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Vertical distribution of zoocenoses in the streams of the Tatra, Caucasus and Balkans Mts.

MARTA KOWNACKA and ANDRZEJ KOWNACKI

With 6 figures in the text

The aim of the present work was to represent the vertical distribution of bottom fauna in high mountain streams and to give an ecological classification of these streams. These investigations initiated by Professor KAROL STARMACH have been carried out for many years in the Polish part of the High Tatra by the Laboratory of Water Biology of the Polish Academy of Sciences in Cracow.

Thanks to the scholarship of the Polish Academy of Sciences and the support of the U. S. S. R. Academy of Sciences, especially of Professor A. G. KASYMOV from the Institute of Zoology of the Azerbaijan Academy of Sciences, and of Dr. O. I. CCHOMELIDZE from the Institute of Zoology of the Georgian Academy of Sciences a rich comparative material of bottom fauna was collected from streams of the Caucasus.

Investigations were also carried out in mountain streams of the Central Balkans in the course of a scientific expedition of the Institute of Zoology of the Bulgarian Academy of Sciences, in which the authors could participate thanks to Professor A. VALKANOV and Doc. G. PESHEV.

In the Tatra Mts samples were collected from streams taking their rise from patches of perpetual snow of flowing out from high-mountain lakes at a height of 2000 to 500 m (Fig. 1).

In the Caucasus the investigations were chiefly carried out in glacier streams flowing down from slopes of the Kazbek at a height of 3000 to 1700 m above sea level, giving rise to the river Terek, and in glacier streams in Svaneti 3500 to 1500 m, which are high-mountain tributaries of the river Inguri.

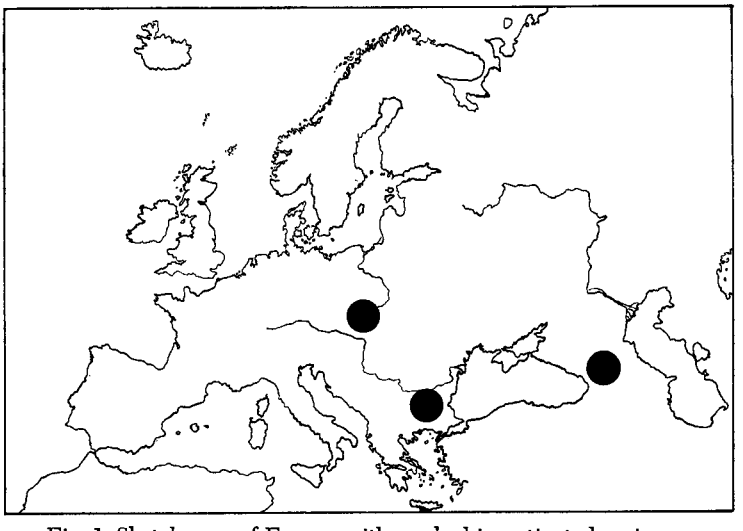


Fig. 1. Sketch map of Europe with marked investigated regions.

In Bulgaria the investigations covered the streams flowing down from the northern slopes of the central Balkan, which are tributaries of the Danube, and streams flowing down from the southern slopes, belonging to the catchment basin of the Aegean Sea.

From each station several samples were collected with a hand-net. All animals above 2 mm in length, i. e. the macro- and mesobenthos, were taken out in the laboratory. The material obtained was converted to the volume of 2 dm^3 of stones. To discriminate the communities of bottom fauna the index of dominance

$$d = \frac{Q \cdot 100}{\Sigma Q} \cdot \frac{n}{N}$$

was applied, where Q is the mean number from all samples in the station for one species. ΣQ = the total number of animals in the station, N = the number of samples in the station, n = the number of samples in which the given species occurred. The dominant species have a value of the index of dominance from 10 to 100, the subdominants from 1 to 9.9, while below 1 those are adominants. The present considerations were based on dominants.

The chief component of bottom fauna in high-mountain streams are larvae of insects, especially those of Chironomidae, Ephemeroptera, Plecoptera, and Trichoptera, and in some stations Simuliidae larvae. Hydracarina, Hirudinaea, Nematoda and Ostracoda and of the remaining insects Coleoptera, Hemiptera, and other Diptera play an insignificant part in the whole of the fauna. It was only in the sources of the Balkan that Oligochaeta were the main component of bottom fauna.

In the streams of the High Tatra Mts about 200 taxonomic units were identified, in the Balkan streams 160, while in the Caucasus only 90 species. The small number of forms is by no means an evidence of scantines of aquatic fauna in the Caucasus as compared with other mountains of the world; it is merely the result of the choice of the object of investigations. Streams and glacier rivers were investigated in the Caucasus chiefly in their highest parts, which are much poorer than the streams rising in springs, these not being taken into account in the present study.

When observing the distribution of fauna along the course of the stream, several communities were distinguished differing both in the number of indivi-

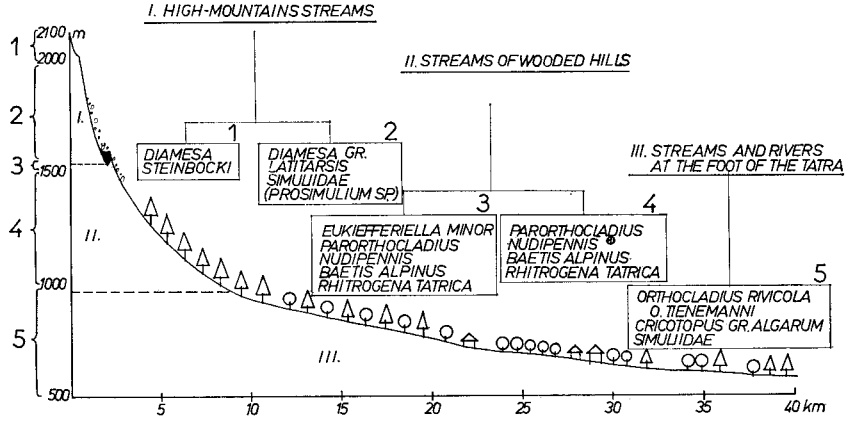
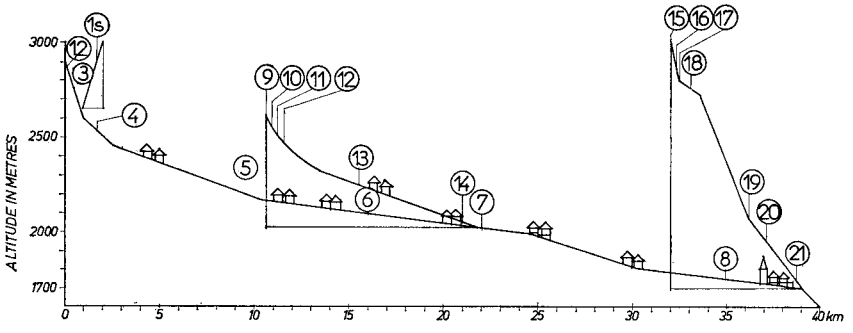


Fig. 2. Distribution of bottom fauna communities in the high Tatra streams. 1 *Parorthocladius nudipennis* — first dominant on the limestone substratum, *Orthocladius rivicola* — first dominant on the granite substratum.

duals and in the specific composition, as well as in the characteristic dominant species.

In the highest parts of the Tatra streams (Fig. 2) flowing out from snow at a height of above 2000 m a community develops chiefly composed of larvae and pupae of the genus *Diamesa* (Chironomidae) with the dominant *Diamesa steinbocki*. With the decreasing height the share of the latter in the community grows smaller, while larvae of *Diamesa latitarsis* group begin to prevail. Apart from them, larvae of Simuliidae of the genus *Prosimulium* appear, as well as representatives of other genera of Chironomidae: *Chaetocladius, Eukiefferiella,* stone-flies of the genera *Protonemura, Leuctra* and *Amphinemoura,* caddis flies *Drusus* and *Rhyacophila,* and a Triclad — *Planaria alpina.* No mayflies were found there as yet. The two distinguished communities characterized by a very small number of forms and individuals are typical high mountain communities. At a height of 1550 m from the spot where strong sources flow into the stream which does not dry up nor freeze over throughout the year, the composition of the communities changes violently. The dominant species here are *Eukiefferiella minor* and *Parorthocladius nudipennis* (Chironomidae) in streams with a calcareous substratum, or *Orthocladius rivicola* in those with a granite substratum. A more stable element of these communities irrespective of the character of the substratum are mayflies



	SUATISI and TEREK								MNAISIDON						CZHERI						
	1s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
DIAMESA SP (JUV.)	12		29	12	+	–	–	–	–		100		–	+	–		egg	48		–	–	–
DIAMESA GR LATITARSIS	22		16	48	+	+	+	–	–			100	95	54	20			16	82	64	42	15
ORTHOCLADIUS RIVICOLA	43			–	23	49	+	+	–					+	–					–	–	–
EUKIEFFERIELLA CYANEA					–	20	78	81	75					–	43					–	+	32
DIAMESA GR INSIGNIPES			23	–	15	+	–	–	–				+	+				+		+	+	–
DIAMESA GR CINERELLA													–	+	+				+	–	–	–
PROTONEMOURA SP	15			18	–	+	+	–	–					+	–					+	+	+
BAETIS GR RHODANI					+	–	–	–	–					–	+					–	+	12

Fig. 3. Distribution of bottom fauna communities in the Caucasus streams: Terek, Suatisi, Mnaisidon and Czheri. (The communities are composed according to the index of dominance. Number in circle = First dominant, + = subdominant, — = adominant, S = source streams.)

Baetis alpinus and *Rhitrogena tatrica** (2nd and 3rd dominant). This community is characterized by a large number of species and individuals and can be determined as a mountain community.

In streams flowing at the foot of the Tatra Mts a community develops, in which the dominant forms are *Orthocladius rivicola* and *Orthocladius thienemanni* and larvae of the genus *Cricotopus* and Simuliidae. Although a number of new species of mayflies appear here, their role in the community is much less important than in the mountain zone.

Investigations in the Caucasus were chiefly carried out in glacier streams (Fig. 3). In the stream flowing directly under the glacier no representatives of fauna were found, though above the stream numerous Chironomidae (of the genus *Diamesa*) were flying, as well as stone-flies *Protonemura alticola*. However, already 50 m below the glacier eggs of Chironomidae and single very young larvae of the genus *Diamesa* were encountered. At a distance of 500 m from the glacier a characteristic community develops, chiefly composed of larvae *Diamesa* gr. *latitarsis*. These larvae are difficult to determine, but on the basis of imagines found the occurrence of at least two species can be ascertained. This community in the tributaries of the Terek, Mna and Czheri develops almost up to their outlet. On the other hand, in the stream Suatisi taking its rise in a glacier and in numerous sources, the above described community develops only in glacier streams In the source stream the first dominant were larvae of *Orthocladius rivicola*. This species was also predominant along the whole length of Suatisi from the place of junction of all streams. This testifies to the considerable influence of source streams and numerous springs situated on the border of the river on the character of zoocenoses. On the other hand, in the investigated section of the Terek at a height of 2200—1700 m a community develops, chiefly composed of larvae of *Eukiefferiella cyanea*. This species is also predominant in all sections near the outlets of the Terek tributaries.

Investigations were also carried out in the region of Svaneti in the streams Dolra and Mestinka, tributaries of the river Inguri (Fig. 4). Here also we observe a similar distribution of communities. At the glacier mouth no animals occur, while further juvenile larval stages of *Diamesa* appear, and at a distance of 100—200 m from the glacier a community develops, chiefly composed of *Diamesa* gr. *latitarsis* larvae and of less numerous other species of this genus, as well as young larvae of the stone-fly *Protonemura alticola*. In the inflowing small source streams in which the water is transparent and the alga *Hydrurus* develops abundantly, larvae of *Orthocladius rivicola* predominate. These tributaries have a considerable influence on the community of the main stream. Although it continues to have the character of a glacier stream and the first dominant are larvae of *Diamesa* gr. *latitarsis*, the second dominant are usually *Orthocladius rivicola* larvae. This last species together with larvae of the mayfly *Epeorus* sp. (IRON) predominants in the lower part of the river Dolra.

Balkan streams taking their rise in small springs on the slopes of the Botew (2200 m), (Fig. 5) a community develops in which larvae of *Diamesa* gr. *latitarsis*

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* *Rhitrogena Loyolaea* NAVAS = *R. tatrica* syn. n.

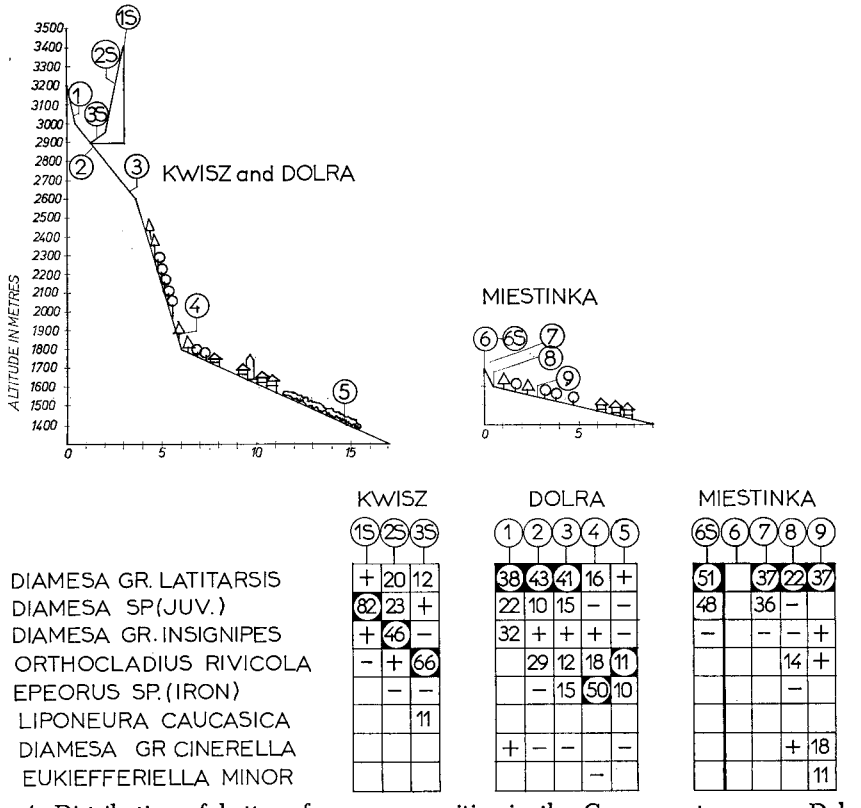

Fig. 4. Distribution of bottom fauna communities in the Caucasus streams — Dolra, Kwisz and Mestinka (marks identical as in Fig. 3).

are dominant. This section however is very short. In the overflow-arms forming below typical pelophilous forms appear, such as *Macropelopia* and *Pseudodiamesa branicki*. At the timber line (height about 2000 m) a community appears in which the first dominant are mayflies *Baetis alpinus*. A similar community was observed in the forest stream Ribarica, flowing down from the northern slopes of the Wezen Mt at a height of 1850—900 m. In the lower part of this stream at the outlet to the stream Biały Wit, the first dominant are larvae of Chironomidae — *Eukiefferiella clypeata*. The communities developing in springlets are different. Oligochaeta predominate here while Nematoda and Turbellaria occur in large numbers.

As can be seen from the diagrams presented the fauna of the investigated streams is very much alike, especially in their highest part.

Investigations carried out by STEINBÖCK (1934), THIENEMANN (1936), DORIER (1937) and BRETSCHKO (1969) in the Alps showed that it is also in the highest parts of Alpine streams that a community develops composed above all of *Diamesa* larvae (*Diamesa steinbocki, D.* gr. *latitarsis*). The same community was indentified as well in glacier streams of Scandinavia (THIENEMANN 1941, SAETHER 1968, STEFFAN 1971). Evidently various species may form part of the composition

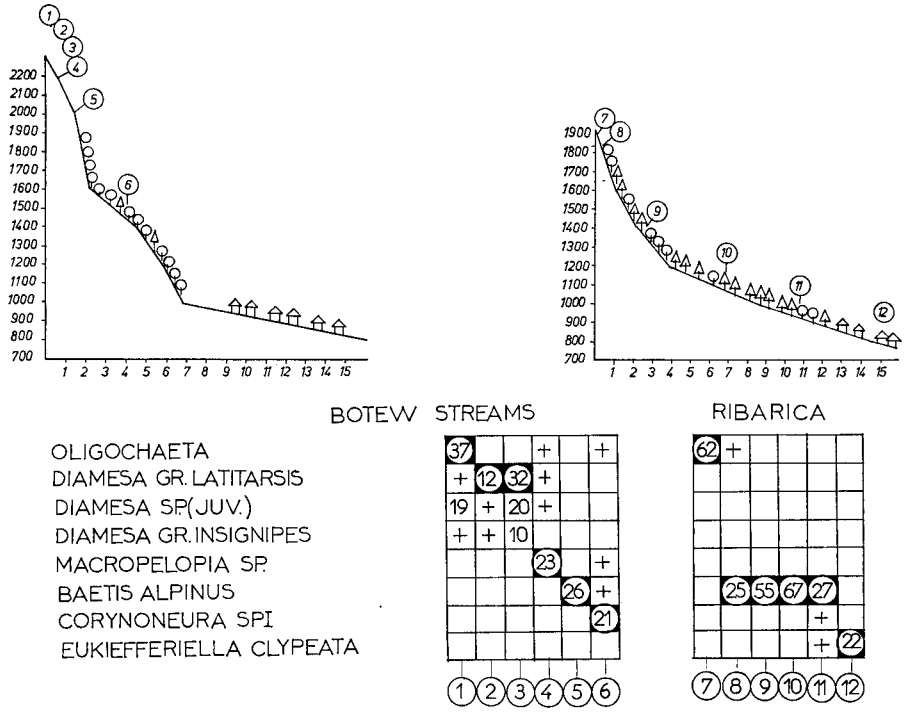

Fig. 5. Distribution of bottom fauna communities in the Middle Balkans streams (marks identical as in Fig. 3).

of high-mountain communities. Thus, for example, in streams of the northern regions the dominant species are *Diamesa steinbocki, Diamesa davisi, Diamesa lindrothi* and *D. valkanovi,* while in the streams of the Alps and of the Tatra Mts *Diamesa steinbocki, D. latitarsis* and *D. laticauda.*

On the other hand in streams of the Caucasus homologues of these species develop, which probably have been new for science. Since the community composed of larvae *Diamesa* gr. *steinbocki* and *D.* gr. *latitarsis* is very characteristic in all mountain massifs of our continent, it was considered that it marks out an independent zone being equivalent to the crenon, rhithron and potamon (Illies & Botosaneanu 1963) but not forming part of any of these zones. The individual character of these communities was noted by Thienemann (1954), who discriminated the streams „*Gletscherbach*" and „*Hochgebirgsbach*" in contradistinction to „*Übergangsbach*" and „*Mittelgebirgsbach*" and by Vaillant (1967), who distinguished the zone O, or Shadin who assigned to a separate group streams of Caucasian type, and finally by Illies & Botosaneanu (1963) who observed that their classification does not include high-mountain streams. On the other hand, one cannot agree with those authors who consider this zone to be a source area. It seems most proper to follow Steffan's (1971) suggestion giving the name of *kryal* to determine this biotope and that of *kryon* to the community living there. We shall assign to *kryal* streams taking their rise in glaciers patches of perpetual snow, and small high-mountain periodical springlets, as well as outflows from

some high-mountain lakes. *Kryon*, the community developing here, is characterized by the occurrence of *Diamesa* larvae.

According to STEFFAN (1971) the *kryal* can be divided into two zones: an upper one — *metakryal* — in which a community composed chiefly of *Diamesa* larvae develops, and a lower one — *hypokryal*, in which Simuliidae of the genus *Prosimulium* are dominant. This division is correct with regard to the northern and Tatra streams of a relatively small annual discharge. But in glacier streams and rivers the composition of zoocenoses is different. No zone occurs in them in which Simuliidae larvae would be developing in large quantities.

It seems therefore necessary to complement this division by introducing groups of streams and only then to apply further classifications (Fig. 6). The following were discriminated: high-mountain streams and rivers, middle-high mountain streams and rivers, corresponding to ILLIES & BOTOSANEANU's classifications and lowland rivers and streams, to which rivers of the Volga-Dnieper type (SHADIN 1949) or the river Susaa (BERG 1948) can be assigned.

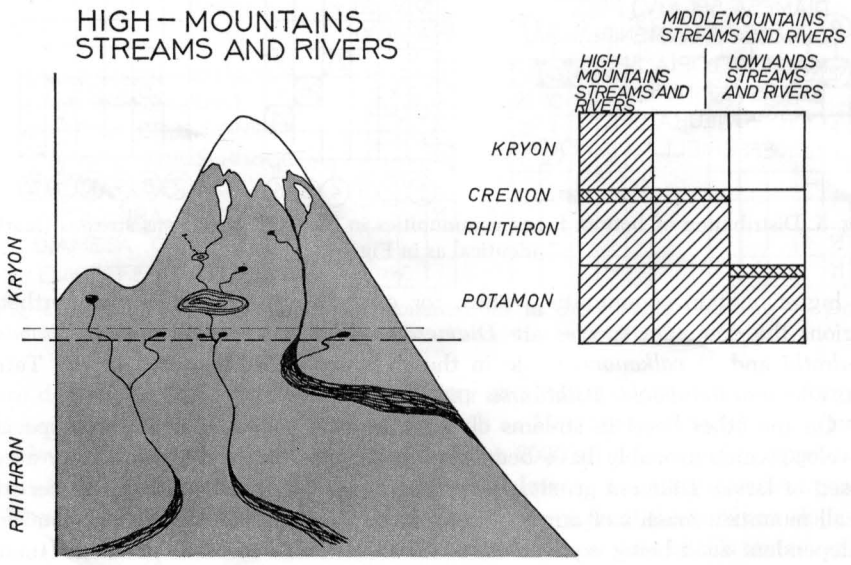

Fig. 6. Zonation of running water ecosystems with special regard to the group of high-mountain streams and rivers.

In the group of high-mountain streams and rivers the distribution of zones varies. The metakryon of large glacier streams passes into the zone of high-mountain rivers, the meta- and hypokryon in the Tatra streams, similarly as in rivers of north Scandinavia, passes into the high-mountain rhithron, in the Balkan Mts the short section of metakryal passes into rhithron, and in the high-mountain streams taking their rise in springs, a community of high-mountain rhithron develops, which may act on the kryon of glacier streams.

As concerns factors influencing the development of the kryal zoocenosis, it seems that the decisive factor is the height above sea-level and the latitude. The

further to the north the lower the limit of this zone is shifting. This principle is correct with regard to the streams taking their rise in patches of perpetual snow, high-mountain lakes and periodical springlets, but does not concern glacier springs in which the lower limit of the kryon depends on the height to which the glacier moves down. E. g. in the stream Mestinka and its tributary Czaład rising in the glacier Lekzyr and Czaład, the lowest situated in the Caucasus, the community in which *Diamesa* gr. *latitarsis* prevails, develops at the height of 1400 to 1700 m although in the glacier streams in the Kazbek it ended at a height of 2000 m. Also the turbidity cannot be a factor responsible for the development of the biocenosis of the kryon, since e. g. in the Tatra Mts in spite of the lack of glacier streams with turbid water, a typical kryal community develops. It seems that the essential factor is a low temperature not exceeding 8 to 10° C — the optimum being 1 to 6° C.

The significance of low temperature to the development of this community would be corraborated by the fact of its shifting in the Tatra Mts in winter up to the height of 1000 m above sea-level.

The next factor is the freezing over of these streams in winter, partial in the Caucasus and entire in the Tatra Mts. Probably only some species of the genus *Diamesa* can survive this period, whereas the other ones also cold-water, developping in source-streams need to their development an uninterrupted flow of water. It was also found that the investigated biocenosis lives in water of slightly acid reaction with the pH below 7.

This paper delas only with the problem of vertical distribution of zoocenosis in streams, no account being taken of a number of problems, such as the influence of the "mosaic of biotops" on communities or on their changes in the particular seasons of the year.

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Discussion

MORDUKHAI-BOLTOVSKOI: Have you found Amphipods in high-mountain streams?

KOWNACKI: Amphipods were encountered in single specimens or did not occur at all, though in other massifs of the Carpathians they represent a very important component of the fauna, being also encountered in large numbers in streams in the Little Caucasus.