conductivity	> 100 µS	10–40 µS
PH	variable	usually≤ 7
Bottom	stable	often mobile (glacial stream)
Suspended solids	low	often high (glacial stream)
Water transparency	transparent	turbid (glacial streams)

Tab. 9. Comparison of *rhithron* and *kryon* macroinvertebrate communities

	Rhitron	*Kryon*
Abundance	high	low
Diversity	high (> 100 taxa)	low (1–20 taxa)
Domination	Chironomidae (Orthocladinae 30–70%) Ephemeroptera (*Baetis, Rhithrogena, Ecdyonurus*) Plecoptera (*Protonemura, Leuctra,* Teniopterygidae) Trichoptera (*Rhyacophila, Drusus, Allogamus*)	***Metakryon*** domination *Diamesa* genus (Chironomidae) ***Hypokryon*** = lake outlet domination Simuliidae + *Diamesa* ***High mountain springbrooks*** *Diamesa* + some taxons characteristics for *rhitron* communities, without mayflies Very often *metakryon* communities passes directly into *rhithron*

munities of high mountain stream Rio Madricio, originating from spring. Apart from the larvae of the genus *Diamesa*, fairly numerous were the representatives of other groups; Plecoptera (*Protonemura* sp.), Trichoptera (*Drusus* sp.) and Ephemeroptera (*Rhithrogena*). The similar type of communities was already described (Bretschko 1969). Classification of these communities is difficult. Their character is between that of *kryon* and *rhithron*.

The first suggestion was that occurrence of characteristic communities in glacial streams depends on high loads of suspended solids from glacial flour (Steinböck 1934, Dorier 1937). From a synthesis of information on glacial rivers, Milner and Petts (1994) proposed a conceptual model in order to predict the gradient of macroinvertebrate communities in these streams. This model suggests that two principal features, very low temperature, not exciding 4^{o}C and channel stability, determine occurrence of *kryon* community. Also Ward (1994), Hynes (1970) thought that temperature was a dominant ecological feature in *kryal*. Those factors are important, but not only they decide about the occurrence of *kryon* communities. In the Mnichowy stream, with transparent water, the same community as in glacial stream was observed. However, in Wywierzysko Olczyskie spring, where the temperature is similar as in glacial stream and oscillating from 3.8^{o}C to 4.8 ^{o}C per year, communities were completely different (Tab. 7). It should be agreed that many factors (Tab. 8) have an important influence on the development of *kryon* communities (Tab. 9).

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