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Fauna denna dorzecza Kamienicy Nawojowskiej**Bottom fauna in the basin of the River
Kamienica Nawojowska**

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Abstract — In the described basin a dominance of rheo- and lithorheophilous species due to the prevailing stony bottom was noted. Other factors, however, contributed to the formation of different animal communities in spring trickles of the Kamienica and some of its tributaries, in small and middle-sized streams, in the upper sector of the Kamienica, in the lower part of the Kreszczaty stream, and in the middle reaches of the Kamienica and the Kamionka.

In the years 1964—1965 the Laboratory of Water Biology of the Polish Academy of Sciences carried out, under the direction of Professor K. Starmach, investigations of the river Kamienica Nawojowska, which flows out from the slopes of Mt Przysłop (at about 800 m above sea level), cuts the Beskid Sądecki Mts and joins the river Dunajec in Nowy Sącz (at about 283 m above sea level). The Kamienica Nawojowska is about 28 km long and collects many mostly left-bank tributaries, which rise on the slopes of the Jaworzyna Chain. The right-bank hydrographical net is considerably less developed, as it consists of small brooklets and only in the lower sector of the Kamienica does a single large right-bank tributary (the river Kamionka together with the Królówka stream) flow into it. More detailed physiographical data are contained in a paper of Kolder (typescript), who investigated also the ichthyofauna of this river. The chemical composition of its water and the geological structure of its basin are given by Pasternak (1968 a, 1968 b). The present paper aims at describing the bottom fauna of invertebrates inhabiting the river.

Special attention was paid to the upper sector of the Kamienica and

to its tributaries (sampling-places 1—7, fig. 1) where samples were collected on September 28—29, 1964, June 5—6, July 26, and September 21—23, 1965. In order to obtain a general view of the river fauna, samples

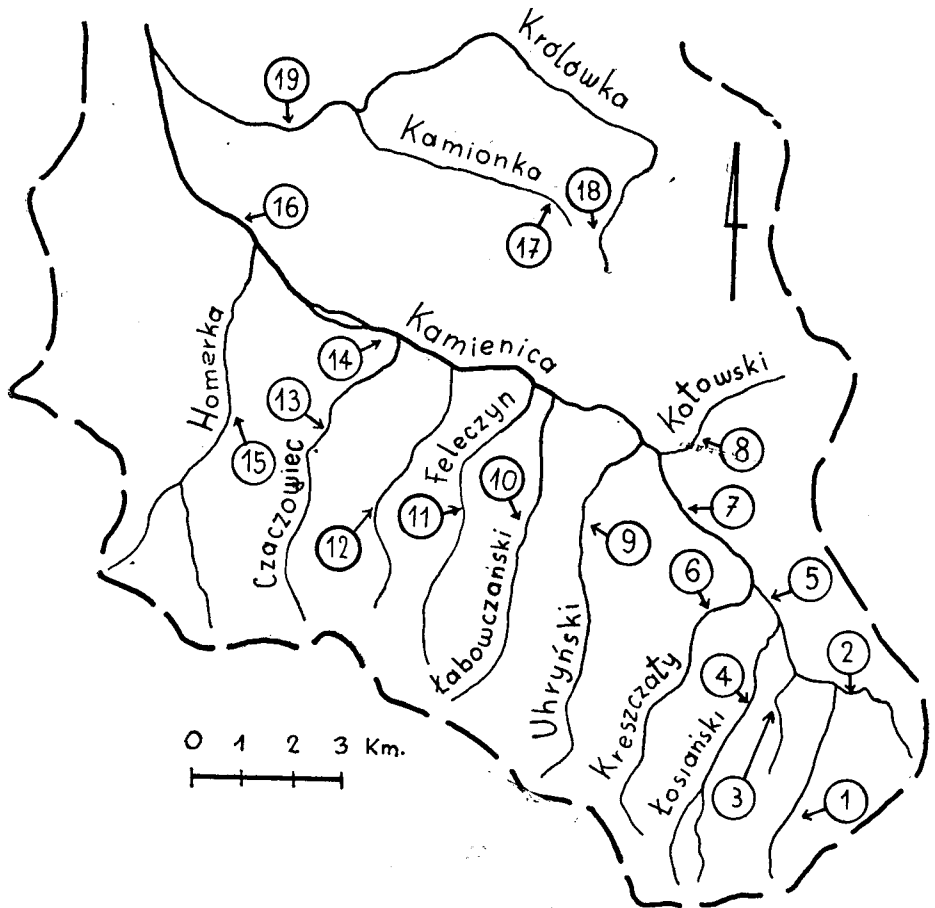


Fig. 1. Location of sampling-places in the basin of the river Kamienica Nawojowska

of the benthos were collected once (on July 27—29, 1965) in the middle course of the Kamienica and in tributaries flowing into it (sampling-places 8—19), and spring trickles of the Kamienica (on September 30, 1964) and the Kreszczaty stream (on September 21, 1965) were also investigated once.

Samples from an area of 0.1 m² of bottom were collected with a scraper provided with a bag of No 5 bolting cloth. The collected material was fixed with 4% formalin, and after being sorted and identified in the laboratory, with a 20% mixture of formalin and alcohol (ratio 1:3). For every species mean population densities at sampling-places were calculated, and for taxonomic groups their per cent shares in the river

community were computed. Coefficients of faunistic similarity (P) of sampling-places in the upper basin of the Kamiénica were calculated according to Czekanowski's formula (Starmach, type-script):

$$P = \frac{c}{a+b-c} \cdot 100,$$

where a — number of species at one of the two compared sampling-places, b — number of species at the second sampling-place, c — number of species in common at the two sampling-places.

Faunistic components

Among 49 993 specimens collected (Table I) the following taxa were identified.

Vermes (61 specimens — 0.1% of all specimens collected) were represented solely by *Dugesia gonocephala* Dug., appearing mainly in the upper part of the Kamiénica basin, and by *Gordius aquaticus* Duj., found as single specimens in the upper basin and in the streams: Składziszczanski, Czaczowiec, Homerka, and (somewhat more numerous) in the Kotowski stream.

Oligochaeta (623 specimens — 1.2%) occurred especially numerous at sampling-places 5 (the Kamiénica) and 9 (the Uhryński stream), while at others they either did not appear at all, or they reached a small population density (up to 72 specimens per 1 m² of bottom).

Hirudinea (25 specimens — 0.1%) appeared singly in the upper Kamiénica basin, while in the Składziszczanski stream a somewhat more numerous occurrence of *Herpobdella octooculata* f. *vulgaris* O. F. Müller was noted once (on July 27, 1965).

Crustacea (2269 specimens — 4.5%). *Gammarus pulex fossarum* Koch. occurred very numerous in two small tributaries of the Kamiénica (461 specimens per 1 m² at sampling-place 2 and 843 specimens at sampling-place 3), less numerous in the Feleczyn stream (145 specimens per 1 m²), and singly or in small numbers in the upper basin and in some other tributaries of the Kamiénica.

Apterygota (16 specimens — less than 0.1%) were also represented only by a single species (*Spinisotoma pectinata* Stach), occurring sporadically at some sampling-places in the upper basin and in the streams Składziszczanski and Czaczowiec.

Ephemeroptera (24 069 specimens — 48.1%) were a dominating group of benthic organisms, found in the whole basin of the Kamiénica. The most frequent and abundant representatives of the family *Baëtidae* were collected, but mainly as larvae in the 1st instar (larvulae), unidentifiable more precisely. These specimens belonged undoubtedly to the species *Baëtis rhodani* Pict. occurring numerous or in masses, or to the somewhat less common species *B. carpaticus* Mort. and *B. scambus*

<i>Leuctra nigra</i> Kmpf.	21	3	24	56	14	44	+	60	97	53	5	205	15	13	+	+	50	15
- sp.	517	84	24	56	14	44	+	60	97	53	5	205	15	13	+	+	50	15
<i>Periodes intricata</i> Pict.	71	11	3	9	6	6	+	1	7	7	1	5	15	10	+	10	30	30
- dispar Ramb.	1758	239	327	225	196	111	+	241	110	17	160	20	15	70	250	+	130	10
<i>Perla marginata</i> Pz.	25	1	1	1	1	2	+	10	5	7	7	25	20	3	3	+	5	5
- burmeisteriana Clasn.	18	64				47	+	3	3	3	3	3	3	3	+	3	5	5
Hemiptera	3					1	+											
<i>Graptodytes lepidus</i> Ol.	3					1	+											
<i>Deronectes</i> sp.	1					4	+					1						
<i>Gyrinus</i> sp.	15					4	+											
Ochtebius sp.	68		15	1	8	2	+	6	20	9			15	7				
<i>Eubria</i> sp.	256	4	29	3	38	37	+	12	67	7	115	1	15	7				
<i>Hydrocyphon</i> sp. div.	34	2	1	1	7	1	+	1	9				40	7	5		20	20
<i>Helichus</i> sp. div.	633	37	92	6	63	56	+	72	62		130	95	60	60	15		35	160
<i>Helms</i> sp. div.	326	14	60	12	38	27	+	23	109	7	15	2	95	60	15		5	5
<i>Dupophilus brevis</i> Muls et Rey.	6						+										5	10
Coleoptera imagines non det.	415	72	48	14	48	15	+	31	81	7	55	1	55	20	+	15	30	3
<i>Tipula</i> sp. div.	44		18	1	1	1	+	1	+	3								
<i>Phalacroera</i> sp.	16	2	4				+		4									
<i>Antocha</i> sp. div.	262	1	5			24	+	84	134		5							
<i>Helobia hybrida</i> Meig.	9						+											
<i>Gonomyia</i> sp.	2						+											
<i>Trimicra</i> sp.	6						+		1			1						
<i>Limmophila</i> sp.	12	3	1				+	1	1									
<i>Pedicia</i> sp.	8						+	2	2									
<i>Dicranota</i> sp. div.	118	12	6	19	5	9	+	8	4	4	45	15	10	13	10	150		5
<i>Eriocera</i> sp.	38	17	6			2	+	3	+	3								
<i>Psychoda severini</i> Tonn. (Satchell)	7					1	+											
- surcouffi Tonn.	39	1					+		3		5							
<i>Dixa</i> sp.	3						+											
<i>Ablabesmyia tetrasticta</i> Kieff.	12		1				+	1	1									
- ex gr. lentiginosa Pries.	91		3	8	5	4	+	13	6	37	20	15	10	7	+	75	3	10
- ex sp. mollis L.	174	4	11	7	26	24	+	10	28	17	30		3	3	40	15	15	20
<i>Clinotanytus nervosus</i> Meig.	102			102			+											
<i>Procladius</i> sp. div.	202	7	15	33	63	5	+	3	7	33	15	15	10	7	3	15	50	+
<i>Corynoneura celeripes</i> Winn.	28		3			4	+	1	5				3	3	10	5	5	5
<i>Thienemannia zavéeli</i> Kieff.	431	4	132	22	21	41	+	13	70	33	35	80	64	10	30	5	14	10
<i>Frodiamesa bathyphila</i> Kieff.	4						+					5	3	3				15

Table I. cont.

	Number of specimens	Mean population density (specimens per 1 m ²) in sampling-places:																			
		A																			
		1	2	3	4	5	B	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pyralididae	3				1	1															
<i>Argyrota aquatica</i> L.	6	2		1																	
Hydracarina larvae	4						2														
<i>Hydrovolzia placophora</i> Montl	1							1		5											
<i>Pseudohyrrhantes parvulus</i> Viets.	12	2	3		2		4						3			5					
<i>Thyas</i> sp.	5					1		3													
<i>Lebertia salebrosa</i> Koenike	3				1	2															
<i>Lebertia</i> sp.	10				1			9													
<i>Atractides amplexus</i> Koenike	5					1		+					3								5
- <i>connexus</i> Koenike	4					1															
- <i>ovalis</i> Koch.	6				1																
<i>Hygrobatas</i> sp.	1				1																
<i>Megapus tener</i> Sig. Thor.	1																				
<i>Theodoxus fluviatilis</i> L.	1					1															
<i>Rythinnella austriaca</i> Frfld.	3								+												
<i>Redix limosa</i> L.	5					1															
- - <i>f. peregra</i> Müll.	8				2																
<i>Ancylus fluviatilis</i> Müll.	29	1	3		3		8		12							10					
<i>Pisidium casertanum</i> Poir.	110	1	5	1	5	80															
T o t a l	4999 1/2	2341	6840	4985	7248	3027		3273	5920	4746	6950	2070	3720	3720	4540	2460	9715	6805	900	1300	4570

Etn. The large number of 1st instar specimens collected (15 401) is, however, noteworthy, as compared with that of all older instars of representatives of the genus *Baëtis* (4702). This fact may be evidence of a high mortality in the 1st instar of these mayflies.

Larvae of *Rhitrogena semicolorata* Curt., *Ecdyonurus venosus* Fabr., *Ephemerella ignita* Poda, *Torleya major* Kl p., and *Caenis macrura* Steph. were also found at nearly all sampling-places. On the other hand, *Heptagenia fallax* Hagen was limited almost exclusively to waters of the upper Kamienica basin, and larvae of remaining species were found only sporadically.

Plecoptera (4131 specimens — 8.3%). Among stone-flies larvae of *Perlodes dispar* Ramb. prevailed, appearing especially numerous in the upper basin and in the streams Uhryński, Czaczowiec, and Homerka, as well as those of *Protonemura* sp., reaching their highest population density also in the upper part of the Kamienica basin and in the Łabowczański stream. Less numerous were specimens of *Leuctra* sp., which only at sampling-place 10 (the Łabowczański stream) occurred in the quantity 205 specimens per 1 m². The remaining representatives of this order were found much more rarely.

Hemiptera (64 specimens — 0.1%) found sporadically in some sectors of the Kamienica and Kreszczaty and somewhat more numerous only at sampling-place 5, almost exclusively comprised representatives of the genus *Corixa*. As an exception one specimen from the genus *Mesovelica* was found in the Składziszczanski stream on July 27, 1965.

Coleoptera (1757 specimens — 3.2%). Among collected larvae and adults of beetles, species of the family *Dryopidae* (*Helichus* sp. div. and *Helmis* sp. div.) were the most numerous and were found in varying numbers in the whole Kamienica basin (with the exception of the Kamienica spring trickle). Less numerous species of the genus *Eubria* showed a similar distribution, while other beetles were found only sporadically, mostly in the upper part of the basin and in the Feleczyn stream.

Diptera (13 939 specimens — 27.9%), quantitatively the second group of benthic organisms, was represented mostly by *Tendipedidae* larvae (11 711 specimens), among which species of the genus *Cricotopus* (almost exclusively *Cr. ex gr. algarum* Kieff.) dominated, appearing numerous or in masses in the whole Kamienica basin. Other species, less frequent, were found either at nearly all sampling-places (*Ablabesmyia* ex gr. *lentiginosa* Fries., *A. ex gr. monilis* L., *Procladius* sp. div., *Thienemanniella zavřeli* Kieff., *Rheorthocladus saxicola* Kieff. (?), *Eukiefferiella* cfr *similis* Zavřel, *Polypedilum* ex gr. *pedestre* Meig., and *Tanytarsus* ex gr. *gregarius* Kieff.), or mostly in the upper part of the basin (*Prodiamesa olivacea* Meig. and *Microtendipes* ex gr. *chloris* Meig.). The remaining representatives of *Tendipedidae* were collected only sporadically, but single cases were noted of numerous or

mass appearance of some midges (*Clinotanypus nervosus* Meig. and *Polypedilum* ex gr. *nubeculosum* Meig. on September 1964 on a shallow covered with slime and vegetable remnants in the Łosiański stream, *Stictochironomus* ex gr. *histrion* Fabr. on July 28, 1965 on stony bottom of the Kamienica at Nawojowa, *Polypedilum brevi antennatum* Tschern. on July 27, 1965 on stones in the Uhryński stream).

Among the remaining dipteran families only *Melusinidae* (*Simulium* sp.) reached a high population density, occurring in the whole Kamienica basin, the most differentiated species composition being revealed in the family *Tipulidae*, whose representatives (though less numerous) were found in nearly the whole basin (*Dicranota* sp. div.) and mainly in its upper part. The family *Heleidae* was represented mostly by species of the genus *Stilobezzia*, collected in small numbers at the majority of sampling-places, by several specimens of *Culicoides* sp. (in the right-bank tributary and in the Łosiański stream), and one specimen of *Dasyhelea* sp., found at Maciejowa. Representatives of other dipteran families (*Psychodidae*, *Culicidae*, *Rhagionidae*, *Tabanidae*, *Stratiomyidae*, *Empididae*, and *Anthomyidae*) were noted only sporadically and mainly in the upper part of the basin.

Neuroptera (36 specimens — 0.1%). In the upper Kamienica basin and in its upper tributaries there occurred mostly larvae of the 1st instar, unidentifiable more precisely, and single specimens of *Sialis fuliginosa* Pict. and *S. lutaria* L.

Trichoptera (2786 specimens — 5.6%) showed a fairly differentiated specific composition. The most numerous group consisted of 1st instar larvae of *Rhyacophila*, unidentifiable more precisely, but belonging indubitably to the following species, whose representatives were found in many parts of the basin: *Rh. vulgaris* Pict., *Rh. nubila* Zett., and *Rh. septentrionis* McLach.; or, mainly in its upper part: *Rh. obtusidens* McLach., *Rh. obliterated* McLach., *Rh. tristis* Pict., and *Rh. philopotamoides* McLach. A considerable population density was also reached by: *Hydropsyche pellucidula* Curt., found in all sampling-places except 14, *Psychomyia pusilla* Fabr., assembling mostly in the upper part of the basin, and *Sericostoma pedemontanum* McLach., inhabiting the upper reaches of the Kamienica and the majority of its tributaries. Other species of caddis-flies appeared either in considerably smaller numbers or singly, and were found exclusively, or almost so, in the upper sector of the basin in question.

Lepidoptera (3 specimens — less than 0.1%). Caterpillars of the family *Pyralididae* collected in the Kamienica and in the Łosiański stream were too small to allow their identification.

Araneina (6 specimens — less than 0.1%) were represented exclusively by *Argyroneta aquatica* L., found only in the upper reaches of the Kamienica, in its left-bank tributary, and in the Łosiański stream.

Hydracarina (52 specimens — 0.1%) occurred too infrequently and scantily for their distribution to be discussed precisely. In any case, very rare specimens of the species *Hydrovolzia placophora* Monti, *Lebertia* sp., *L. salebrosa* Koenicke, *Atractides connexus* Koenicke, and *Hygrobates* sp. were collected only in the upper Kamienica basin.

Mollusca (156 specimens — 0.3%) were represented for the most part by *Pisidium casertanum* Poli, occurring in small numbers in the upper basin and in the Kotowski stream, and collected somewhat more numerous (93 specimens) only on September 28, 1964 in sampling-place 5 in a shallow, on a coastal sandy shoal covered with a thin layer of slime and detritus. Other molluscs were collected sporadically in the upper basin, several specimens of *Ancylus fluviatilis* Müll., however, being found also in the Homerka stream.

Benthic communities in individual sampling-places

Spring trickle of the Kamienica. The Kamienica rises in a small pool on the slopes of the mountain Przysłop; it is 0.5×0.7 m in side and overgrown with moss and water plants, while its bottom is covered with a layer of brown slime. The valley of the stream is V-shaped here (definitions of the types of valleys are given according to Starmach 1956), and its steep slopes are overgrown by coniferous forest with a dense underbrush. The spring fauna is very scarce, while *Oligochaeta*, *Tipula* sp. div. larvae, and less numerous *Gammarus pulex fossarum* predominate. Several hundred metres below, the bed of the trickle stream is formed of small stones on a substratum of fine-grained sand, a brown slime gathering only in small bends with a slow water current. Besides prevailing specimens of *Gammarus pulex fossarum* there are present single specimens of stone-flies (*Leuctra* sp., *L. nigra*, *Perlodes intricata*, *P. dispar*), beetles (*Hydrocyphon* sp., *Helmis* sp., *Eubria* sp.), flies (*Helobia hybrida*, *Cricotopus* ex gr. *algarum*, *Tanytarsus* ex gr. *gregarius*, *Stilobezzia* sp., *Wiedermannia* sp.), and caddis-flies (*Stenophylax nigricornis*, *Sericostoma pedemontanum*).

A greater differentiation of specific composition of the bottom fauna may be observed only at a distance of about 300 m from the spring, where the bed of the stream consists of stones of different sizes. It is inhabited by *Gammarus pulex fossarum*, dipterous larvae (besides the above-mentioned also *Psychoda* sp. sp., *Microtendipes* ex gr. *chloris* and others), mayflies (*Rhitrogena semicolorata*, *Ecdyonurus* sp. sp., *Baëtis rhodani*, *Paraleptophlebia cincta*), stone-flies (*Protonemura* sp. besides those named above), beetles (for the most part *Helichus* sp. div.), and caddis-flies (*Rhyacophila* sp., *Plectrocnemia geniculata*, *Psychomyia pu-*

silla, *Silo piceus*). Small brooklets, which flow into the spring trickle of the Kamienica, show a similar specific composition, but a distinct increase in the number of *Gammarus pulex fossarum* is visible.

At a distance of about 800 m from the spring, the Kamienica valley is still V-shaped, but inclined slightly diagonally, the bed of the stream is overlaid with large stones covered by brown slime and overgrown with moss, and small shoals of sand are formed near the banks. Benthic communities which inhabit this environment are even more distinctly differentiated as regards species, since apart from species occurring in the spring zone, there are also present forms found only in sampling-places situated below (Table I). It is perhaps worth stressing that representatives of some species (e.g. *Torleya major*, *Leuctra* sp., *Psychoda surcoufi*, *Cricotopus* ex gr. *algarum* etc.) were never found on coastal sandy shoals, on which, however, *Gammarus pulex fossarum* and *Microtendipes* ex gr. *chloris* appeared in large numbers.

Sampling-place 1 lies at a distance of about 1 km from the Kamienica spring, above the village Roztoka Wielka, on the edge of coniferous forest. The valley of the stream is shaped similarly as in the sampling-place described above, its bed being built of stones of varying size (Table II), without moss or layers of slime, and sparsely overgrown with algae. In places with slower current small shoals of sand and gravel occur from time to time. Many species of mayflies, stone-flies, flies, and caddisflies appear there, while *Baëtis rhodani*, *Perlodes dispar*, *Protonemura* sp., *Cricotopus* ex gr. *algarum*, and *Tanytarsus* ex gr. *gregarius* reach a considerable population density. The majority of species found there live on stones lying in the current of stream and only on coastal shoals of sand and gravel do specimens of *Gammarus pulex fossarum*, *Tanytarsus* ex gr. *gregarius*, *Stilobezzia* sp., *Odontocerum albicorne*, *Sericostoma pedemontanum*, and snails (found sporadically) occur more frequently than on stones.

At a distance of about 4.5 km from its spring the Kamienica, which flowed thus far northward, turns to the north-east; its valley becomes gradually wider and wider, while a horizontal inclination of the valley bottom, covered with alluvial deposits in the middle and lower reaches of the river (sampling-places 14 and 16), is more distinctly visible. Forests grow principally only on the summit parts of the adjacent mountains and hills, while the valley itself is filled with meadows, arable land, and scattered farm buildings. Similar characteristics are shown by the considerably narrower valley of a small right-bank tributary of the Kamienica, which flows out from the Krzyżówka pass (sampling-place 2), while other streams (except the Kamionka) flow in valleys shaped similarly as that of the Kamienica spring sector. In all of them a numerical preponderance of mayflies (especially of *Baëtis rhodani*) and flies (mainly of *Cricotopus* ex gr. *algarum*) is marked, and in the upper

Table II. Characteristics of the bed of the streams in individual sampling-places

Sampling- Place	Distance from the spring	Width in m	Maximum depth in m	Structure of bottom in % (size of stones in cm)					Vicinity of sampling-place
				>50	15-50	5-15	1-5	0, 1-1	
1	1	0.5-1	20		30	30	20	20	coniferous forest
2	2	0.7	20		20	40	30	10	meadows and arable land; farm buildings above it
3	1.2	0.6	10	20	20	40	15	5	coniferous forest
4	4	2-3	20	20	20	30	30	30	coniferous forest and arable land, farm buildings above it
5	6.5	6-7	50	20	30	30	15	15	arable land, meadows and farm buildings
6	5	4-5	100		10	40	30	20	coniferous forest
7	9	6-7	60		20	40	30	10	farm buildings and meadows
8	3	2	30		60	20	10	10	coniferous forest; arable land and farm buildings above it
9	5	4-5	60	30	30	30	5	5	coniferous forest and meadows
10	4	4-5	80	20	30	20	20	10	coniferous forest and meadows
11	3	4	60	10	30	30	20	10	coniferous forest; a forester's cottage above it
12	2	4-5	60		70	20	10		meadows and arable land; farm buildings above it
13	4	5-6	50	20	30	30	20	20	farm buildings and meadows
14	16	15	100		20	30	30	20	farm buildings, meadows, and arable land
15	4	4-5	60		50	30	20		meadows, arable land, and forest
16	21	25	150		30	40	30		meadows and arable land
17	1	2	40		30	20	40	10	mixed forest and meadows
18	0.5	1-2	30		20	40	40		coniferous forest
19	6.8	7	60		40	30	20	10	farm buildings, meadows

part of the basin also that of stone-flies (mostly of *Protonemura* sp. and *Perlodes dispar*) and of less numerous caddis-flies.

Sampling-place 2 (the right-bank, un-named tributary of the Kamienica) shows a great differentiation of the bottom fauna, while the number of *Tanytarsus* ex gr. *gregarius* larvae diminishes (in comparison with sampling-place 1), and, on the other hand, in spring 1964 a mass appearance of *Gammarus pulex fossarum* (344 specimens in a sample from a small sand shoal) was noted as well as a numerous occurrence of *Paraleptophlebia cincta* and *Thienemanniella zavřeli* larvae in autumn 1965. Such rarely found forms as infrequent specimens of *Helobia hybrida*, *Trimicra* sp., *Sialis fuliginosa*, *Rhyacophila obtusidens*, *Stenophylax latipennis*, and *Potamorites biguttatus* were collected here. It is perhaps worth mentioning that though the current zone stretches over the whole narrow bed of the stream, near its banks small sandy shoals arise temporarily, not slimed over, and sometimes only covered with tiny particles of coal (probably floated down from villages situated higher up); on such shoals relatively large numbers of specimens of *Gammarus pulex fossarum*, *Baëtis* sp. (1st instar larvae), *Protonemura* sp., and *Sericostoma pedemontanum* were collected.

Sampling-place 3 lies in a small left-bank tributary of the Kamienica, which flows in a deep ravine through coniferous forest. The fauna of the brook, though quantitatively the poorest in species, is nevertheless distinctly similar to communities of bottom invertebrates found in the upper sector of the Kamienica. Here again, similarly as in sampling-place 1, a considerable population density is shown by *Gammarus pulex fossarum* and *Tanytarsus* ex gr. *gregarius* larvae (besides species dominating in the whole basin of the Kamienica), and as regards forms not found in sampling-places situated higher up, only single specimens of *Epeorus assimilis*, *Brillia modesta*, *Hemerodromia* sp., and one unidentified specimen of the family *Syrphidae* were collected. Moreover, a single more numerous appearance of *Heptagenia lateralis* and *Polypedilum breviantennatum* larvae (on 22 September 1965) may be mentioned. An assembly of many specimens of the latter might depend on some changes in environmental conditions. Usually the brook in question shows a fairly uniform current which makes impossible any formation of windings with slower flow, but in autumn 1965 in consequence of a reduced water level, narrow, coastal lenitic stretches covered with a thin layer of deposited slime emerged from the current. In such stretches larvae of *Polypedilum breviantennatum*, *Procladius* sp. div., and *Prodiamesa olivacea* as well as many specimens of *Gammarus pulex fossarum* (132 individuals in a sample) were found. The few other specimens were probably present there only accidentally.

Sampling-place 4 in the Łosiański stream, which flows among woods, meadows, and between farms, shows a specific composition and number

of forms similar to those in preceding sampling-places, but the number of *Rhitrogena semicolorata*, *Heptagenia fallax* (on 22 September 1965), *Baëtis carpaticus*, and *Simulium* sp. increases, while the population density of *Ecdyonurus venosus* larvae and *Gammarus pulex fossarum* decreases, this latter species appearing in much smaller numbers in the further sampling-places (except the Feleczyn stream). In sampling-place 4 exclusively specimens of *Halesus tessellatus* and *Hygrobatas* sp. were found and a single mass appearance of *Clinotanypus nervosus* and *Polypedilum* ex gr. *nubeculosum* was noted (on September 28, 1964, in a bend with a slow current and covered with grey slime and detritus). In similar bends there were also collected less numerous larvae of *Torleya major*, *Ephemera danica*, *Prodiamesa olivacea*, *Tabanus* sp., and *Sialis lutaria*, which did not appear on stones washed with a strong current of water.

Sampling-places 5 and 7 in the Kamiénica in the village Nowa Wies (among gardens, meadows, and farm buildings), though situated at a distance of about 2.5 km from each other, show a very similar qualitative and quantitative composition of their bottom fauna. The total number of fauna being moderate (3027 specimens per 1 m² of bottom in sampling-place 5 and 5920 specimens in sampling-place 7), a great population density is reached by species which dominate in the whole Kamiénica basin, and moreover by *Oligochaeta* (in sampling-place 5), and by *Rhitrogena semicolorata*, *Caenis macrura*, *Helmis* sp. div., *Antocha* sp. div., *Simulium* sp., and *Psychomyia pusilla* (in sampling-place 7). The presence of comparatively many forms inhabiting these sectors of the Kamiénica exclusively, or nearly so, is outstanding; these are *Helobdella stagnalis*, *Paraleptophlebia submarginata*, *Graptodytes lepidus* (occurring also in the Kotowski stream), *Gyrinus* sp., *Psychoda severini* (found also in the spring reaches of the Kamiénica), *Eulalia* sp., *Hydroptila sparsa*, *Stenophylax luctuosus*, *Hydrovolzia placophora*, *Thyas* sp. (appearing also in the Homerka), *Lebertia salebrosa*, *Atractides connexus*, and *Theodoxus fluviatilis*. The parts near the bank with a slower current of the river are characterized by a smaller specific differentiation of the benthos and a comparatively greater occurrence of *Oligochaeta*, *Gammarus pulex fossarum*, *Corixa* sp., *Prodiamesa olivacea*, *Polypedilum* ex gr. *pedestre*, and *Pisidium casertanum*.

Between sampling-places 5 and 7 a sector of the Kamiénica is regulated: there are artificial concrete sills and also concrete-laid wide and shallow sheddings. In qualitative samples collected from moss which grows on the sills, the appearance of not too many *Oligochaeta* (*Eiseniella tetraedra* and others) and larvae of *Baëtis* sp., *Tanytarsus* ex gr. *gregarius*, and *Melanochelia* sp. was noted. On boulders scattered in concrete-laid sheddings larvae of *Baëtis* sp., *Ablabesmyia* ex gr. *monilis*, *Cricotopus* ex gr. *algarum*, *Rheorthocladus saxicola*, *Microtendipes* ex gr. *chloris*, and *Stilobezzia* sp. were present. Other specimens found were so few

that they may be regarded as allochthonic forms carried down by the current from the upper reaches of the Kamienica.

Spring trickle of the Kreszczaty stream. In the research period the spring of the stream was hidden by stones (probably as a result of improvement works on a forest path near by), hence samples could be collected only at a distance of (presumably) about 1 km from the spring. On small stones and gravel forming the bottom in this sector of the stream, the presence of comparatively numerous *Gammarus pulex fossarum*, *Baëtis* sp., and *Perlodes dispar* was noted (the few other species were represented by single specimens, while in the parts of the bottom covered with sand and slime mixed with detritus the bottom fauna turned out to be even more scanty. However, at a distance of about 800 m, where the stream already flows as a marked uniform current, its fauna becomes somewhat richer, because there are present, though still not numerous, specimens of other mayflies, stone-flies, and flies. A remarkable increment in number and differentiation of the benthos composition is clearly visible in the middle reaches of the Kreszczaty, where its valley widens slightly and is V-shaped, inclined somewhat diagonally, while the bottom of the stream contains stones of different size, and narrow stretches of sand and gravel, sometimes covered with thin layers of grey slime. In the whole sector the bottom fauna considerably resembles that in the spring trickle of the Kamienica, mainly differing from it in the appearance of certain mayflies, stone-flies, flies, caddis-flies, and water mites (Table I).

In the lower sector of the Kreszczaty (sampling-place 6) also flowing through coniferous forest, only *Psychomyia pusilla* and *Hydropsyche pellucidula* — besides species dominating in the whole basin — reach a great population density. Representatives of other numerous species occur in varying but usually small number, and only on 28 September 1964 was a mass appearance of *Prodiamesa olivacea* larvae (100 specimens in a sample) noted in a marginal stagnant water sector with a sandy bottom covered with ashen-grey slime and detritus — i. e. in an environment which in this stream is usually characterized by a decidedly small number of species. Among forms absent in other sampling-places only specimens of *Agapetus comatus*, *Mesophylax impunctatus*, and *Brachycentrus montanus* were found there, and among species rare in the Kamienica basin, *Epeorus assimilis* and *Perla marginata* appear here somewhat more frequently.

Tributaries of the middle reaches of the Kamienica include the streams: Kotowski (sampling-place 8), Uhryński (sampling-place 9), Łabowczański (sampling-place 10), Feleczyn (sampling-place 11), Składziszczanski (sampling-place 12), Czaczowiec (sampling-place 13), and Homerka (sampling-place 15). In these streams — similarly as in the upper Kamienica basin — a considerable constancy of occurrence and population

density are shown by species: *Baëtis rhodani*, *Perlodes dispar*, *Cricotopus* ex gr. *algarum*, *Simulium* sp., and *Hydropsyche pellucidula*; a striking increase is visible in the number of *Ecdyonurus venosus*, *Ephemerella ignita*, *Caenis macrura*, and *Polypedilum* ex gr. *pedestre*, which in the upper part of the basin appear with marked constancy but in considerably smaller numbers. On the contrary, *Protonemura* sp. dominating in the preceding sampling-places, occurs much less frequently in tributaries of the middle reaches of the Kamienica (except for the Łabowczański stream), and *Gammarus pulex fossarum*, a typical inhabitant of the spring trickle and two small tributaries of the Kamienica (sampling-places 2 and 3), appears abundantly only in the Feleczyn stream, i. e. also in a small forest brook. As for the remaining species, only some of them were noted more frequently in respective streams (Table I), and as for forms not found anywhere else during the researches, larvae of *Hydroptila MacLachlani*, *Hydropsyche saxonica*, *Silo piceus* (in the Uhryński stream), *Deronectes* sp. (in the Łabowczański stream), *Mesovelina* sp. (in the Składziszczański stream), and *Gonomyia* sp. (in the Homerka stream) were collected.

Middle course of the Kamienica (sampling-places 14 in the village Maciejowa and 16 in the village Nawojowa) differs from its upper part mainly in the smaller number of species found (resulting, perhaps, from its being sampled only once) and by the fact that species frequent in sampling-places 5 and 7 occur much more rarely or do not appear at all in the middle reaches (only larvae of *Baëtis rhodani* and *Cricotopus* ex gr. *algarum* being an exception). On the other hand, an increase in number of certain forms less frequent or not found at all at Nowa Wies was noted here (*Podypedilum* ex gr. *pedestre* at Maciejowa, *Helichus* sp., *Dicranota* sp., *Eukiefferiella* cfr *similis*, and *Stictochironomus* ex gr. *histrion* at Nawojowa, and *Rheorthocladus saxicola* in both these sampling-places). Similarly, however, as in the upper course of the river, a visible quantitative and qualitative decrease in bottom fauna was noted on small marginal sandy shoals in the current, shoals of sand and slime in places with a weaker current, and river arms with stagnant or slowly flowing water. It is perhaps worth mentioning that in sampling-place 16 one specimen of *Oligoneuriella rhenana* and in sampling-place 14 one larva of the genus *Dasyhelea* were collected, which were never found in other sectors of the river.

The largest tributary of the Kamienica, the Kamionka stream, flows into its lower sector and arises from the union of two large brooks: the Kamionka and the Królówka. Samples from this tributary were collected in spring trickles of both brooks (sampling-place 17 in the Kamionka and sampling-place 18 in the Królówka) and below their meeting in the village Kamionka (sampling-place 19). The fauna of the spring trickles of the Kamionka (among meadows and mixed forest) and the

Królowka (in coniferous forest) is fairly poor in quantity and quality, but in general it resembles the benthos of the Kamienica spring trickle, or — perhaps even more — that of the upper and middle reaches of the Kreszczaty, on account of the presence of certain species (*Dixa* sp., *Ablabesmyia tetrasticta*, *Brillia modesta*, *Rheorthocladus saxicola*, *Eukiefferiella* cfr *similis* in the Kamionka, and *Baëtis carpaticus*, *Rhyacophila nubila*, *Rh. septentrionis* in the Królowka), which in the Kamienica appear only in sampling-place 1 or below it. Besides, *Gammarus pulex fossarum*, represented more numerously in the spring trickle of the Kamienica than in the Kreszczaty, occurred in small numbers in sampling-place 17 and was not collected in sampling-place 18.

The environmental conditions and faunistic composition of sampling-place 19 (the Kamionka stream in the village Kamionka) cause a resemblance to the lower reaches of the Kamienica and sectors of its several tributaries (near their mouths), although a comparatively large number of *Ecdyonurus helveticus* and *E. venosus* larvae would rather point to some analogies with the Kotowski stream, which has a similarly shaped bottom though a considerably smaller depth and width, and a markedly swifter current. Besides, among forms rarely occurring in the Kamienica basin, *Pedicia* sp. (found only in the Kreszczaty stream) and *Megapus tener* (not found anywhere else) were collected here.

Ecological remarks

The water environment of the Kamienica Nawojowska basin is relatively little differentiated and in general typical for Carpathian rivers. It consists of streams of similarly shaped bed structure (Table II), an extensively developed lotic zone, and water that is clean or only slightly polluted with sewage from near by settlements. The upper basin of the Kamienica may be regarded as waters of the trout zone, and its middle and lower reaches as waters of the grayling zone (Kolder, typescript). A stony bottom and strong or fairly strong current provide favourable habitat conditions for rheo- and lithorheophilous forms, mostly for mayflies (*Rhitrogena semicolorata*, *Ecdyonurus helveticus*, *E. venosus*, *Baëtis carpaticus*, *B. scambus*, *Paraleptophlebia cincta*), stoneflies (*Protonemura* sp., *Perlodes intricata*, *P. dispar*), caddis-flies (*Rhyacophila vulgaris*, *Rh. septentrionis*) and some flies (*Eukiefferiella* cfr *similis*, *Simulium* sp.). In the same habitats, however, are found (sometimes even in large numbers) species generally regarded as forms typical for waters with a weak current (*Baëtis rhodani*, *Caenis macrura*, *Psychomyia pusilla*) or as ubiquitous forms (*Ephemerella ignita*, *Polycentropus flavomaculatus*, *Hydropsyche pellucidula*, *Notidobia ciliaris*, and *Pisidium casertanum*).

Owing to the considerable gradient and strong current in the Kamienica and its tributaries no lenitic zone was formed, and only in places with weaker current do sand fine-grained gravel accumulate, sometimes with thin layers of slime. Such small shoals of sand are usually inhabited

Table III. Coefficients of faunistic similarity

Sampling places	2	4	3	1	7	5	6
2	100.0	65.2	62.8	58.8	52.1	53.6	57.3
4	65.2	100.0	58.1	63.6	58.2	59.6	56.8
3	62.8	58.1	100.0	63.2	53.4	51.6	55.4
1	58.8	63.6	63.2	100.0	60.7	60.4	53.9
7	52.1	58.2	53.4	60.7	100.0	70.7	57.4
5	53.6	59.6	51.6	60.4	70.7	100.0	58.9
6	57.3	56.8	55.4	53.9	57.4	58.9	100.0

by representatives of species found mostly on stony bottom, but besides them *Gammarus pulex fossarum*, *Torleya major*, *Procladius* sp. div., *Polypedilum breviantennatum*, *Stilobezzia* sp., and *Sericostoma pedemontanum* appear there somewhat more numerous, as well as specimens of pelo- and psammophilous species (*Ephemera danica*, *Prodiamesa olivacea*, *Microtendipes* ex gr. *chloris*, *Polypedilum* ex gr. *nubeculosum*, *Tanytarsus* ex gr. *gregarius*, and *Odontocerum albicorne*). As a rule, however, the marginal parts of the river, with a weaker current and fine-grained bottom, are characterized by a reduced specific differentiation and smaller number of fauna.

Owing to the fact that a stony bottom inhabited by rheophilous organisms prevails in the described streams, and very many species occur in the whole Kamienica basin, or at least in its whole upper part, coefficients of faunistic similarity calculated for sampling-places 1—7 always show high values (from 52.1 to 70.7% — Table III). Nevertheless, one can distinguish certain habitats closely resembling each other.

1. The spring trickles of the Kamienica and of the streams: Kreszczaty, Kamionka, and Królówka have a rather poor fauna, whose number and differentiation gradually increases as the stream flows further from the spring. Beside rheo- and lithorheophilous species, also krenobionts (*Leuctra nigra*, *Brillia modesta*, *Agapetus comatus*, *Stenophylax nigricornis*, and *Bythinella austriaca*) occur there as well as less numerous ubiquitous species.

2. The habitats of small and medium-sized streams (coefficient of similarity 58.1—65.2%) are characterized by the numerical diminution of krenobionts and a marked dominance of rheo- and lithorheophilous forms. The upper sector of the Kamienica (sampling-place 1), its left-

bank tributary (sampling-place 3), and the Łosiański stream (sampling-place 4) without doubt provide similar conditions of habitat for invertebrates, as they are streams with a stony bottom, a high gradient, and a strong current, and, moreover, they all flow in dense coniferous forest. Only in the middle reaches of the Łosiański stream, in an extension of its valley, are there arable lands and farm buildings. It is possible that an inflow of waters from the cultivated part of the catchment area of the stream induces some environmental changes which facilitate the survival of species usually found in unforested parts of the Kamienica (*Ablabesmyia tetrasticta*, *Stictochironomus* ex gr. *histrionis*, *Polypedilum* ex gr. *nubeculosum*, *Rhyacophila philopotamoides*, *Polycentropus flavomaculatus*, *Potamorites biguttatus*, *Silo pallipes*, and *Notidobia ciliaris*). It might account for a relatively high coefficient of similarity between sampling-places 4 and 5 or 7 (58.2 and 59.6%). On the other hand, there is a surprising similarity between the streams in question and the small right-bank tributary of the Kamienica (sampling-place 2), presenting altogether different environmental conditions, as it flows through a comparatively wide unforested and well insulated valley. Perhaps, therefore, one may presume that, essentially, the gradient and the velocity of the current and, to a much lesser degree, insolation and the immediate surroundings of the stream are factors deciding the populations in this tributary. Moreover, a numerous or mass appearance of *Gammarus pulex fossarum* is typical for the described small streams (and also for the tiny Feleczyn stream); as this calciphilous species appeared to be much less frequent in the sampling-places situated below, one might accept this fact as evidence of larger calcium contents in the small streams of the upper Kamienica basin.

3. A different type of habitat is presented by sampling-places 5 and 7 (the Kamienica in the village Nowa Wies) marked by peculiar environmental conditions (a wider valley, greater depth and breadth of the river, a weaker current, the proximity of meadows, arable land, and farm buildings), a greater differentiation of bottom fauna, the highest number of species in common, and the highest coefficient of faunistic similarity (70.7%). Numerous rheo- and lithorheophilous species occurring also in other parts of the Kamienica basin prevail there, but beside them many ubiquitous forms (species of the genus *Corixa* and others) appear and even those typical for slow-flowing rivers (*Paraleptophlebia submarginata*, *Perla burmeisteriana*, *Hydroptila femoralis*, and *Theodoxus fluviatilis*).

4. Another different water habitat is present in the lower course of the Kreszczaty stream (sampling-place 6). In spite of a relatively small catchment area, this stream carries a fairly large amount of water and, although it flows in a narrow wooded valley, it has a considerable depth and width while in its bottom small stones and gravel prevail. As

regards its fauna, sampling-place 6 somewhat approaches sampling-places 5 and 7, mainly in the presence of fairly numerous ubiquitous species and those typical for slow-flowing waters. The faunistic similarity (coefficients: 57.4 and 58.9%) is probably a result of the near proximity of the three sampling-places (the Kreszczaty flows into the Kamienica between the sampling-places 5 and 7). On the other hand, the fauna of sampling-place 6 shows marked analogies with animal communities of the spring trickle and middle reaches of the Kreszczaty; this is shown, among other factors, by the presence in sampling-place 6 of krenobiontic larvae of *Brillia modesta* and *Agapetus comatus* and also of larvae of *Mesophylax impunctatus* and *Brachycentrus montanus*, found only in this stream.

5. Somewhat different animal communities are present in the middle reaches of the Kamienica and the Kamionka (sampling-places 14, 16, and 19). They have been discussed above but they are not included in the Table of coefficients of faunistic similarity, on account of the material's having been sampled there only once.

Bottom communities of the Kamienica basin, and especially those in its upper part resemble in general those noted in stony-lotic habitats in other Carpathian rivers and streams (Dra t n a l, S z c z ę s n y 1965, K o w n a c k a, K o w n a c k i 1965, K r z a n o w s k i, F i e d o r, K u f l i k o w s k i 1965, S o w a 1965), but show a qualitative impoverishment of their fauna, due mainly to the lack of any well developed lenitic zone and the absence of many species which usually inhabit it. The number of bottom fauna in the Kamienica basin varies in a fairly large range, from 900 specimens per 1 m² of bottom (spring trickle of the Kamionka) to 9715 specimens per 1 m² (the Homerka stream). In general, however, the population density is higher here than on a stony bottom in the Beskid stream, Wielka Puszcza (S o w a 1965), and approaches rather values calculated for lower reaches of the streams Biały Dunajec, Rogóżnik, and Lepietnica (K r z a n o w s k i, F i e d o r, K u f l i k o w s k i 1965).

In the Kamienica basin, similarly as in other Carpathian rivers, the type of bottom determines a numerous appearance of lithorheophilous species, but the velocity of the water current, the features of the catchment area, and probably also the immediate vicinity of the stream and changes in the chemical composition of water are the factors which make possible the formation of individual bottom communities.

I should like to express my sincere gratitude to Professor K. S t a r m a c h for entrusting me with this study and for his scientific direction during the work.

STRESZCZENIE

W ramach badań zespołowych Zakładu Biologii Wód PAN, prowadzonych w latach 1964—1965 pod kierunkiem Prof. Dr K. Starmacha, zebrano próbki fauny dennej z dorzecza Kamienicy Nawojowskiej (prawobrzeżnego dopływu Dunajca), szczególną uwagę zwracając na górną partię dorzecza (ryc. 1). Wśród zebranych 49 993 okazów (tabela I) przeważały jętki, muchówki, chrzączki, widelnice i chrząszcze. Pod względem liczebności dominowały: *Baëtis rhodani*, *Cricotopus ex gr. algarum*, *Protonemura* sp. i *Perlodes dispar*.

Dorzecze Kamienicy reprezentuje środowisko wodne dość typowe dla rzek karpackich. Składają się na nie głównie potoki o kamienistym dnie, dużym spadku silnie rozwiniętej strefie lotycznej i o wodzie czystej lub słabo tylko zanieczyszczonej ściekami bytowymi z położonych w ich pobliżu osiedli (tabela II). Znaczne ujednoczenie siedlisk, zamieszkałych przede wszystkim przez gatunki reo- i litoreofilne, warunkuje również duże podobieństwo składu gatunkowego omawianych potoków (tabela III). Pomimo to, w dorzeczu Kamienicy można wyróżnić pewne odrębne siedliska:

1. Odcinki źródłowe Kamienicy i potoków: Kreszczatego, Kamionki i Królówki mają dość ubogą faunę, której liczebność i zróżnicowanie zwiększa się stopniowo w miarę oddalania się od źródła. Oprócz form reo- i litoreofilnych występują tu charakterystyczne krenobionty i mniej liczne gatunki ubikwistyczne.

2. Siedliska małych i średnich potoków cechują się zmniejszeniem liczby krenobiontów i zdecydowaną przewagą form reo- i litoreofilnych.

3. Górny bieg Kamienicy wykazuje znaczne zróżnicowanie składu gatunkowego i występowanie — oprócz form spotykanych w innych częściach dorzecza — liczniejszych gatunków ubikwistycznych, a nawet typowych dla rzek wolnopłynących.

4. Dolny odcinek potoku Kreszczatego upodobnia się pod względem faunistycznym do górnego biegu Kamienicy (dość liczne gatunki ubikwistyczne i właściwe wodom wolno płynącym), lecz wykazuje również podobieństwo do strefy źródłowej i średniego biegu Kreszczatego (m. in. występowanie pewnych gatunków krenobiontycznych).

5. Średni bieg Kamienicy i Kamionki wykazuje zespoły zwierzęce, zbliżone nieco pod względem składu gatunkowego do fauny górnego biegu Kamienicy, lecz różniące się od niej liczebnością poszczególnych gatunków.

O liczonym występowaniu gatunków reo- i litoreofilnych decyduje przede wszystkim charakter dna, lecz czynnikami umożliwiającymi powstawanie odrębnych zespołów dennych są: szybkość prądu wody i charakter zlewni, a prawdopodobnie także bezpośrednio otoczenie potoku i zmiany w składzie chemicznym wody.

REFERENCES

- Draţnal E., Szczęśny B. (ed.), 1965. Benthic fauna of the Dunajec River. Kom. Zagosp. Ziemi Górskich PAN, 11, 161—214.
- Koźder W., Gęstość zasiedlenia ryb w krainie pstrąga w niektórych potokach w dorzeczu Dunajca. (w maszynopisie, in typescript).
- Kownacka M., Kownacki A., 1965. The bottom fauna of the river Białka and of its Tatra tributaries, the Rybi Potok and Potok Roztoka. Kom. Zagosp. Ziemi Górskich PAN, 11, 129—151.
- Krzyszowski W., Fiedor E., Kuflikowski T., 1965. Fauna denna kamienisto-prądowych siedlisk dolnych odcinków Białego Dunajca, Rogoźnika i Lepietnicy. Zesz. Nauk. UJ, 103, Prace Zoolog. 9, 43—60.

- Pasternak K., 1968a. Charakterystyka podłoża zlewni rzeki Dunajec. Acta Hydrobiol., 10, 3, 299—317.
- Pasternak K., 1968b. Skład chemiczny wody rzek i potoków o różnych skałach i glebach zlewni. Acta Hydrobiol., 10, 1/2, 1—25.
- Sowa R., 1965. Ecological characteristics of the bottom fauna of the Wielka Puszcza stream. Acta Hydrobiol., 7, Suppl. 1, 61—92.
- Starmach K., 1962. Badanie zbiorowisk organizmów wodnych. (w maszynopisie. typescript).
- Starmach K., 1956. Rybacka i biologiczna charakterystyka rzek. Pol. Arch. Hydrobiol., 3 (16), 307—332.

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