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## Ecological characteristics of the bottom fauna of the Wielka Puszcza stream

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### Introduction

In spite of the fact that the bottom fauna of streams in the mountainous regions of Europe have been a subject of great interest for research workers for more than half a century, relatively few publications can be noted that contain an analysis of the entire macrofauna as to its ecological connections of time and surface, taking into consideration individual species. Macan (1961) considers as especially valuable the publications of Illies (1952) and Dittmar (1955), concerning the regions of Lipper Bergland and Sauerland in Germany.

There have hitherto been no studies of this kind in Poland. The larger systems of streams have been investigated in the general faunistic studies of Tomaszewski (1932) in the region of the Karkonosze mountains and the Kłodzka Basin and of Michejda (1954) on the streams of the Stołowe Mountains — discussing the dependence of bottom animals on the chemical conditions of the milieu. More numerous are the works concerning

individual groups of bottom fauna in different regions, as for instance those of Mikulski (1928, 1937, 1950), mostly dealing with mayflies, of Dudziak (1954, 1956) on triclads, of Pawłowski (1959) containing an analysis of the leech fauna and of Kamler (1960, 1962) on Tatra mayflies.

An attempt to determine as accurately as possible the species composition and quantitative relations and, simultaneously, the ecological dependence of the bottom macrofauna of a Carpathian stream during a period of investigation of one year, was undertaken. The stream chosen was the Wielka Puszcza, flowing into the river Soła through a region which until now had not been taken into consideration in hydrobiological investigations. The work is part of a collective study of the Soła basin, carried out on the initiative of Professor Karol Starmach with the aid of the Laboratory of Water Biology of the Polish Academy of Sciences in Cracow and the cooperation of the Chair of Hydrobiology of the Jagiellonian University.

The choice of this stream for more detailed investigation was motivated by: its natural state, only slightly disturbed by sparse settlement, the drainage area largely overgrown by forests and the typical appearance of a mountain stream, with a stony bed, a high unitary gradient, and a considerable straightening of the channel. The investigations were carried out during the year 1959, and partly also in the two following years. They were supported by hydrochemical (Bombówna 1965), and algological (Wasyluk 1965) investigations as well as by unpublished studies of fish.

The analysis concerned all groups of bottom macrofauna with the exception of the *Trichoptera*, which were studied by Zaćwiličowska (1964). I acknowledge gratefully the determination of the species of the *Simuliidae* (*Diptera*) by Dr W. Zwolski from Lublin and the verification of the *Amphipoda* species by Dr W. Micherdziński from Kraków. Some of the animals could not be determined with sufficient accuracy, especially those of the *Tipulidae* s.l. and *Empididae* (*Diptera*).

In the present paper the characteristics of the investigated milieu and ecological characteristics of the bottom fauna, as well as an attempt at the classification of the stream are presented. A detailed analysis of the systematic groups of macrofauna of the Wielka Puszcza stream will be the subject of a separate publication.

I wish to express my profound gratitude to Professor Karol Starmach for assigning this subject to me and for his scientific direction during the work. I sincerely thank Dr K. Zaćwiličowska for her aid in field-work and for data concerning the *Trichoptera*, as well as Drs M. Bombówna, K. Pasternak, and K. Wasyluk for much information concerning the studied region.

### Description of the stream

The stream Wielka Puszcza, a right-bank affluent of the river Sola, flows mainly in a westerly direction, with a slight orientation towards the north. It cuts fairly deeply between the two parallel mountain ranges of the Beskid Mały. Its total length is 9.0 km, its sources are situated at 720 m, and its mouth at 305 m above sea level. The considerable straightening of the bed of the stream (fig. 1) is demonstrated by the

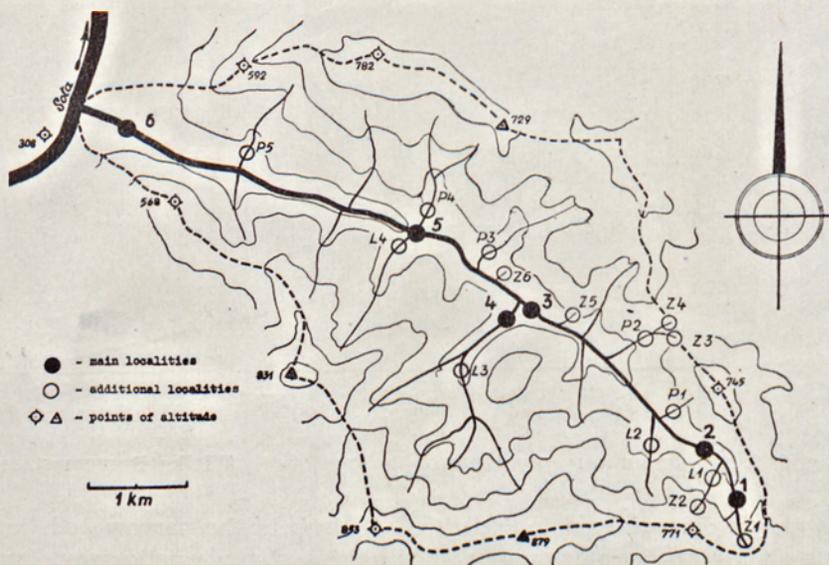


Fig. 1. Map of the Wielka Puszcza stream. The contour lines designate differences of levels of 100 m.

distance between the sources and the mouth, amounting to 8.2 km in a straight line. The drainage basin with a total area of 19.3 km<sup>2</sup> is delimited from the south by a mountain range not exceeding in height 900 m above sea level, and from the north by a range not reaching 800 m above sea level and bordering with the submontane region. On the area of the drainage basin forests with a mixed vegetation and a total surface of 15.3 km<sup>2</sup> dominate, the remainder consisting of cultivated fields, meadows, and settlements. The small village of Wielka Puszcza is situated slightly above half the length of the stream, while near its mouth the village of Porąbka is steadily developing. The mean unitary gradient is 46.1‰. According to the differentiation of unitary gradients, the stream can be divided into four sectors (fig. 2).

The source of the Wielka Puszcza stream is situated on the north-western slope of the Kocierska Pass and is of a limnolohelocrene type. The trickle draining the water cuts shallowly into the slope which is overgrown

by thickets of alder (*Alnus incana* (L.) M nch.) and hazel (*Corylus avellana* L.). At a distance of 150 m the trickle stream already forms a distinct V-shaped valley with steep slopes overgrown by a tall forest with mixed vegetation, where beech trees (*Fagus silvatica* L.) and hornbeam (*Carpinus betulus* L.) prevail at first and are succeeded by spruce (*Picea excelsa* (La m.) L.k.) and fir trees (*Abies alba* Mill.). The bed of the stream is lined with fine gravel at the beginning and further on, after cutting into the slope, with flat stones of various sizes. The stones are

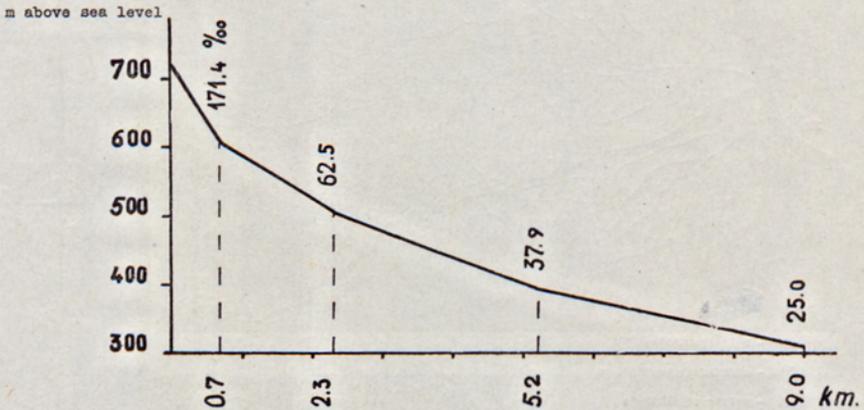


Fig. 2. Curve for unitary gradients of the bed of the Wielka Puszcza stream.

strewn in a disorderly manner, often piled up in the narrow bed, causing small amounts of water to flow down in a characteristic way, forming numerous cascades or filling small pools with gravel and deposits of mud.

About 800 m below the source, where the sides of the valley are still steep, the stream enters into the first distinctly developed, though narrow, terrace. The current does not cover the entire breadth of the lag gravel bank formed here. More distinct and longer sectors with a lotic current as well as deeper places with a slow current are formed, their bottom stony or composed of gravel and sand. The bottom of larger pools is usually covered with a layer of mud and detritus. After a course of about 2 km the stream flows out from the forest into a broad expanse of the valley in which the Wielka Puszcza village is situated. It then flows through a deep valley which is again narrower and mostly overgrown with spruce and fir. Here its greatest left affluent, L<sub>3</sub>, flows in. It then proceeds as a fairly large (3—5 m broad) mountain stream, through a rather narrow depression in the first terrace, on a substrate mostly composed of flat stones, through which the bed-rock appears in places. Because of the straightening of the bed and a more rapid flow of the water, pools occupying the entire width of the stream are seldom formed; instead, small sand-gravel banks of several metres and still water places occur



Fig. 3. Wielka Puszcza stream, locality 1.



Fig. 4. Wielka Puszcza stream, locality 2.



Fig. 6. Wielka Puszcza stream, locality 5



Fig. 5. Affluent L<sub>3</sub>, locality 4.



Fig. 7. Wielka Puszcza stream, locality 6.



Fig. 8. Affluent 4, near its meeting with the Wielka Puszcza



Fig. 9. Source Z<sub>1</sub>, the beginning of the Wielka Puszcza.



Fig. 10. Backwater of the Wielka Puszcza, near locality 3.

frequently behind large stones or rocks. At about 1.5 km before the mouth, the Wielka Puszczka valley gradually becomes broader and the stream flows already through the depression of the second terrace, forming near the Soła a broad lag gravel bank.

Higher aquatic plants do not develop as a rule in the principal bed of the Wielka Puszczka. Owing to the instability of the bottom in the middle and lower sector of the stream, water moss (*Fontinalis antipyretica* L.) grows on larger boulders and rocks only in the upper course of the Wielka Puszczka. Some backwaters are overgrown by clusters of *Veronica beccabunga* L. and *Myosotis* sp.

The Wielka Puszczka stream contains, however, communities of algae, especially abundant in its middle and lower course, which are important for animals not only as food, but also as a special habitat, both in the current and in the marginal parts of the bed. Of the characteristic species which form greater agglomerations, there are found here *Cladophora glomerata* (L.) Kütz. and *Ulothrix zonata* Kütz., typical for the stony bottom parts with a strong current, *Spirogyra* sp., *Vaucheria* sp., and *Melosira varians* Agr., often developing in large agglomerations in still waters near the stream banks, and *Oedogonium borisianum* (Le Clerc) Wittr. and *Stigeoclonium subsecundum* Kütz., common in some limnocene sources situated higher.

Lateral affluents flowing into the stream do not exceed (with the exception of the L<sub>3</sub> tributary) a length of 1.5—2 km. They nearly all resemble the upper sector of the main stream. Apart from them the Wielka Puszczka stream is supplied by dribbles of underground waters, especially numerous in its upper and middle course and mostly located at the bottom of the bed or in its margins. Some of them supply part of the various small stagnant water reservoirs situated near the stream. These last can be roughly divided into two groups: 1. Stagnant water reservoirs appearing beyond the channel of the stream, which are not covered by its waters during a flood. They are formed in the upper course by „eyelets”, very small and shallow pools on the gravel or between the stones, which are supplied by underground waters and also partly by water from the stream; in the middle course, however, there are old separated fragments of the stream bed — the pool-like backwaters — which are supplied in a similar manner or sometimes by water near the sources. 2. Marginal pools cut off in the channel of the stream, occurring on a more or less broad lag gravel bank when the flood waters subsided. Shallow (up to 20 cm deep) and of different sizes they are fed by water from the stream and are usually maintained between successive floodings. Their bottom is most frequently lined with a layer of mud with plant remnants.

The phenomenon of the drying out of sectors near the sources in some lateral affluents and also in the main stream, taking place in the summer period and connected with a low productivity of limnocene sources

situated higher, should be stressed. The current appears in the stream at a certain distance from its source, after the addition of a sufficient amount of underground water. This phenomenon occurs in the main stream 200—250 m from the source.

A sudden rising in the water level, especially in the spring and summer months, is a characteristic feature of the Wielka Puszczka, as well as of other Carpathian streams and rivers. As a result of the rapid flow the water displaces the rubble at the bottom, mostly in the middle and especially in the lower sector of the stream, often altering the course of the bed, disturbing and partly destroying the vegetal and animal communities existing there. In 1959 only one violent rise was noted at the end of June; it transformed the structure of the bottom in the middle and lower course of the stream. A very low water level was observed in the Wielka Puszczka in September and October, not exceeding 20 cm in its lower sector. This was connected with a very low rainfall in the region of the drainage area in the autumn period.

The Wielka Puszczka stream should be described, in a general manner, as a typical Carpathian stream, with a considerable gradient and a bottom mainly composed of weakly disintegrated rock material. The large amount of forest in the drainage area and a considerable straightening of the stream bed, mentioned previously, must be stressed. Limnocene sources prevail in the drainage area, while springs of rheocene type being seldom seen. There are no karst springs but small dribbles of underground water appear in the walls and bottom of the bed of the stream as well as various pools of stagnant water connected with it.

The terrain forming the substrate of the drainage area of the Wielka Puszczka is, from the geological point of view, of typical Carpathian flysch formation, of the Cretaceous and earlier Tertiary periods. The basis of the substrate is composed of a series of rock formations of Godula flat surfaces (Pasternak 1960) formed of sand-slate schists, morphologically differentiated formations, composed of diverse layers of glauconite sandstone and green shales. These rocks are characterised in general by their resistance to weathering processes and, in their surface strata, by a lack or only minimum amount of  $\text{CaCO}_3$ .

The rocky formations are covered by a very thin layer of soil, mostly loams with an admixture of stones and gravel. Pasternak (1960) considers them as being weakly developed brown humus soils.

The climate of the investigated and neighbouring areas is generally characterised by heavy rainfall during the summer months and a relatively protracted winter season. A frequent succession of cold and warm years, depending on the prevailing influence of the continental or of the Atlantic climate, is characteristic here. July and August are usually the warmest and January and February the coldest months of the year (Table I).

According to data for the years 1954—1957 of the meteorological station of Porąbka, the annual number of hot days with a maximum temperature of about 25.0 °C varied from 25 to 38 in the valley of the stream, and that of frosty days with a minimum temperature below 0.0 °C from 87 to 123, including 5 to 32 days with a minimum temperature below — 10.0 °C.

Rainfall in the drainage area is relatively abundant, often considerably exceeding 1000 mm of a column of water in the scale of one year. It is highest in the months from May to September and rain is most abundant in June and July (Table II).

The number of days with snowfall in the drainage area varied in particular winter periods of the years 1952—1961 between 36 and 123, (81 on the average). The snow usually lies from the end of November till the end of March, sometimes even till the second or third decade of April. In the winter of 1959/1960, that is at the beginning of the period of investigation, the snow lay for 63 days, from September 30 to February 28.

Winds have a serious influence on the climate of the valley. They usually blow from a south-western direction and also from due west and south.

For constant quantitative investigation six localities were chosen, five of them situated in characteristic sectors of the main stream and one on the affluent  $L_3$  (fig. 1).

Locality 1, at a distance of about 500 m from the source of the stream, in the forest (fig. 3). The valley is V-shaped; there is in the bed area of the stream 60 per cent of large stones (over 30 cm in diameter), 20 per cent of medium stones (15—30 cm in diameter) and small ones (up to 15 cm in diameter); the remaining 20 per cent consists of sand with mud sediments. The width of the stream amounts to 0.5—1.0 m, the depth being from 0.1 to 0.2 m at an average water level. Rapidity of the current in the cascades and narrow places of the bed: 0.53—0.85 m/sec., in broader stretches of still water and pools 0.10—0.45 m/sec.

Locality 2, about 1200 m from the source, in the forest (fig. 4). The valley is inclined slightly diagonally, with high slopes and a developed narrow first terrace. Along the bed of the stream a rather narrow lag gravel bank is visible. On the bottom area large and medium stones prevail (60 per cent); in places there are banks of sand-gravel, several metres long. There is a distinct differentiation of the stream into narrower lotic places and broader stretches and pools. The width of the stream is from 0.5 to 1.5 m, with a depth of 0.1 to 0.5 m. Current rapidity in the runs: 0.75—1.25 m/sec., in quieter places 0.36—0.44 m/sec.

Locality 3, below the settlement of Wielka Puszcza, about 3.6 km from the source. The bed straightens, the stream flows along the left steep slope of the valley, slightly inclined horizontally. The bottom contains 60 per cent of medium stones. Gravel banks are rare. The width of the

Table I

Mean temperature of air, for many years and for the years 1954-1957, according to data of meteorological stations (of the State Institute of Hydrology and Meteorology) in Bielsko-Biala and Porąbka (in °C)

Years	Months												Per year Amplitude	
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		
1881-1930	-2.1	-1.2	2.9	7.5	12.6	15.6	17.4	16.7	13.3	8.9	3.0	-0.6	7.8	19.5
1954	-2.9	-7.8	4.0	4.5	12.4	17.0	16.3	17.4	15.4	9.4	4.0	3.4	7.3	25.2
1955	-2.6	-2.1	-0.1	4.7	11.4	14.6	17.6	16.4	14.0	9.2	3.5	2.6	7.4	20.2
1956	0.3	12.4	0.7	6.7	11.8	15.3	17.3	16.2	13.4	8.8	-0.3	0.6	6.5	29.7
1957	-0.2	3.6	4.2	7.6	9.6	17.7	18.4	15.8	12.4	9.9	5.4	0.2	8.7	18.6

Table II

Total monthly rainfall in mm of a column of water, according to data from the meteorological station (of the State Institute of Hydrology and Meteorology) in Porąbka.

Years	Months												Total for year	
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	May-Sep.	May-Sep.
Mean for 1951-1960	50.1	47.4	49.6	81.2	102.0	130.6	163.7	97.9	70.0	59.1	56.7	51.3	564.2	959.5
1959	70.5	14.2	49.5	84.0	124.3	233.5	198.5	44.9	8.3	16.2	50.5	76.5	609.5	970.9
1960	51.3	23.0	16.7	72.1	92.2	128.7	402.3	143.2	79.3	45.1	58.7	33.8	845.7	1136.4

stream is 0.5 to 2.0 m, and the depth 0.2 to 0.4 m. Current rapidity in the runs: 0.88—1.18 m/sec., in lenitic places 0.36—0.44 m/sec.

Locality 4, on the left bank affluent  $L_3$ , at a distance of 2.6 km from its source (fig. 5). The valley is slightly diagonally inclined, the bed being morphologically similar to that of the preceding locality, though its gravel banks are more distinct. The width of the stream in narrow places with a rapid current is from 0.6 to 0.8 m, and in broader stretches up to 3.0 m, with differences of depth of 0.2—0.6 m. The rapidity of the current in narrow and lotic places: 0.79—0.90 m/sec., in lenitic parts 0.54—0.70 m/sec.

Locality 5, at a distance of 5.0 km from the source (fig. 6). The valley is slightly inclined diagonally, the stream flowing near the steep left side. The bottom, with a prevalence of large stones (50 per cent), is also covered with rocks and stones of the two remaining classes (30 per cent). The stream is 1.4 to 5.0 m wide, with a depth of 0.3 to 0.6 m. The rapidity of the current varies, similarly as in the next locality, between 0.80 and 1.30 m/sec. in the narrow parts and 0.40 and 0.70 m/sec. in wider places.

Locality 6, at a distance of 600 m from the mouth of the stream (fig. 7). The valley is slightly inclined horizontally, and the borders of the first terrace are at a certain distance from the stream, that is made deeper by the second terrace. On the bottom there is a prevalence at first of large stones (45 per cent) and then middle and small stones (40 per cent). Sand-gravel banks with mud sediments are formed. The stream is up to 2.5 m wide in more distinct narrow parts and up to 6 m in lenitic places. The corresponding depths are 0.3 and 0.7 m.

Besides the main stream, some of its affluents were additionally investigated. These are, on the left side,  $L_1$ ,  $L_2$ , and  $L_3$  (above locality 4) and  $L_4$ , and on the right side  $P_1$ ,  $P_2$ ,  $P_3$ ,  $P_4$ , and  $P_5$ . None of them (except  $L_3$ ) are more than 1 m wide at an average water level and 0.3 m deep. Of the left bank affluents the affluent  $L_4$  was distinguished by a considerable gradient (137.9 pro mille) and a bottom strewn with large boulders and rocks, with numerous small waterfalls and cascades (fig. 8). Of the right bank affluents  $P_2$  was distinguished from the others, flowing down from cultivated fields in the open, with a gravel bottom.

Some sources scattered on the slopes of the valley or situated near the stream were also the subject of additional investigation:

$Z_1$ , a source of limnohelocrene type (fig. 9), overgrown, with dimensions of  $1 \times 1.5$  m, 0.3 m deep, its bottom muddy, with decaying organic matter, from which the Wielka Puszcza originates.

$Z_2$ , of limnocrene type, with dimensions of  $1.5 \times 2.0$  m and a depth of 0.3 m, with a darkly coloured muddy bottom.

$Z_3$  and  $Z_4$ , of limnocrene type, artificially embanked, with muddy bottoms of dark colour, situated in close proximity on the slope of the valley.

Z<sub>5</sub>, of rheocrene type, wells forth from the steep slope near the stream, above locality 3, with a stony bottom.

Z<sub>6</sub>, of rheolimnocrene type, on the first terrace of the stream, near the affluent P<sub>3</sub>, with a muddy bottom containing a considerable amount of organic remnants. Dimensions of 1 × 4 m, depth 0.4 m.

Various stagnant water reservoirs near the stream (fig. 10), discussed previously, were also investigated in the principal localities, especially 1, 3, and 4 and also small meadow pools at the end of the valley.

### Chemical and thermic conditions

Bombówna (1965), in her study of the Wielka Puszcza, demonstrated the great dependence of the chemical composition on the water level and distinguished two periods: a. the spring-summer period, with a greater flow of surface waters washing out the upper strata of soil, mostly from forests, and with a pH decrease of under 7.0 (6.8—6.9) and an increase in nitrate content (up to 2.0 mg/l NNO<sub>3</sub>) and chlorides (up to 8.22 mg/l Cl); b. the autumn-winter season when, as the water level falls, rock material even from deeper strata is mostly washed out and

Table III

Physical and chemical data for some sources and affluents of the Wielka Puszcza stream in 1961

	Date	Water temperature (in °C)	pH	mg/l CaCO <sub>3</sub>	Total hardness	
sources	Z <sub>1</sub> Aug. 17	15.5	5.4	11.0	1.30	
	Z <sub>2</sub> Aug. 9	12.9	6.7	-	-	
	Z <sub>3</sub>	Jul. 20	16.5	7.5	56.0	3.40
		Aug. 5	15.1	7.9	-	-
	Z <sub>4</sub>	Jul. 20	14.7	5.7	20.0	2.00
		Aug. 5	14.3	5.7	-	-
Z <sub>6</sub> Jul. 18	7.8	6.5	50.0	3.60		
right bank affluents	P <sub>1</sub>	Jul. 20	12.0	6.8	46.0	3.20
		Dec. 3	4.4	7.0	52.5	3.65
	P <sub>2</sub>	Jul. 21	16.2	6.6	45.0	2.64
		Dec. 3	4.4	6.9	62.5	3.70
	P <sub>3</sub>	Jul. 18	12.7	6.9	54.0	3.60
		Dec. 3	3.9	7.1	52.5	3.60
	P <sub>4</sub> Jul. 18	9.9	-	27.0	2.32	
	P <sub>5</sub>	Jul. 18	13.4	6.8	30.0	2.20
		Dec. 3	5.7	7.1	42.5	3.30
	left bank affluents	L <sub>1</sub> Jul. 19	11.6	6.6	21.0	1.80
L <sub>2</sub> Jul. 19		11.4	6.8	30.0	-	
L <sub>4</sub>		Jul. 18	10.9	6.7	38.0	2.42
		Dec. 3	6.6	6.9	35.0	2.90

when the decaying processes of organic matter achieve a greater importance. The total hardness increases then (up to 4.7 in German degrees) as well as the alkalinity (up to 58.0 mg/l CaCO<sub>3</sub>) of the water of the stream, CO<sub>2</sub> appears in greater quantities (up to 17.7 mg/l), oxygenation processes increase (4.48 mg/l B.O.D<sub>5</sub>) and also the amount of nutritional components (4.5 mg/l K<sub>2</sub>O).

As to the content of calcium the stream may be considered, according to Ohle's classification (Dittmar 1955), as belonging to the poorly-calcareous group (0—14 mg/l CaO); it contains only periodically a slightly greater amount of calcium (up to 25.7 mg/l CaO) than in streams with an average CaO content (14—36 mg/l).

The author investigated the pH, alkalinity, and total hardness of the water of the drainage area of the stream in July and August (Table III).

Limnocrene sources, even situated close to each other, show rather different values as to these three components. The most acidified ( $Z_1, Z_4$ ) have the smallest amount of  $\text{CaCO}_3$  and the lowest total hardness.

Marginal pools in the bed of the stream and the backwaters near localities 3 and 4 in its middle course have, during the summer period, a lower pH than that of the main current (6.1—6.7), a slightly higher alkalinity (44.0—50.0 mg/l  $\text{CaCO}_3$ ), and a nearly similar total hardness (2.80—3.20 in German degrees).

Highly situated limnocrene sources sometimes have a fairly high temperature in summer. For instance, the water of source  $Z_3$ , on July 20, when the air temperature was  $18.5^\circ\text{C}$ , had a temperature of  $16.5^\circ\text{C}$ , and the water of the source  $Z_1$ , on August 17, when the temperature of air was  $16.0^\circ\text{C}$ , had a temperature of  $15.5^\circ\text{C}$ . Undoubtedly this close connection of the warmth of the sources with the temperature of the air is in a great measure the result of underground waters flowing near the surface and poorly supplying the sources. Sources situated in the deeper places of the valley have a low temperature ( $7\text{--}10^\circ\text{C}$ ) even on hot summer days.

In spite of the forests covering the neighbouring areas, the trickle sectors of the streams of the drainage basin, and also of the main stream, reach a fairly high temperature in the summer months. An interesting phenomenon can be observed here — the lowering of the water temperature on a certain length of these sectors of streams as the distance from the sources increases. For instance the temperature of the water in the affluent  $L_1$ , measured at midday on August 9, when the temperature of the air was  $21^\circ\text{C}$ , amounted to  $15.0^\circ\text{C}$  at 50 m from the source,  $14.0^\circ\text{C}$  at 100 m further down, and  $11.9^\circ\text{C}$  200 m further. The water of the main

Tabele IV

Thermal conditions of the Wielka Ruzszo stream in periods of collecting material throughout the year 1959/1960 (h - hour,  $t_a$  - temperature of air,  $t_w$  - temperature of water, in  $^\circ\text{C}$ )

Locality	Date	Mar.23	May 5	Jun.11	Jul. 7	Aug.11	Sep.14	Oct.23	Dec. 2	Mar. 3
1	h	9.10	7.45	12.15	-	8.45	14.40	9.50	10.20	12.30
	$t_a$	13.5	9.6	10.3	17.3	18.5	13.8	7.4	13.4	7.2
	$t_w$	6.5	5.0	8.4	10.0	13.5	11.0	6.6	5.5	3.2
2	h	11.40	8.40	13.00	-	10.20	15.40	10.40	11.00	13.20
	$t_a$	17.0	11.0	10.8	17.3	20.8	12.8	5.8	11.4	7.7
	$t_w$	7.0	6.6	9.0	10.0	14.0	-	-	6.0	4.2
3	h	13.50	10.30	13.50	-	12.10	16.50	11.00	12.30	15.25
	$t_a$	16.8	14.3	10.5	21.0	27.5	15.0	7.2	12.3	9.2
	$t_w$	7.2	9.5	11.0	14.0	18.4	13.0	6.8	5.0	3.6
4	h	12.40	9.30	14.15	-	13.00	16.25	11.30	12.00	14.00
	$t_a$	18.5	14.2	10.5	23.5	25.5	13.4	7.6	13.7	9.3
	$t_w$	7.6	8.6	10.0	12.0	18.0	12.8	6.2	5.0	3.8
5	h	14.14	-	-	-	14.50	17.20	12.30	13.05	16.20
	$t_a$	17.7	-	-	25.5	27.8	13.0	7.3	11.0	7.9
	$t_w$	8.2	-	-	14.0	17.6	17.6	12.0	6.6	4.2
6	h	14.55	-	9.45	-	14.90	17.55	13.20	13.55	17.00
	$t_a$	18.1	-	12.0	25.5	27.7	13.4	7.4	13.0	7.2
	$t_w$	8.3	-	10.7	14.3	18.0	12.6	7.5	6.3	4.5

stream which has a rather low temperature during the year, with a difference not exceeding 2—3°C between the extreme localities, is the coldest in the summer period not in locality 1 but in locality 2 (Table IV, fig. 11). This was confirmed by diurnal measurements of the water, on a hot summer's day, in characteristic places of the stream (Table V).

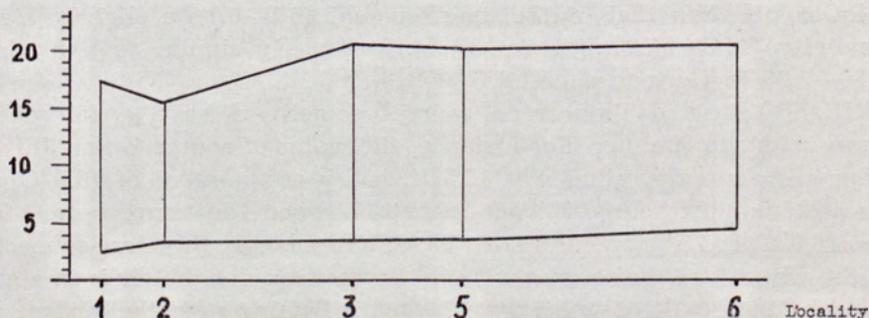


Fig. 11. Amplitudes of water temperature in the Wielka Puszcza noted in the periods of investigation from 1959/1960, at particular localities

The temperature of the water in most affluents in the section near their mouth was fairly uniform in the summer period (11.5—14.5 °C, when the temperature of the air was 17.0—21.8 °C). Especially cold water flows down the streams L<sub>4</sub> and P<sub>4</sub> (8.9—10.9 °C), while the insolated affluent P<sub>2</sub> has a very variable water temperature (up to 23.0 °C).

Table V

Thermal conditions of the Wielka Puszcza stream on August 7, 1960 (ta - temperature of air, tw - temperature of water, in °C)

Hour	Locality 3		1		2		3		4		6	
	ta	tw	ta	tw	ta	tw	ta	tw	ta	tw	ta	tw
4 <sup>00</sup>	19.0	13.1	14.1	15.9	-	15.1						
6 <sup>00</sup>	20.1	-	14.1	15.8	14.4	15.0						
8 <sup>00</sup>	23.2	-	14.1	16.9	14.9	16.1						
10 <sup>00</sup>	27.5	-	14.4	19.2	16.4	17.7						
12 <sup>00</sup>	29.5	-	15.1	20.3	18.1	19.7						
14 <sup>00</sup>	30.5	17.3	15.4	20.5	19.8	20.3						
16 <sup>00</sup>	27.3	-	15.7	20.2	19.7	20.5						
18 <sup>00</sup>	24.7	15.2	15.7	19.3	18.4	19.7						
20 <sup>00</sup>	22.0	15.0	15.7	18.7	17.2	18.2						
22 <sup>00</sup>	22.0	-	-	18.0	16.7	17.7						
Maximum temperature	30.5	17.3	15.7	20.5	19.8	20.5						
Minimum temperature	19.0	13.1	14.1	15.8	14.4	15.1						
Amplitude	11.5	4.2	1.6	4.7	5.4	5.5						

Marginal pools cut off by a lag gravel bank and some uncovered backwaters in the middle course of the stream often have a higher temperature than that of the current of the Wielka Puszcza, their

temperature even rising to 25.0 and 28.0°C on some hot summer days. Those backwaters situated in the shade, however, and the „eyelets” in the upper sector of stream usually have then a temperature several degrees lower than that of the current in the bed of the stream.

### Method of investigation

The material for quantitative investigation was collected in 6 principal localities (see p. 67) in the period from March 1959 to March 1960, at more or less monthly intervals, with the exception of January and February. Samples were collected in these localities by means of a scraper composed of a square metal frame with an opening 22.5 cm broad, on which a bag of bolting cloth (20 threads per cm length) was sewn. The scraper was pressed into the bottom to a depth of 4 to 5 cm against the current, that part of the bottom in front of it being swept into the bag so that the animals, torn off from the substratum and carried away by the current, fell into the net. The size of samples was adapted to the nature of the substratum; material from a stony bottom was collected from the relatively large surface of 0.4 m<sup>2</sup>, owing to the considerable dimensions of the stones; samples from a bottom covered with gravel, sand, or mud were collected on a surface of 0.05 m<sup>2</sup>. The animals were fixed on the spot in 4% formalin.

It was endeavoured to collect samples from the same volume for particular kinds of substratum in all localities. In this was, after counting the number of animals in 1 m<sup>2</sup> of the bottom, the mean density for different habitats and then for successive localities could be determined for the whole period of investigation.

Qualitative samples, both from the main stream, the lateral affluents, sources, and stagnant waters of different types near the stream were collected with a scraper also in 1960 and 1961. Adult specimens of *Ephemeroptera* and *Plecoptera* were captured along the whole length of stream.

Altogether about 250 samples of water and more than 100 samples of imagines caught on land were studied.

The rapidity of the current was measured in individual localities, at an average water level, with the aid of a G.G.I. tachometer (Žadin 1956). pH was studied colorimetrically with Yamada's reagent. Alkalinity was calculated from 50 ml of water, with the aid of 1/10 normal HCl and Methyl orange as an indicator: the total hardness was calculated with the compleximetric method (E.D.T.A. titration method) after W. Christ and J. Kaeding, expressing the results in German degrees.

When discussing the bottom fauna of the stream it was decided to describe localities 3 and 4 together. Situated on the same level, near each other they are similar from the physiological and faunistic point of view.

## General characteristics of the macrofauna of stream

### Sources

The limnocrene and limnohelocrene sources, situated high up on the slopes of the valley, can be compared to the heterothermic sources, the so-called „Tümpelquellen”, distinguished by Beyer (1932), although they are sometimes artificially deepened. They are inhabited by a fauna which differs considerably from the communities of the further sectors of the stream. It is mostly composed of limnobiontic species, characteristic for source zones or of ubiquitous forms. Most frequently seen were the Hemiptera (*Gerris gibbifer*, *Velia caprai*), *Pelopiinae* and *Psectrocladius* ex gr. *dilatatus*, *Leuctridae* and *Nemouridae* larvae with the most numerous *Nemurella picteti*, as well as the carnivorous *Dytiscidae* (*Agabus guttatus*) larvae and *Pisidium casertanum* (*Bivalvia*). The absence in these sources of groups like the *Amphipoda*, *Tricladida*, or *Trichoptera*, usually connected with spring areas, is very striking. Neither were *Ephemeroptera* larvae found here.

Rheocrene and rheolimnocrene sources, situated deeper down the valley, near the bed of the stream, have a different fauna composition. In the case of the rheolimnocrenes, besides the previously mentioned species of the Hemiptera, Plecoptera, Tendipedidae, or *Bivalvia*, also *Gammarus pulex fossarum* and *Ecdyonurus lateralis* appear in large numbers in the animal communities. In rheocrene sources the fauna is poorer in quality, with dominating rheophilous *Trichoptera* and *Gammarus pulex fossarum*. In the fissures in the walls of the stream bed through which underground water trickles, representatives of the subterranean fauna, such as *Niphargus tatrensis* and *Phreoryctes gordioides* and of the hygropetric fauna (*Orphnephila testacea*) were mostly found.

### Main course of the stream

A. Upper sector. In connection with the periodical drying out of a 200—250 m long part near to the source, the majority of representatives of the bottom fauna from further parts of the stream are absent. Only *Plecoptera* larvae with the *Nemouridae* and *Leuctra nigra*, and also *Lumbricidae* and *Pisidium casertanum* live here in greater numbers. More differentiated macrofauna groups appear after 300 m of the course of the trickle stream, when the valley develops more distinctly and the underground waters supply the stream more abundantly. All the more important groups of animals mostly composed of stenothermic and partly also of rheophilic forms typical for trickle zones, are already represented in locality 1. *Gammarus pulex fossarum* lives here in great numbers. Zelinka (1950) stresses the fact of the abundant reproduction of this species in the trickle zones of Carpathian streams. A relatively numerous

and variegated group is that of stoneflies, with the *Leuctridae* and *Nemouridae*. An abundance greater than in further sectors of the stream is achieved by *Ceratopogonidae*, *Hexatominae*, and *Empididae*, while the *Tendipedidae*, represented mostly by the *Pelopiinae* and *Tendipedinae* species, are less numerous. As to mayflies, *Ecdyonuridae* (*Ecdyonurus subalpinus*) larvae and the rheophilous *Baetidae* (*Baetis carpaticus*) mostly live here.

Table VI

Percentage composition of the bottom fauna at particular localities of the Wielka Puszczka, as the mean figure for 1959/1960. Species or groups with more than 0.2% in total of all the localities are included. Animals below 0.05% of one locality are marked with crosses

Animals	Locality	1	2	3, 4	5	6
<i>Dugesia gonocephala</i>		0.3	0.5	0.1	0.1	+
<i>Pelmatohydra oligactis</i>						0.3
<i>Oligochaeta</i>		0.6	1.1	2.4	0.5	23.5
<i>Gammarus pulex fossarum</i>		47.9	51.6	2.5	0.7	+
<i>Ephemera danica</i>				0.1	0.1	0.1
<i>Baetis pumilus</i>			0.1	0.4	0.7	0.5
<i>Baetis rhodani</i>		0.3	0.7	5.2	3.6	3.0
<i>Baetis carpaticus</i>		1.0	1.7	1.9	0.9	0.4
<i>Baetis venustulus</i>				0.3	0.5	0.3
<i>Baetis scambus</i>				0.5	0.4	1.0
<i>Centroptilum luteolum</i>				0.7	1.3	0.1
<i>Ecdyonurus lateralis</i>		0.2		0.1	0.2	0.1
<i>Ecdyonurus subalpinus</i>		1.9	0.6	+		
<i>Ecdyonurus torrentis</i>				1.7	1.5	0.1
<i>Epeorus assimilis</i>				0.6	0.6	0.4
<i>Rhithrogena semicolorata</i>		0.9	2.4	1.6	0.2	0.2
<i>Habroleptoides modesta</i>		0.2	0.2	5.7	3.5	0.4
<i>Habrophlebia lauta</i>			0.1	0.1	0.8	+
<i>Ephemerella ignita</i>				0.1	+	0.2
<i>Caenis pseudorivulorum</i>				1.0	0.6	+
<i>Protonemura praecox</i>		+	0.3	0.2	0.1	
<i>Protonemura lateralis</i>		1.1	1.3	1.0	0.3	0.3
<i>Amphinemura sulcicollis</i>				1.7	0.4	0.6
<i>Amphinemura borealis</i>				0.2	0.5	0.5
<i>Nemoura ex gr. cambrica</i>		1.2	1.7	0.9	1.0	+
<i>Leuctra ex gr. inermis</i>		3.2	6.2	2.8	0.8	0.8
<i>Leuctra nigra</i>		2.6	2.6	0.4	0.2	
<i>Leuctra ex gr. albida</i>		+	0.2	2.9	2.3	0.5
<i>Leuctra fusca</i>				0.8	0.1	0.1
<i>Leuctra braueri</i>		0.7	0.4	+		
<i>Leuctra armata</i>		0.4	+	+		
<i>Leuctra pseudosignifera</i>		+	1.8	0.2	0.1	
<i>Isoperla oxyplepis</i>				2.4	1.4	0.6
<i>Perla marginata</i>				0.3	0.3	0.2
<i>Chloroperla neglecta</i>		0.4	+	0.9	0.2	+
<i>Deronectes rivalis</i>			0.1	0.1	0.6	+
<i>Helodes marginata</i>		0.2	0.2	+		
<i>Hydrocyphon sp.</i>				0.2	0.1	+
<i>Esolus parallelepipedus</i>				0.2	0.2	+
<i>Esolus angustatus</i>		0.4	0.2	0.3	0.1	0.4
<i>Limnius perrisi</i>		0.4	0.7	0.6	0.1	+
<i>Limnius muelleri</i>						0.4
<i>Ceratopogonidae</i>		0.6	0.1	0.1	0.1	+
<i>Tendipedidae</i>		26.8	14.5	45.7	41.1	62.3
<i>Simuliidae</i>		0.4	0.6	1.3	3.5	1.0
<i>Tricyphona spp.</i>		0.1	0.3	+		
<i>Limnophila sp.</i>		0.3	1.2	0.1	0.1	+
<i>Dicranota bimaculata</i>		0.1	0.4	0.1	0.1	+
<i>Hexatominae</i>		0.6	0.2	0.1	0.3	0.2
<i>Hemerodromia spp.</i>		0.5	0.2	0.1	0.4	+
<i>Trichoptera</i>		5.6	6.9	9.6	28.4	1.3
Total		98.9%	99.1%	98.2%	99.0%	99.8%

In locality 2, the community of bottom fauna has, in principle, a similar character. The dominance of *Gammarus pulex fossarum*, attaining here 50 per cent of all the animals (Table VI), is still more apparent, although its density, per unit of the bottom surface, is much smaller than that in the previous locality.

On the whole, the bottom fauna of the upper sector of the Wielka

Puszcza contains a distinctly smaller number of species (Table IX) and is less abundant than that of the following sectors of the stream. This phenomenon seems to be a regular one and is confirmed by the investigations of numerous authors (Eidel 1933, Zelinka 1950, Dittmar 1955, Hynes 1961), being an expression of the derioration, when advancing upstream, of the ecological conditions demanded by most animals. As the chemical pattern is fairly balanced and oxygenation of the water rapid, the small amount of animals, especially of mayflies and tendipedids, in the stony habitats with a current of the upper sector of the Wielka Puszcza (Table VII) may be ascribed to nutritional conditions, i. e. to a less abundant development of algae. Thienemann (1912) and Zelinka (1950) turn their attention to the considerable paucity of the fauna in the forest sectors of mountain streams. A lower water temperature and lesser width of the stream bed must undoubtedly play a certain role in the limitation of the appearance of certain species. The narrowness of the bed may influence the general lack of large *Perlidae* larvae and the small number of *Perlodidae* larvae.

The mean density in this sector of the stream amounts to 2.232 specimens/m<sup>2</sup> of the bottom surface in locality 1, and 1.346 spec./m<sup>2</sup> of the bottom surface in locality 2.

B. The middle sector of the stream is represented by localities 3 and 4, situated near each other on about the same level, and by locality 5, situated below. This is the longest sector of the Wielka Puszcza and the bed of the stream is wider and straighter. Favourable chemical and thermic conditions, a rapid current and a more abundant development of algae, provide for the formation of numerous and more differentiated (Table IX) communities of animals, with a species composition typical for medium sized mountains, where aquatic insects and rheophilic groups dominate.

In localities 3 and 4 the abundance of the *Tricladida* and the *Amphipoda* diminishes considerably, while the participation of the *Tendipedidae* increases, especially in the current (*Orthocladinae* and *Diamesinae*), and also the *Oligochaeta* (*Nais pseudoobtusa*). Mayflies and stoneflies impress their characteristic stamp upon this sector of the Wielka Puszcza. As to the *Ephemeroptera*, *Baetidae* larvae (*Baetis rhodani*, *B. carpaticus*) increasingly prevail and also the *Leptophlebiidae* (*Habroleptoides modesta*) and the *Caenidae* (*Caenis pseudorivulorum*). In the case of *Plecoptera*, besides the most numerous *Nemouridae* (*Protonemura lateralis*, *Nemoura cambrica*), *Perlidae* larvae (*Perla marginata*) and the common *Isoperla oxylepis* (*Perlodidae*) also appear.

A similar disposition of the bottom fauna was observed in locality 5. Of the *Trichoptera*, *Chaetopteryx villosa* (Zacwiličowska 1964) are present here in large numbers and, of the *Coleoptera*, *Deronectes rivalis*, which concentrate in the marginal parts of the stream bed.

The main density is 2.361 specimens/m<sup>2</sup> of the bottom surface for localities 3 and 4, and 3.436 spec./m<sup>2</sup> for locality 5.

C. The lower sector is represented by locality 6. An abundance of true worms, which occupy as to number the second place after the *Tendipedidae* owing to a mass reproduction of *Nais pseudoobtusa*, is characteristic here. The number of mayflies and stoneflies diminishes visibly, however, apparently as the result of water pollution in this sector of the Wielka Puszca. The *Simuliidae* and *Dryopidae* (*Esolus angustatus*, *Limnius muelleri*) and the *Psychodidae* larvae, characteristic for the lower course of the stream, live here in greater numbers.

The main density reaches 4.120 specimens/m<sup>2</sup> of the bottom surface.

#### Small water bodies near the stream

Small pools of the „eyelet” type, situated at the upper course of the Wielka Puszca, are inhabited by a qualitatively poor fauna in which stenothermic forms prevail. Besides the *Gammarus pulex fossarum*, *Niphargus tatrensis* lives here, and also *Leuctridae* larvae (*Leuctra nigra*, *L. braueri*), the *Tubificidae* and *Lumbricidae* species, *Orphnephilidae* and *Culicidae* larvae, and the *Velia caprai*. No mayfly larvae were ever found here.

Backwaters in the middle sector of the stream, up to ten or more metres long, with a stony bottom covered with mud and an abundantly developing mat of algae or clusters of a higher vegetation, have a different faunistic character. Besides plankton organisms, or the *Copepoda* and *Ostracoda* living near the bottom, molluscs (*Lymnaea peregra*, *L. truncatula*, *Pisidium casertanum*), water bugs (*Corixidae*, *Gerris gibbifer*), beetles (*Platambus*, *Agabus*), flies (*Pelopinae*, *Tanytarsini*, *Empididae*, *Culicidae*, *Dicranota*), mayfly larvae (especially *Ephemera danica* and *Ecdyonurus lateralis*), and *Nemouridae* larvae are typical here. Reservoirs of the backwater type demonstrate therefore, from the faunistic point of view, a great resemblance to stagnating small reservoirs of the plains. The influence of the stream makes itself felt by the presence of some stream species, mostly mayflies, stoneflies, and flies.

A distinct faunistic connection with the main stream is demonstrated by marginal pools, situated on lag gravel banks of the stream. The fauna living there forms, in fact isolated parts of animal communities of the main stream. Many species of mayflies of the *Ephemerellidae*, *Leptophlebiidae*, and *Baetidae* (*Centroptilum* spp.) and even *Ecdyonuridae*, as well as stoneflies (*Leuctridae* and *Nemouridae*), beetles (adults *Dytiscidae*), water bugs (*Corixidae*), and flies (*Pelopiinae*, *Tanytarsini*, *Empididae*) live here. A lack of rheophilous and stenothermic species is generally apparent. No larger *Perlidae* and *Perlodidae* larvae, common in the neighbouring current of the stream were found.

### Habitation on different types of substratum

When distinguishing different kinds of substrata in the investigations of water, authors (Thienemann 1912, Žadin 1950, Illies 1952, Albrecht 1953, Dittmar 1955) take into consideration their origin, the degree of disintegration, and the nature and degree of chemical activity, etc. In the typically mountain stream Wielka Puszca, where there are conditions of a considerable gradient in the bed and of a strong current, a stony substratum dominates, with a prevalence of weakly disintegrated elements disposed in a characteristic manner. The mosaic pattern of the individual kinds of substratum and the sometimes considerable degree of their intermixture, as the result of variable current conditions, stressed by various authors (Eidel 1933, Mikulski 1950, Kamler 1960, 1962) appears here distinctly, especially in the upper course of the stream.

Rock is present in the investigated area of the stream in a very insignificant percentage, in the localities 1 and 5. It is inhabited by qualitatively rather poor animal groups, mostly composed of typical lithorheobionts, i.e. of some mayfly *Baetidae* larvae (*Baetis carpaticus*) and *Ecdyonuridae* (*Epeorus assimilis*), and of larvae of *Simuliidae*, *Orthoclaadiinae* (*Eukiefferiella*, *Rheocricotopus*) or *Diamesinae*. Here also *Blepharoceridae* specimens were found.

In all sectors of the stream a stony substratum dominates. It is composed of flat stones of different sizes intermixed and strewn about in a disorderly manner, with admixtures of deeper lying gravel and sand. It should be divided functionally into two kinds: a). a stony bottom situated in a lotic current and b). a stony bottom in lenitic overflows of the stream and in its marginal parts taking as the limit of division the value of 0.4–0.5 m/sec. of current rapidity. The microhabitats existing here, differing in their relation to current and light, concentrate an abundant and qualitatively differentiated macrofauna, especially in the middle and lower course of the stream (Table VII).

The stony bottom in the lotic current is mainly inhabited by typical polyoxybionts. These are: *Baetidae* and *Ecdyonuridae* larvae (*Baetis carpaticus*, *B. venustus*, *Epeorus assimilis*, *Rhithrogena semicolorata*), stoneflies (*Perla marginata*, *Dinocras cephalotes*, species of *Brachyptera* and *Protonemura*), *Orthoclaadiinae* (*Eukiefferiella*, *Rheorthocladus*, *Euorthocladus*) and *Diamesinae*. Typical rheobionts — *Simuliidae*, *Blepharocera*, or *Tathrophila vitripennis* are found mostly on larger stones. *Dryopidae* (*Esolus*, *Elmis*) and *Hydrophilidae* (*Hydraena*) beetles are common here. Owing to a quite considerable structural differentiation, organisms that do not in principle belong to the habitat are found in it, as e.g. *Gammarus pulex fossarum* or *Habroleptoides modesta* and also some *Tendipedidae*.

Table VII

Density of inhabitation of macrofauna of the Wielka Pyszcza, as a mean figure for 1959/1960, calculated for a surface of 1 m<sup>2</sup> (A - stony bottom in the current, B - mud sediments in still water)

Group	Locality		1		2		3,4		5		6	
	Habitat		A	B	A	B	A	B	A	B	A	B
Hydroidea												33
Tricladida			10	2	13	1	3	1		3		
Nematomorpha				2					1		4	
Oligochaeta			1	28	2	28	2	136		33	57	3024
Amphipoda			227	2046	250	1118	15	124		46	1	
Odonata				1								
Ephemeroptera			144	52	133	24	389	611	385	644	315	210
Plecoptera			66	405	82	310	243	529	119	424	140	169
Coleoptera			12	40	14	18	15	77	15	72	9	54
Trichoptera			47	214	40	133	194	274	114	1810	20	128
Psychodidae								1			5	17
Tendipedidae			27	1256	41	345	279	2214	1819	963	2687	2306
Ceratopogonidae				31				4		9		
Simuliidae			18		14	3	50		230	6	59	
Tipulidae s.l.			1	59	2	61	5	25	4	31	2	25
Empididae				26	2	2	3	11		1	26	17
Diptera remaining x)				2		4	1			2	6	
Total			553	4164	593	2049	1199	4007	2690	4074	3302	5933

x) Orphnephilidae, Culicidae, Tabanidae.

Animal settlements differing in composition and number inhabit the stony bottom in lenitic fragments of the stream, but typical rheobiontic species are lacking. Of mayflies the *Ephemerellidae* (*Ephemerella krieghoffi*, *E. ignita*), *Ecdyonurus torrentis*, and some *Baetidae* (*Baetis rhodani*, *B. scambus*) live here. Stoneflies are chiefly represented by *Isoperla oxylepis*, *Nemouridae*, and *Leuctridae*, and *Coleoptera* by *Hydrocyphon* larvae and different stages of *Dytiscidae* headed by the *Deronectes rivalis*. Somewhat small food reserves, owing to the weak development of algae here, hinder the settling of tendipedids, represented by *Diamesinae* and *Pelopiinae*.

The sand-gravel substratum is concentrated near the margins of larger pools, sometimes in the form of narrow banks, with a short-lived and variable disposition. It usually has an admixture of mud. The settlements of animals appearing here show slight differentiation. Of mayflies, *Baetidae* (*Baetis pumilus*, *Centroptilum*) and also *Ephemera danica* are most frequently seen. As to stoneflies, small *Chloroperlidae* larvae are typical. Of flies, representatives of the *Tipulidae* s.l. (*Dicranota*, *Tricyphona*, *Limnophila*) and also *Ceratopogonidae*, *Tabanidae*, and *Rhagionidae* are more abundant. True worms can be found here more often than in the preceding habitats.

The sand-gravel fragments of the bed of the stream, especially in the upper localities, are covered as a rule by mud deposits with decaying organic remnants, usually some centimetres thick. This is sufficient, however, for the development of a macrofauna rich as to species and very abundant. Tendipedids, mostly *Tendipedinae* (*Micropsectra*, *Microtendipes*, *Polypedilum*, *Stempelinella*, *Tanytarsus*) and *Pelopiinae* (*Ablabesmyia*, *Anatopynia*) appear here in the greatest number, although the *Diamesinae* or *Orthocladiinae* are also found. *Gammarus pulex fossarum* and *Nais*

*pseudoobtusa* attain a considerable number. Mayflies, weakly differentiated here are, on the whole, less abundant than in current conditions. *Leptophlebiidae* larvae (*Habroleptoides modesta*) and *Caenis pseudo-rivulorum* are most frequently seen. *Leuctridae* (*Leuctra nigra*, *L. braueri*) and *Nemouridae* (*Amphinemura*) larvae represented the stoneflies.

A rather special habitat of dead beech and hornbeam leaves, covering the marginal parts of the upper sector of the stream in the autumn-winter period, has a certain relation to the substratum under discussion. It is inhabited by *Tipulidae* s.l., *Dixinae*, and *Orphnephilidae*, and also by *Gammarus pulex fossarum* and by *Leuctridae* and *Habroleptoides modesta* larvae.

Plants which can form a habitat for bottom fauna are represented in the main stream only by mosses and algae growths. The moss is inhabited by the earlier larval stages of mayflies, stoneflies, and tendipedids. Larger larvae of the rheophilous *Baetidae* and *Nemouridae* and some species of *Coleoptera* and *Dugesia gonocephala* are less frequently seen. Larger agglomerations of filiform algae in places with a current (*Cladophora*, *Ulothrix*) are inhabited by faunistic elements typical for a stony bottom: *Diamesinae* and *Orthocladiinae* larvae (*Diamesa*, *Brillia*, *Rheorthocladius*, *Eukiefferiella*) which have here good feeding conditions. The rheophilic *Simuliidae* and *Baetidae* (*Baetis carpaticus*) are also present.

The mud sediments of broader stretches of still water and pools (Table VII) have a more abundant macrofauna than the stony substratum in the current, especially in the middle and lower course of the stream. They occupy however, in total a considerably smaller percentage of the surface of the stream bed than the stony substratum in which the animal groups, though less numerous, undoubtedly prevail in the stream as far as the general „biomass” is concerned.

### An attempt at biocoenotic classification of the stream

The problems of biocoenotic divisions of running waters, including mountain streams, and the attempts at classification connected with them, continue to involve serious difficulties and the opinions of different authors do not coincide. Some authors (Žadin 1950, Starmach 1959) distinguish in running waters lithorheophilous, psammorheophilous, pelorheophilous, argillorheophilous, and phytorheophilous biocoenoses, according to the kind of substratum which they inhabit. Marlier (1951) perceives in streams a whole mosaic pattern of animal associations, synusies, in his opinion distinctly separated from each other. Percival, Whitehead (1929), and Mikulski (1950) ascribe a considerable role in the formation of separate communities to the degree of stabilisation of the substratum and distinguish stable and unstable substrata. A far-

-reaching classification of running waters, especially of streams, following the principle of longitudinal division, can be seen in the works of German authors (Thienemann 1912, Illies 1952, 1953, 1955, 1961, Dittmar 1955, Schmitz 1957). Illies (1953) and Schmitz (1957) observe an accordance between the formation of separate benthos communities and the range of fish zones distinguished long ago and the rule of Huets' unitary gradients connected with them (Starmach 1956). The attempt undertaken by Illies (1961) to include in one classification scheme all running waters of the whole world is a summing up of this trend of investigation. This author reaches the conclusion that every river, independently of its geographical situation, can be divided into two fundamental biotopes, inhabited in different geographical regions by ecologically similar biocoenoses, the so-called „isocoenoses". He names these biotopes rhithron and potamon (corresponding to a stream and a river). The criterion for the division is mostly formed by the thermic conditions and the nature of the water current. These basic biotopes are divided by the author into units of a lower rang, corresponding to fish zones distinguished hitherto.

Illies (1953) uses the biological method for distinguishing zoocoenoses in the river Fulda, counting successively the more numerous groups of animals in individual localities and presenting, by means of diagrams, the number of species present in preceding and succeeding localities in the line of the river. In places where the bends of the curve are steep, we are confronted, in the author's opinion, with the frontier zones of adjacent zoocoenoses. It appears that similar results can be obtained by applying the following formula for calculating the coefficient of similarity of the species composition of localities:  $P = \frac{c}{a + b - c} \cdot 100$  in which:  $a$  — the sum of species in a given locality,  $b$  — the sum of species in another locality,  $c$  — the sum of species common for both localities. When calculating the coefficient of similarity for the investigated localities in the main stream, three groups of animals representing the greatest amounts of accurately determined species, the *Ephemeroptera*, *Plecoptera*, and *Coleoptera* were selected as a basis for the analysis. Two groups of localities stand out distinctly (Table VIII): the first is composed of

TABLE VIII

Coefficients of similarity of bottom fauna between the localities of the Wielka Puzcza, taking into consideration Ephemeroptera, Plecoptera and Coleoptera species (in percentage)

	1	2	3	4	5	6
1	100.0	61.7	35.1	37.7	31.1	28.3
2	61.7	100.0	32.3	36.2	30.2	25.9
3	35.1	32.3	100.0	72.4	73.3	69.6
4	37.7	36.2	72.4	100.0	81.8	65.5
5	31.1	30.2	73.3	81.8	100.0	66.7
6	28.3	25.9	69.6	65.5	66.7	100.0

localities 1 and 2, and the second of the remaining ones. The coefficient of similarity between them does not exceed 38 per cent. The two first localities demonstrate a fairly considerable resemblance (coefficient of similarity of more than 60 per cent), but not so distinctly as the localities 3, 4, and 5 (coefficient of similarity of 70—80 per cent).

It may be assumed, therefore, that we have in the compared length of the Wielka Puszca stream two clearly distinguished zoocoenoses: the zoocoenose of the spring-trickle region, the biotope of which consists of the upper sector of the stream with localities 1 and 2, and the zoocoenose of the epirhithron or the upper salmonid region (Illies 1961) with a biotope contained in the zone of the localities 3, 4, and 5. This division finds its confirmation both from the point of view of criteria used in fishery classification (Starmach 1956, Schmitz 1957) and in the macrofauna discussed here. Apart from the studied groups differences also appear in the analysis of the remaining part of the bottom fauna. Thus, for instance, the number of *Tendipedidae* species in the region of spring-trickles and also their abundance diminish considerably in relation to the epirhithron, and inversely, the *Gammarus pulex fossarum*, which had a dominating position in the spring-trickles zone, clearly disappears in the epirhithron situated below. From the physiographical point of view, corresponding zones of the stream present also considerable differences in the value of the structure of the bottom, and the thermal conditions of the water. In this last case it seems, however, that the criteria of division of Illies (1952), and Dittmar (1955) for the region of spring-trickles up to 5 °C and for the epirhithron from 5 to 10 °C of mean annual amplitude, may be slightly too low in relation to the Wielka Puszca.

This division is also confirmed in communities of algae. Wasylik (1965) distinguishes in the Wielka Puszca stream — mainly on the basis of diatoms — a separate community, the *Diatometum hiemale-Meridionetum*, settled in the upper sector of the stream, as well as a transitory community, the *Diatometum vulgare-Cymbelletum affinis*, which develops in further sectors of the stream and is also characteristic for the upper sector of the Soła and its affluents.

Difficulties arise in the attempt to classify locality 6. From the faunistic point of view it is, closer to locality 3 than to locality 5 and, similarly as locality 5, it demonstrates the greatest resemblance to locality 4. It is possible that this is the consequence of a thermic resemblance of these two pairs of localities. When comparing the animals of locality 6 with the zoocoenoses of the upper Fulda, distinguished by Illies (1953), a considerable accordance with the metarhithron communities („mittlere Salmonidenregion”) can be ascertained. In the opinion of this author, and also of Schmitz (1957), considerable difficulties in a regular differentiation of this zoocoenose exist, owing to the fact that many of

the species appearing there also live in large numbers in adjacent biotopes.

Within the region of spring-trickles two biotopes, according to Dittmar (1955) were distinguished, greatly differing in environmental conditions: the zone of sources for the investigated limno- and limnohelocrene sources, and the trickle-stream zone itself. Dittmar stresses, for both these biotopes, a considerable distinctiveness of the animal communities which inhabit them. This can be confirmed in the case of the Wielka Puszca, although the sources were not the subject of more accurate investigation.

Indicator species (i.e. species with a high degree of constancy and presence in the given biotope) were selected for individual biotopes: 1. for the zone of sources: *Agabus guttatus*, *Ablabesmyia binotata*, *Pisidium casertanum*; 2. for the trickle-stream: *Dugesia gonocephala*, *Gammarus pulex fossarum*, *Ecdyonurus subalpinus*, *Isoperla sudetica*, *Heterotrissocladius marcidus*; 3. for the epirhithron: *Ecdyonurus torrentis*, *Habroleptoides modesta*, *Isoperla oxylepis*, *Deronectes rivalis*, *Esolus parallelepipedus*, *Paraorthocladus nudipennis*, *Tathrophila vitripennis*.

As Illies (1952, 1953) and Schmitz (1957) have already stated, it is not possible to find a sharp delimitation between particular zoocoenoses. This is caused by a highly unequal settlement in streams of individual species, which may have all kinds of types of vertical ranges. Illies (1952) distinguished in the Mölle stream 8 types of the longitudinal disposition of bottom fauna in the salmonid region. Dittmar (1955), in a similar area of the Aabach stream, groups the animals living there into 12 units of distribution. In the Wielka Puszca at least 10 groups of species could be mentioned, according to the manner in which they inhabit the main line of the stream.

Numerous authors, when referring to the mosaic pattern of animal communities in streams, connect their existence with the type of substratum and the conditions of the current. Thus Thienemann (1912) distinguishes the fauna of a stony bottom, the fauna of mosses etc., and differentiates the lotic and lenitic places. Geijskes (1936) is inclined to consider the elements of the substratum as biotopes of a higher order. The relation of animal settlements to the substrate and the conditions of the current is undoubtedly very distinct. In an extreme case differences in the settlement on separate sides of a single stone can be perceived. But are we confronted in such a case with different communities? Mikulski (1958), states that communities disposed in a mosaic pattern, distinguished in relation to the character of the bottom, have many species in common, and form a series of transitions between themselves; he defines them as a typical ecotone. Illies (1952) finds in current communities a great convergence between the fauna of mosses and the typical fauna of a stony bottom. Many typical inhabitants of moss pass, owing to its absence in

a given stream, into the lithorheophilous fauna. Similar observations were also made in the Wielka Puszcza, as, for instance, in the case of *Ephemerella krieghoffi* or *Hydraena nigrita*, typical forms inhabiting mosses.

While leaving the final conclusion as to these questions until further investigations has been carried out, a decision may be made, taking into consideration the opinions of Illies (1952), Albrecht (1953), and Dittmar (1955), to distinguish in streams four biotopes with regard to the character of the substratum and acknowledging the formative role of the current (the so-called biotopes of the IIIrd order, according to Dittmar, in accordance with the basic types of substratum as distinguished by Thienemann (1912) — assuming that the substratum, in a narrow scope (a single stone, different kinds of plants) forms only a structural part of the biotope as a whole. In this manner we may consider, in the case of the Wielka Puszcza, two principal and distinctly differentiated biotopes with corresponding animal communities — that of the stony bottom in the current and that of bottom mud sediments in still water. Their description was given in the preceding chapter.

### Seasonal changes

Seasonal variability in the relative abundance of components of the bottom macrofauna of the stream were studied in the previously distinguished epirhithron (localities 3, 4, and 5), considered here as an ecological whole (fig. 12).

We perceive in the course of the year an enormously predominant abundance of aquatic insects. Of other groups, the *Oligochaeta* and the *Amphipoda*, the number per cent of which is rather low in most months of the year and only increases distinctly in the autumn period, have a certain importance. As to insects, the tendipedids considerably predominate and their dominance increases in periods of abundant development of algae. Hynes (1961) presents, for a corresponding biotope of an investigated Welsh stream, somewhat similar relations in the course of seasonal changes; there also the prevalence of aquatic insects is substantial and the *Tendipedidae* have three distinct maxima of dominance during the year.

The relative abundance of the *Trichoptera* takes a different form. It attains its greatest importance in the spring period (up to 54 per cent of participation) and diminishes gradually in further periods.

Mayflies, considered as a whole, play an important role in this biotope throughout the year. The observed variability in the relative abundance of individual species is related to their more developed larval stages, similarly as in other insect groups. Stoneflies participate in the greatest

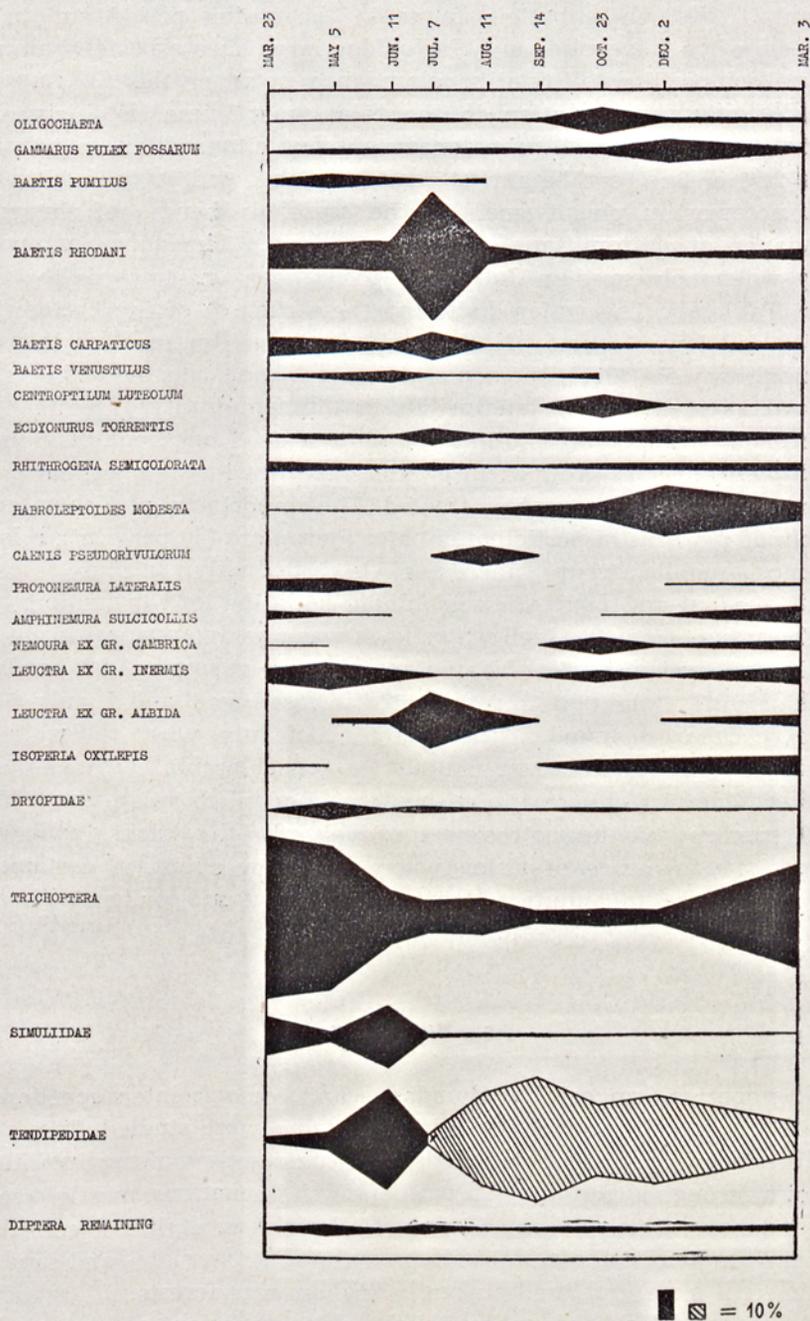


Fig. 12. Percentage composition of the bottom fauna throughout the period of investigation 1959/1960, as the mean figure from localities 3, 4, and 5. Species or groups attaining, even if only in samples for one month, a participation of at least 2% of the whole fauna, are included.

amount in the whole bottom fauna in the spring period and in early summer, when *Leuctridae* and *Perlodidae* larvae are especially abundant.

The composition of relative abundance between the *Ephemeroptera* and *Plecoptera*, in relation to the total macrofauna, is fairly similar throughout the year. A prevalence per cent of mayflies, in relation of about 2 : 1 or 3 : 2, can be almost constantly observed.

A noteworthy phenomenon in the seasonal changes of the relative abundance of bottom fauna is the catastrophic influence of suddenly rising waters observed in July after torrential rains towards the end of June (Table II). The water disturbed the structure of the bottom in the middle and lower course of the stream, rolling over most of the stones, washing away the algae and sometimes even displacing the bed of stream. The participation of the tendipedids in the community of bottom fauna diminished considerably, falling to only a few per cent. The heavier *Trichoptera*, usually grouped in greater numbers in the marginal parts of the stream, were not greatly affected. The importance of *Ephemeroptera* (nearly 60 per cent of participation) and *Plecoptera* (20 per cent); relatively the most mobile groups, increases very distinctly. In July especially *Baetis rhodani* and *Leuctra* ex gr. *albida* have the lead in number.

The influence of the high water level was clearly apparent in the mean density of settlement in this biotope. If, for example 1.985 and 1.988 specimens/m<sup>2</sup> of the bottom were noted in localities 3 and 5, only 606 and 343 spec./m<sup>2</sup> were found at the beginning of July, when the waters had subsided. But already in August a considerable development of *Tendipedidae* was observed, and the density of inhabitation was 2.252 and 5.859 spec./m<sup>2</sup> of the bottom respectively. In the trickle zone of the stream, the influence of rising water was very slight. A certain small decrease in the inhabitation density was noted in locality 2 (from 813 to 649 specimens/m<sup>2</sup> of bottom).

### Summary

The species composition, abundance and ecologic interdependences of the bottom macrofauna of the Wielka Puszca were studied. This stream, an affluent of the river Soła, is typical for mountains of medium altitude. It flows through a terrain of Carpathian flysh formations, mostly composed of sand-slate schists of the Godula flat surfaces. It has a considerable unitary gradient and a stony bottom containing flat slate- and sandstones of different sizes, and its drainage basin has large forests.

As a result of the rather slight differentiation of the geological substratum of the drainage area the chemical properties of the water of the stream have an equilibrated system in which two periods can be distinguished, the spring-summer and the autumn-winter period, connected

with variations in the water level in the stream. As to calcium content, the Wielka Puszcza is a typical poorly-calcareous stream during most months of the year.

The water of the stream, usually cold, may become warmer during warm summer days and reaches 20 °C in the middle and lower course, with diurnal fluctuations up to 5 °C. In the upper course the water is coldest not near the sources but in the depth of the forest covered valley, after a larger quantity of underground water had flowed into the stream. A 200—250 m sector of the stream near the sources sometimes dries out almost completely.

Among the macrofauna of the water system of the stream 250 animal forms (including *Trichoptera*) were determined, within the limits of 19 systematic groups of which the following acquire the greatest importance in the main stream as to number of species and density of inhabitation: the *Diptera*, *Ephemeroptera*, *Plecoptera*, *Coleoptera*, and *Trichoptera* (Table IX).

On the basis of established physiographic and faunistic differences and on that of the principles accepted by Illies (1952, 1953, 1961), Dittmar (1955), and Schmitz (1957), two principal biotopes with the bottom zoocenoses inhabiting them have been distinguished: the biotope of the spring-trickle region, represented by the upper sector of the Wielka Puszcza and the biotope of the rhithron (salmonid-region), represented by further sectors of the stream. The Wielka Puszcza contains only a part of this last biotope, the epirhithron (upper salmonid-region) which forms the most extensive middle sector of the stream. In the spring-trickle region, the limno- and limnohelocene sources were distinguished as a separate biotope, as well as the stream in the trickle zone.

Among the distinguished biotopes the most differentiated bottom fauna was found in the epirhithron, where rheo- and polyoxybiontic species, typical for streams from medium sized mountains, are numerous. When approaching the sources of the stream, the qualitative differentiation in the limits of larger groups of bottom animals diminishes, and a decrease in its abundance is visible, especially in the parts with a current. This is undoubtedly caused, independently of other ecological factors, by the forests surrounding the upper sector of the Wielka Puszcza.

As to characteristic habitats, the most abundant fauna concentrates in still water places of the stream, with bottom deposits of mud and organic remnants. However, as they occupy much greater parts of the bottom, communities of the stony bottom in the current prevail in the general „biomass” of the macrofauna of the Wielka Puszcza.

Of ecological factors, the greatest role in the formation of different communities of the macrofauna is placed by the current of water, which segregates the animals directly or by means of forming the substratum. This is connected with the considerable influence of suddenly rising

Table IX

Composition of fauna caught in the area of the Wielka Puszczka stream  
(excepting Trichoptera)

Animals	Localities of the stream					Limmocrenes and limnohelocrenes	Rheocrenes and rheolimocrenes	Backwaters and "eyelet" pools	Marginal pools
	1	2	3, 4	5	6				
HYDROIDEA									
1. Pelmatohydra oligactis (Pall.)						+			
TRICLADIDA									
2. Dugesia gonocephala (Dug.)	+	+	+	+	+			+	+
NEMATOMORPHA									
3. Gordionus violaceus (W.Baird.) ?		+							
4. Gordius nonmaculatus Heinze									
MOLLUSCA									
5. Bythinella austriaca Frfld	+	+							
6. Lymnaea peregra O.F.Müll.									
7. - truncatula O.F.Müll.									+
8. Ancylus fluviatilis O.F.Müll.									+
9. Gyraulus albus O.F.Müll.							+		+
10. Vertigo antivertigo Drap.									+
11. Pisidium personatum Malm.									+
12. - casertanum Poli						+			+
OLIGOCHAETA									
13. Slavina appendiculata Udek.			+						
14. Nais pseudobtusa Pig.				+	+				+
15. Propappus volki Mich.									+
16. Phreocetes gordioides Hartm.									+
17. Tubifex sp.	+	+	+						+
18. Eiseniella tetraedra (Sav.)	+	+	+						+
HIRUDINEA									
19. Erpobdella monostrata (Gedr.) Pawł.									
20. Haemopsis sanguisuga (L.)									+
HYDRACARINA									
21. Sperchon brevisstris Koen.			+	+	+				+
22. - glandulosus Koen.	+	+	+	+	+				+
23. - plumifer Thor									+
24. - clupeiifer Piers.									+
25. Lebertia rufipes Koen.			+	+					+
26. - spp.	+	+	+	+	+				+
27. Torrenticola connexa Koen.			+	+					+
28. - anomala (C.L.Koch)	+	+	+	+					+
29. - elliptica Maglio			+	+	+				+
30. Hygrobatas fluviatilis (Ström.)			+	+	+				+
31. - porrectus Koen.			+	+	+				+
32. - calliger Piers.	+	+	+	+	+				+
33. Atractides nodipalpis nodipalpis Th.	+	+	+	+	+				+
34. Feltria sp.	+	+	+	+	+				+
35. Ljanja bipapillata Thor	+	+							+
36. Arrenurus sp.									+
OSTRACODA									
37. Candona candida (O.F.Müll.)									+
38. - sp. (? compressa (Koch))									+
39. Eucypris pigra (Tisch.)?									+
AMPHIPODA									
40. Niphargus tatrensis f. schneebergensis Schell.	+	+	+	+	+				+
41. Gammarus pulex fossarum (Koch)	+	+	+	+	+				+
EPEMEROPTERA									
42. Ephemera danica Müll.			+	+	+				+
43. Baetis pumilus Burm.		+	+	+	+				+
44. - rhodani Pict.	+	+	+	+	+				+
45. - carpaticus Mort.	+	+	+	+	+				+
46. - venustus Etn.			+	+	+				+
47. - scambus Etn.			+	+	+				+
48. - vernus Curt., + tenax Etn.			+	+	+				+
49. Centroptilum luteolum L.			+	+	+				+
50. - pennulatum Etn.			+	+	+				+
51. Ecdyonurus lateralis (Curt.)	+	+	+	+	+				+
52. - fluminum Pict.			+	+	+				+
53. - subalpinus Klapp.	+	+	+	+	+				+
54. - torrentis Kimm.			+	+	+				+
55. Epeorus assimilis Etn.			+	+	+				+
56. Rhithrogena semicolorata Curt.	+	+	+	+	+				+
57. Habroleptoides modesta (Hag.)	+	+	+	+	+				+
58. Habrophlebia lauta Etn.			+	+	+				+
59. Ephemerella krieghoffi (Ulm.)			+	+	+				+
60. - ignita Poda			+	+	+				+
61. - major (Klapp.)			+	+	+				+
62. Caenis pseudovivulorum Kefferm.			+	+	+				+
ODONATA									
63. Cordulegaster bidentatus Sel.	+								
64. Libellula depressa L.									+
PLECOPTERA									
65. Brachyptera seticornis (Klapp.)	+	+	+	+	+				
66. - risi (Mort.)					+				
67. Protonemura praecox (Mort.)	+	+	+	+	+				

Table IX cont

Animals	Localities of the stream					Limnocoenes and limnolocoenes	Rheocoenes and rheolimnocoenes	Backwaters and "eyelet" pools	Marginal pools
	1	2	3, 4	5	6				
68.	Protonemura meyeri (Pict.)		+						
69.	- lateralis (Pict.)	+	+	+	+				
70.	- auberti Illies	+	+	+	+				
71.	- intricata Ris			+	+				
72.	- nitida (Pict.)Ris			+	+				
73.	Amphinemura sulcicollis (Steph.)			+	+				
74.	- borealis (Mort.)			+	+			+	
75.	Nemoura cinerea (Retz.)			+	+				
76.	- cambrica (Steph.)	+	+	+	+				
77.	- sinuata Ris			+	+				
78.	- mortoni Ris			+	+				
79.	Nemurella picteti Klap.	+	+	+	+				
80.	Leuctra inermis Kemp.		+	+	+			+	+
81.	- rauscheri Aubert		+	+	+				
82.	- aurita Nav.		+	+	+				
83.	- nigra Oliv.		+	+	+			+	+
84.	- major Brinck		+	+	+				
85.	- albida Kemp.		+	+	+				
86.	- fusca (L.)		+	+	+			+	+
87.	- braueri Kemp.	+	+	+	+				
88.	- hippopus Kemp.				+				
89.	- armata Kemp.		+	+	+				
90.	- pseudosignifera Aubert	+	+	+	+				
91.	Diura bicaudata (L.)		+	+	+				
92.	Perlodes microcephala (Pict.)			+	+				
93.	- dispar (Ramb.)				+				
94.	Isoperla grammatica (Poda)			+	+				
95.	- rivulorum (Pict.)		+	+	+				
96.	- goertzi Illies		+	+	+				
97.	- sudetica (Kol.)	+	+	+	+				
98.	- oxylepis (Desp.)			+	+				
99.	- difformis (Klap.)			+	+				
100.	Dinocras cephalotes (Curt.)			+	+				
101.	Perla burmeisteriana Claass.			+	+				
102.	- marginata (Panz.)			+	+				
103.	Chloroperla torrentium (Pict.)			+	+			+	+
104.	- neglecta (Rost.)	+	+	+	+			+	+
COLEOPTERA									
105.	Hydroporus ferrugineus Steph.			+	+				
106.	Deronectes platynotus Germ.			+	+				
107.	- rivalis Gyll.		+	+	+				
108.	Platambus maculatus L.			+	+				
109.	Agabus guttatus Payk.			+	+				
110.	Helophorus brevipalpis Bed.			+	+				
111.	Hydraena nigrita Germ.			+	+				
112.	- pygmae Waterh.		+	+	+				
113.	- gracilis Germ.	+	+	+	+				
114.	- rufipes Curt. ?				+				
115.	Laccobius biguttatus Gerh.			+	+				
116.	- striatulus F.				+				
117.	Helodes marginata F.	+	+	+	+				
118.	- minuta L.			+	+				
119.	Hydrocyphon sp.			+	+			+	+
120.	Esolus parallelepipedus (Müll.)			+	+				
121.	- angustatus (Müll.)	+	+	+	+				
122.	Elmis maugetii Latr.	+	+	+	+				
123.	Oulimnius tuberculatus (Müll.)	+	+	+	+				
124.	Limnius perrisi (Duf.)	+	+	+	+				
125.	- muelleri (Erich.)				+				
NEUROPTERA									
126.	Sialis fuliginosa Pict.		+						
127.	Osmylus chrysops L.				+				
DIPTERA									
128.	Anopheles claviger Meig.			+	+			+	+
129.	Dixa maculata Meig.			+	+				
130.	- sp.			+	+				
131.	Palpomyia-Bezzia sp. "verniformes"	+	+	+	+			+	+
132.	Ablabesmyia binotata (Wied.)			+	+				
133.	- flavida Kieff.	+	+	+	+			+	+
134.	- ex gr. lentiginosa (Fries.)	+	+	+	+			+	+
135.	Anatopynia trifascipennis (Zett.)			+	+				
136.	- sp. Tehern		+	+	+				+
137.	Corynoneura lemnae Frauenf.			+	+				
138.	- minuta Winn.		+	+	+				
139.	Thienemanniella fusca Kieff.		+	+	+				
140.	Heptagya punctulata Goetgh.			+	+				
141.	- sp. B Saund				+				
142.	Prodiamesa olivacea (Meig.)		+	+	+				
143.	Diamesa campestris Edw.			+	+				
144.	- gaedei Meig.			+	+				
145.	- prolongata Kieff.			+	+				
146.	- sp.			+	+				
147.	Brillia modesta (Meig.)	+	+	+	+				
148.	Metriocnemus fuscipes (Meig.)	+	+	+	+				
149.	- atratulus (Zett.)			+	+			+	

Table IX cont.

Animals	Localities of the stream					Limnocoenens and limnohelocrenens	Rheocrenens and rheolimnocoenens	Backwaters and "eyelet" pools	Marginal pools
	1	2	3, 4	5	6				
150.	<i>Symbiocladius rhithrogenae</i> (Zavřel)			+					
151.	<i>Pseudorthocladus curtistylus</i> (Goetgh.)	+	+	+					
152.	<i>Heterotanytarsus apicalis</i> (Kieff.)								+
153.	<i>Synorthocladus semivirens</i> (Kieff.)		+		+	+			
154.	<i>Eucricotopus</i> ex gr. <i>silvestris</i> (Kieff.)			+	+	+			
155.	<i>Trichocladus algarum</i> Kieff.		+		+	+			
156.	<i>Rheorthocladus saxicola</i> (Kieff.) ?	+		+	+	+			
157.	<i>Paratrachocladus inaequalis</i> (Kieff.)			+	+	+			
158.	<i>Psectrocladius</i> ex gr. <i>dilatatus</i> (v.d.Wulp)			+	+	+	+		
159.	<i>Rhaecricotopus</i> ex gr. <i>fuscipes</i> (Kieff.)					+			
160.	<i>Euorthocladus rivicola</i> (Kieff.)			+	+	+			
161.	<i>Paraorthocladus nudipennis</i> (Kieff.)			+	+	+			
162.	<i>Heterotrissocladus marcidus</i> (Walk.)	+	+						
163.	<i>Eukiefferiella atrofasciata</i> Goetgh.	+	+	+	+	+			
164.	- <i>bavarica</i> Goetgh.								
165.	- <i>discoloripes</i> Goetgh.					+			
166.	- <i>clypeata</i> (Kieff.)				+	+			
167.	- <i>longicalcar</i> (Kieff.)					+			
168.	<i>Orthocladus potamophilus</i> Tahern.					+			
169.	<i>Cryptochironomus camptolabis</i> (Kieff.)			+					
170.	<i>Microtendipes</i> ex gr. <i>chloris</i> (Meig.)		+					+	
171.	<i>Polypedilum</i> sp. (Fend. "gen.nr 3" Lp.)	+	+	+		+			
172.	- ex gr. <i>nubeculosum</i> (Meig.)	+							
173.	<i>Stempellina bausei</i> (Kieff.)			+				+	
174.	<i>Stempellina brevis</i> Edw.	+	+						
175.	<i>Micropectra</i> e gr. <i>praecox</i> (Meig.)	+	+	+	+	+			+
176.	<i>Tanytarsus</i> ex gr. <i>gregarius</i> Kieff.	+			+			+	
177.	- ex gr. <i>exiguus</i> Joh.			+					
178.	- ex gr. <i>lauterborni</i> Kieff.			+					+
179.	<i>Prosimulium nigripes</i> End.	+	+	+	+	+			
180.	<i>Eusimulium</i> ex gr. <i>latipes</i> (Meig.)	+	+	+	+	+			
181.	- <i>costatum</i> (Fried.)	+	+	+					
182.	<i>Obuchovia auricoma</i> (Meig.)					+			
183.	<i>Odagmia ornata</i> (Meig.)			+	+				
184.	- <i>variegata</i> (Meig.)	+	+	+	+	+			
185.	- <i>monticola</i> (Fried.)	+	+	+	+	+			
186.	- <i>rheophila</i> Knöz	+	+	+	+	+			
187.	<i>Tathrophila vitripennis</i> Meig.			+	+	+			
188.	<i>Ormosia</i> sp.			+	+	+			
189.	<i>Erioptera</i> sp.			+	+	+			
190.	<i>Dicranota bimaculata</i> Schumm.	+	+	+	+	+		+	+
191.	<i>Tricyphona immaculata</i> Meig. ?	+	+	+	+	+			
192.	- sp.	+	+	+	+	+			
193.	- <i>Limnophila</i> sp. I	+	+	+	+	+		+	+
194.	- sp. II	+	+	+	+	+			
195.	<i>Dicranomyia</i> sp.	+			+				
196.	<i>Monophilius</i> sp.		+	+	+	+			
197.	<i>Trichocera</i> sp.		+	+	+	+			
198.	<i>Tipula</i> sp. I			+	+	+			
199.	- sp. II			+	+	+			
200.	- sp. III		+	+	+	+			
201.	- sp. IV			+	+	+			
202.	<i>Hexatominae</i> n.det. ( <i>Elephantomyia</i> sp.?, <i>Poecilostola</i> sp.?)	+	+	+	+	+		+	+
203.	<i>Liponeura cinerascens</i> Loew.	+			+				
204.	<i>Orphnephila testacea</i> Ruth	+			+				
205.	<i>Pericoma canescens</i> Meig.				+	+			
206.	- sp. ( <i>neglecta</i> Etn. ?)			+					
207.	<i>Psychoda altermata</i> Say					+			
208.	- sp. ( <i>cinerea</i> Bks. ?)					+			
209.	<i>Beris</i> sp.				+	+			
210.	<i>Tabanus</i> sp.		+	+	+	+		+	+
211.	<i>Atherix marginata</i> Fabr.			+	+	+		+	+
212.	<i>Hemerodromia</i> sp. ( <i>unilineata</i> Zett. ?)			+	+	+		+	+
213.	- <i>praecatoria</i> Tell.	+	+	+	+	+		+	+
214.	<i>Wiedemannia</i> sp. ( <i>lamellata</i> Lw. ?)			+	+	+		+	+
215.	<i>Atalanta</i> sp. ( <i>appendiculata</i> Lw. ?)	+						+	+
HEMIPTERA									
216.	<i>Callicorixa praeusta</i> (Fieb.)			+			+	+	+
217.	<i>Subsigara falleni</i> (Fieb.)			+			+	+	+
218.	<i>Retrocorixa venusta</i> (Dougl., Sc.)			+			+	+	+
219.	<i>Nepa rubra rubra</i> L.						+	+	+
220.	<i>Velia caprai</i> Taman.						+	+	+
221.	- <i>sauli</i> Taman. ?	+					+	+	+
222.	<i>Gerris gibbifer</i> Schumm.						+	+	+
PISCES + AMPHIBIA									
223.	<i>Salmo trutta</i> m. <i>fario</i> L.			+	+	+			
224.	<i>Cottus poecilopus</i> Haeck.	+		+	+	+		+	
225.	<i>Triturus montandoni</i> (Boul.)	+							
226.	<i>Bombina variegata</i> (L.)						+	+	+

waters which periodically destroy the structure of the bottom and the communities inhabiting it and make impossible the existence of some species, even of the rheophilous ones, in the stream.

Seasonal changes of the bottom fauna studied on the example of epirhithron, allowed the observation of a constant and considerable prevalence per cent of aquatic insects of the *Trichoptera*, *Ephemeroptera*, *Plecoptera*, and especially of the *Tendipedidae* in which an increase of dominance is distinctly connected with the periods of more abundant development of algae.

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