

## Zonation of mayflies (*Ephemeroptera*) in several streams of the Tatra Mts and the Podhale region

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**Abstract** — The zonation of mayfly larvae in several streams of the Tatra Mts and the Podhale (submontane) region was investigated. In Podhale streams, larvae communities are unaffected by pollution and correspond to 1—3 zones of settlement. In the high-mountain Waksmundzki stream characterized by difficult environmental conditions, only 4 species were found. In this stream mayflies reach up to the altitude of 1400 m only.

**Key words:** Zoogeography, streams mayflies, longitudinal zonation.

### 1. Introduction

The zonation of mayfly larvae was investigated in four largest streams of the Podhale region: Czarny Dunajec, Białka (below 1000 m a/s/l, and Rogoźnik (with the Bystry stream). The object of the work was to find out to what extent the zonation of different species — apart from ecological factors — depended upon the effects of human activity.

Moreover, preliminary observations were carried out on the zonation of mayflies in the Waksmundzki stream (High Tatra Mts) and, for comparing the results, in the Pyszniński and Kościeliski streams (Western Tatra Mts).

Except for the Bystry stream to which no reference has been made in previous publications on the subject, mayflies in the above streams were already investigated by C i s z e k, S o s i ń s k a (1965), K a m l e r (1960),

Kownacka, Kownacki (1965, 1971), Krzanowski, Fiedor, Kuflikowski (1965), and Sowa (1975).

## 2. Investigation area

### 2.1. The Podhale region

The streams Białka and Czarny Dunajec flow from the Tatry Mts; the springs of Rogoźnik lie in the Podhale region on the northern slopes of Gubałówka at about 1100 m a/s/l. The whole course of the Białka stream shows features characteristic of mountain streams (bottom covered with stones; stones without sediments; rapid water current) while in the lower sectors of the streams Czarny Dunajec and Rogoźnik there are places where fine-grained suspension settle on stones and depressions filled with mud are formed along the banks. The number of inhabitants is fairly large there, with villages spreading along the streams.

### 2.2. The Tatra Mts: Waksmundzki and Pyszniański-Kościeliski streams

The Waksmundzki stream flows across the High Tatra Mts in a steep and deeply cut Waksmundzka Valley running northwards. Even for Tatra conditions its gradient is exceptionally high, reaching 100—400‰ (Wit-Józwiak 1974). The Waksmundzki stream belongs to the few streams of this part of the Tatra Mts which are not fed from standing water bodies. Neither has it one main spring; starting from debouchments from the rock waste at 1900 m a/s/l. The stream is lying on a substratum of crystalline rocks. Owing to the rapid flow through the rock waste whose amounts were rather small there, the content of mineral salts in water was poor (total hardness of 0.75 mval/l was quoted by Oleksynowa, Komornicki 1965). In spring and summer the stream carried large amounts of water, flowing from patches of melting snow which lie in some places of the upper part of the valley till late summer. In autumn and winter water disappears in the sectors of the rock waste. This phenomenon was observed above 1600 m and below 1200 m a/s/l.

The Pyszniański-Kościeliski streams are typical of the region of the Western Tatra Mts. The investigation was carried out in one of the spring streams of the Pyszniański, at the summit of Mount Kamienista, and in the Kościeliski streams. The Pyszniański stream starts from numerous springs and debouchments. With the changing water level, it tends to disappear in some of the sectors. The two streams flow on a substratum of sedimen-

tary rocks. The water of these two streams contains more salts (the total hardness in the Kościeliski reaches 2.3 mval/l, Oleksynowa, Komornicki 1965). Water yields in this stream are less variable than in the Waksmundzki.

### 3. Method

#### 3.1. The Podhale region

The investigation was carried out in 1979 at 15 stations (fig. 1). At each station one large semiquantitative sample was taken from different types of habitats, as follows:

- main current,
- outside the main current, and
- bays along the bank, with standing water, filled with fine-grained material.

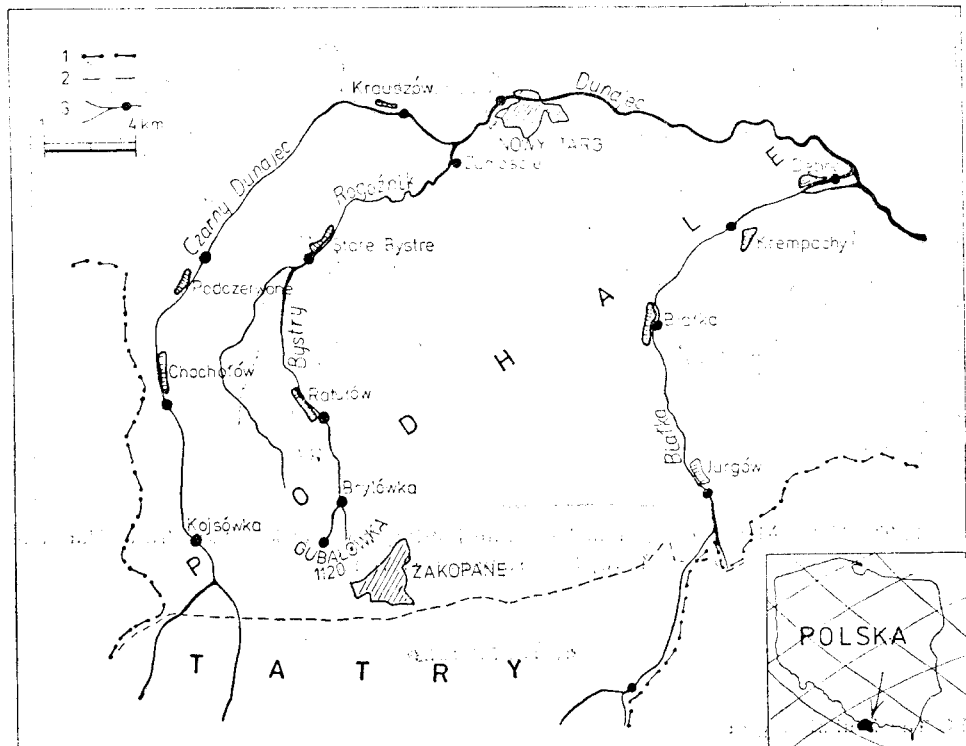


Fig. 1: The Podhale region investigation. 1 — state border; 2 — border of Tatra National Park; 3 — sampling stations

A standard bottom sampler (similar to the Surber sampler) with a 25-centimetre frame covered with 0.3 mm mesh net was used. Five samples were taken at each station throughout all seasons of the year (early spring, spring, summer, autumn, winter). The animals were fixed in 4% formalin.

### 3.2. The Tatra Mts: streams Waksmundzki and Pyszniański-Kościeliski

The investigation was carried out at 10 stations in the Waksmundzki and at 8 stations in the streams Pyszniański and Kościeliski, in the years 1979 and 1980 (fig. 2). The difference of altitude between individual stations reached 100 m. At each station one qualitative sample was taken with a net (frame diameter 13 cm, net mesh of 0.3 mm). Above 1300 m the samples were taken twice (summer and autumn) and below 1300 m during the year at 1-month intervals. The animals were fixed in 4% formalin.

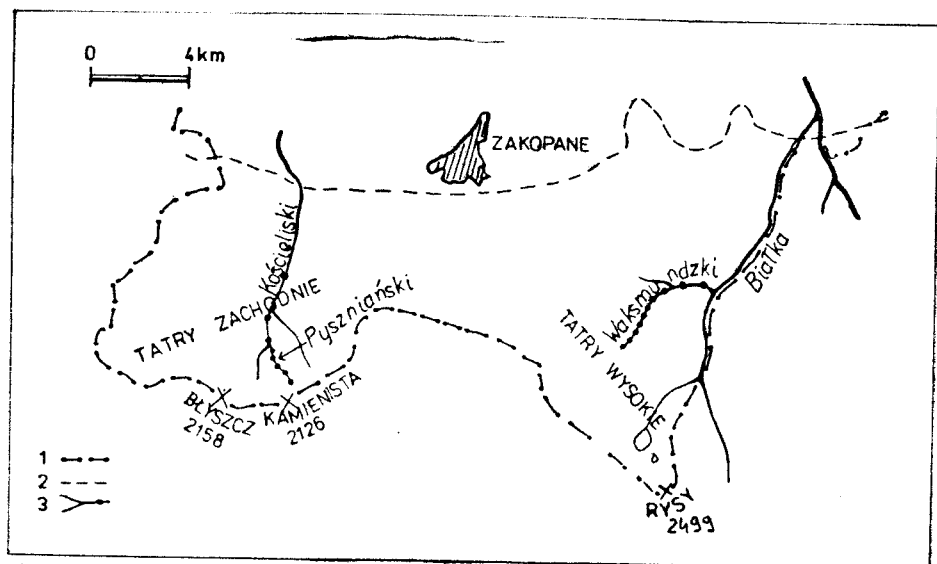


Fig. 2. The Tatra Mts investigation. 1 — state border; 2 — border of the Tatra National Park; 3 — sampling stations

## 4. Discussion

### 4.1. The Podhale region

Almost 12,400 mayfly larvae of 37 species were collected in the investigated area. Two high-mountain species were found: *Rhithrogena*

Table I. The Białka stream - distribution and percentage of different mayfly species  
The predominating species are underlined. a - altitude above sea level in m;  
b - distance from the spring in km

Species	Stations		Ujście Waksmundzkiego	Jurgów	Białka T.	Krempachy	Dębno
	a	b	1000	800	680	600	500
			6.5	15.0	23.0	31.5	38.0
<i>Baetis alpinus</i> (Pict.)			61.3	44.1	32.6	16.1	21.1
<i>Rhithrogena hybrida</i> Etn.			13.0	2.8			
<i>Baetis rhodani</i> (Pict.)			12.0	18.8	30.3	28.4	28.2
<i>Rhithrogena iridina</i> (Kolenati)			4.0				
<i>Baetis melanonyx</i> (Pict.)			3.9	9.7	0.2		0.2
<i>Baetis vernus</i> Curt.			2.9	0.8			
<i>Epeorus sylvicola</i> (Pict.)			1.0	3.2	8.8	11.3	24.0
<i>Ecdyonurus venosus</i> (F.)			0.9	7.0	2.3	1.7	0.5
<i>Ephemerella krieghoffi</i> (Ulm.)			0.3	0.3	0.5	4.0	1.7
<i>Ameletus inopinatus</i> Etn.			0.6	0.7			
<i>Rhithrogena ferruginea</i> Nav.			0.1	7.9	3.4	8.0	3.8
<i>Baetis sinicus</i> (Bog.)				0.3	11.5	6.5	7.9
<i>Rhithrogena hercynia</i> Landa				2.8	3.6	2.8	1.2
<i>Baetis muticus</i> (L.)				1.0	0.8	2.6	1.3
<i>Habroleptoides modesta</i> (Hag.)				0.6	0.5	0.8	0.1
<i>Baetis lutheri</i> H.-L.					3.1	5.9	3.4
<i>Caenis beskidensis</i> Sowa					1.6	1.8	0.8
<i>Siphonurus lacustris</i> (Etn.)					0.4	1.1	1.0
<i>Ecdyonurus lateralis</i> (Curt.)					0.2	0.8	0.8
<i>Centroptilum luteolum</i> (Müll.)					0.1	1.7	
<i>Baetis niger</i> (L.)					0.1		
<i>Baetis scarabus</i> Etn.						2.7	1.1
<i>Rhithrogena diaphana</i> Nav.						1.0	
<i>Ecdyonurus torrentis</i> Kimm.						1.7	0.4
<i>Ecdyonurus dispar</i> (Curt.)						0.3	0.1
<i>Ephemerella ignita</i> (Poda)						0.8	1.2
<i>Baetis fuscatus</i> (L.)							1.0
<i>Ephemerella major</i> (Klep.)							0.2
Number of individuals			795	968	826	814	1328

Table II. The Czarny Dunajec stream - distribution and percentage of different mayfly species. The predominating species are underlined. a - altitude above sea level in m; b - distance from the spring in km

Species	Stations		Wojsówka	Chochołów	Podczarniec	Krauzów	Nowy Targ
	a	b	850	700	700	650	600
			13.6	19.5	26.8	37.0	43.5
<i>Baetis alpinus</i> (Pict.)			63.5	33.0	14.0	7.3	2.8
<i>Baetis rhodani</i> (Pict.)			12.8	23.1	25.9	27.4	36.2
<i>Rhithrogena hybrida</i> Etn.			9.1	13.9	0.3		
<i>Rhithrogena ferruginea</i> Nav.			3.1	16.0	14.5	24.8	12.9
<i>Ecdyonurus venosus</i> (F.)			7.0	4.0	6.8	2.2	2.8
<i>Ameletus inopinatus</i> Etn.			0.4				
<i>Habroleptoides modesta</i> (Hag.)			0.3	0.4	0.3	0.6	0.6
<i>Baetis muticus</i> (L.)			1.6	1.5	6.3	0.6	3.8
<i>Ephemerella krieghoffi</i> (Ulm.)			1.6	1.4	6.3	1.6	3.6
<i>Rhithrogena hercynia</i> Landa			0.2	1.1	6.0	3.2	7.2
<i>Epeorus sylvicola</i> (Pict.)			0.2	0.4	2.0	7.1	2.7
<i>Baetis melanonyx</i> (Pict.)			0.2	1.1	0.3		
<i>Baetis sinicus</i> (Bog.)				2.5	2.3	7.0	2.1
<i>Caenis beskidensis</i> Sowa				1.6	3.7	0.5	
<i>Baetis scarabus</i> Etn.					6.5	3.4	3.4
<i>Baetis lutheri</i> H.-L.					4.0	7.3	6.8
<i>Ecdyonurus lateralis</i> (Curt.)					0.1	0.2	
<i>Ephemerella major</i> (Klep.)					0.7	3.8	
<i>Ephemerella ignita</i> (Poda)						1.3	11.1
<i>Centroptilum luteolum</i> (Müll.)						0.1	
<i>Habrophlebia fusca</i> (Curt.)						0.1	0.1
<i>Rhithrogena semicolorata</i> (Curt.)							1.7
<i>Ephemera danica</i> Müll.						0.5	0.2
<i>Baetis fuscatus</i> (L.)						0.2	0.3
<i>Siphonurus lacustris</i> (Etn.)						0.6	
<i>Ecdyonurus dispar</i> (Curt.)						0.2	
<i>Oligoneuriella rhenana</i> (Imh.)							1.8
<i>Rhithrogena germanica</i> Etn.							0.1
Number of individuals			896	793	648	1398	1013

Table III. Rogoźnik stream (with Bystry stream) - distribution and percentage of different mayfly species. The predominating species are underlined. a - altitude above sea level in m; b - distance from the spring in km

Species	Stations		Bystry 1100	Bryłówka 900 2	Ratużów 800 5.5	Stare Bystre 650 11.8	Zamoście 600 22.0
	a	b					
<i>Ecdyonurus subalpinus</i> Klap.			<u>63.0</u>				
<i>Rhithrogena loyolaea</i> Nav.			4.8				
<i>Baetis alpinus</i> (Pict.)			<u>25.8</u>				
<i>Rhithrogena iridina</i> (Kolenati)			3.2	<u>29.6</u>	<u>42.6</u>	<u>21.0</u>	6.0
<i>Ameletus inopinatus</i> Etn.			1.6	7.5	1.9		
<i>Baetis vernus</i> Curt.			1.6	2.5	0.5		
<i>Baetis rhođani</i> (Pict.)				15.6	<u>25.5</u>	<u>27.6</u>	<u>32.4</u>
<i>Ecdyonurus venosus</i> (P.)				11.1	2.2	4.2	8.9
<i>Baetis melanicus</i> (L.)				5.0	7.6	7.0	4.3
<i>Baetis melanonyx</i> (Pict.)				4.5	1.1		
<i>Rhithrogena ferruginea</i> Nav.				3.0	4.8	7.0	2.7
<i>Epeorus sylvicola</i> (Pict.)					1.6	2.5	3.9
<i>Baetis sinaiicus</i> (Boz.)					6.6	1.6	7.0
<i>Habroleptoides modesta</i> (Hag.)					0.5	1.8	1.8
<i>Rhithrogena hercynia</i> Landa					1.3	1.6	2.3
<i>Ephemérella krieghoffi</i> (Ulm.)					3.3	<u>12.0</u>	2.2
<i>Baetis scambus</i> Etn.					0.5	5.9	<u>10.3</u>
<i>Baetis lutheri</i> M.-L.						3.8	7.4
<i>Caenis beskidensis</i> Sowa						1.4	2.3
<i>Ephemérella ignita</i> (Foda)						0.3	3.9
<i>Oligoneuriella shenana</i> (Imh.)						0.5	0.8
<i>Ecdyonurus lateralis</i> (Curt.)						0.3	0.8
<i>Ecdyonurus dispar</i> (Curt.)						0.3	0.3
<i>Ecdyonurus torrentis</i> Kimm.						0.2	0.3
<i>Ephemérella major</i> (Klep.)						1.0	1.2
<i>Epheméra danica</i> Müll.							0.7
<i>Centroptilum luteolum</i> (Müll.)							0.3
<i>Rhithrogena diaphana</i> Nav.							0.3
<i>Ecdyonurus submontanus</i> Landa							0.3
Number of individuals			62	199	1489	914	256

*loyolaea* Nav. and *Ameletus inopinatus* Etn. The former appeared in the spring sector of the Bystry stream while the latter was also found even, at the altitude of 800 m (Tables I, II, and III). In the investigated streams mayfly larvae are typical of the 2nd and 3rd zone of communities in Carpathian rivers (Sowa 1975, 1980), this corresponding to epirhitron and metarhitron biocenoses (Illies, Botosaneanu 1963). Spring sectors are only represented by the upper course of the Bystry stream. The latter, however, differs from a similar zone in the Tatra streams which drain wet meadows lying on the border of agricultural areas. Differences in settlement are probably due to the character of these springs: in the upper course of the Bystry stream *Ecdyonurus subalpinus* Klap. — a species rare in the Tatra Mts — distinctly dominates; Sowa (1975) reports its occurrence in the Strążyski stream only, although it commonly occurs in spring zones of Beskid streams.

The longitudinal zonation of mayfly larvae and their dominations are similar in all three streams (Tables I, II, III) and basically correspond to the communities quoted by Sowa (1975, 1980) from this area and from other Carpathian streams. The only differences were observed with regard to some species which appeared in small numbers and whose single specimens were noted in the samples. The following species have not been reported from stations in Czarny Dunajec and Rogoźnik: *Caenis be-*

*skidensis* S o w a, *Oligoneuriella rhenana* (I m h.), *Siphonurus lacustris* (E t n.), and *Ephemerella major* (K l a p.). On the other hand, the occurrence of *Rhithrogena semicolorata* (C u r t.) in the Białka (K o w n a c k a, K o w n a c k i 1965, S o w a 1975) and of *Habroleptoides modesta* (H a g.) at stations below 900 m (S o w a 1975) was not supported.

The qualitative composition shows that the natural character of mayfly larvae communities at different altitudes has been preserved, this suggesting that in spite of the fairly dense population, the type of agricultural management of agricultural areas in the Podhale region does not threaten the macrofauna of streams yet.

#### 4.2. The Tatra Mts — the Waksmundzki and Pyszniański-Kościeliski streams

In the Waksmundzki stream the mayfly larvae reach the altitude of 1400 m (Table IV) only, a few juvenile specimens of *Baetis alpinus* being noted there. No older larvae have been encountered. They were

Table IV. Distribution and percentage of different mayfly species. The arrangement of stations begins at the spring of the stream. \* - specimens caught in the spring. The predominating species are underlined. a' - altitude above sea level in m; b - distance from the spring in km

Stream	Stations		1	2	3	4	
	a	b	1400	1300	1200	1070	
			2	2.4	3.6	4.5	
Waksmundzki	<i>Baetis alpinus</i> (Pict.)		100.0	71.7	77.7	90.9	
	<i>Ameletus inopinatus</i> Etn.			18.1	13.5	9.6	
	<i>Rhithrogena loyolae</i> Nav.			10.2	8.8	1.7	
	<i>Rhithrogena hybrida</i> Etn.					0.8	
	Number of individuals		7	43	216	94	
Pyszniański-Kościeliski			1-2	3-4	5-6	7	8
			1700-1600	1500-1400	1300-1200	1100	1000
			0.1-0.6	0.8-1.4	1.6-2.5	3.8	5.2
	<i>Baetis alpinus</i> (Pict.)		22.2	86.6	66.0	62.0	62.8
	<i>Rhithrogena loyolae</i> Nav.		77.8	13.4	29.3	29.6	16.2
	<i>Ameletus inopinatus</i> Etn.				4.7	1.0	2.0
	<i>Ecdyonurus venosus</i> (P.)					0.3	1.3
	<i>Rhithrogena hybrida</i> Etn.					1.5	7.9
	<i>Baetis muticus</i> (L.)					1.5	1.9
	<i>Rhithrogena iridina</i> (Kolenati)					1.9	2.4
	<i>Baetis vernus</i> Curt.						3.1
<i>Rhithrogena ferruginea</i> Nav.						0.4	
Number of individuals		171	112	85	580	927	

not found above 1400 m, in spite of the fact that in the Pyszniański stream larvae of two species, *Rhithrogena loyolae* and *Baetis alpinus* were caught even at the altitude of 1700 m (Table IV). In other Tatra streams, to the altitude of 1600 m, larvae of these species constantly occurred and were observed during the entire year (S o w a 1975). Thus, it is possible that juvenile forms encountered at 1400 m in autumn, hatch from eggs laid by females in upstream compensatory migration, while their absence

above 1400 m is caused by the great seasonal variation of water yields in the upper part of the valley.

All developmental stages of larvae of four mayfly species were caught in the sector between 1300—1070 m but below 1200 m they were found only in the period with water movement in the stream, i.e. from April to the beginning of November. In samples collected in winter from the rock waste covering the stream bed no mayfly larvae were encountered.

Of the species found in this sector only *Baetis alpinus* can undergo all developmental stages in the period when water flows in the stream. The three other species need a year (*Rhithrogena hybrida* and *Ameletus inopinatus*) or even two years (*Rhithrogena loyolaea*) to achieve the full life cycle. The disappearance of water in winter prevents the development of larvae, therefore it seems that species encountered in summer come from higher stations. They go through all developmental stages there and are washed down with spring risings of streams. Juvenile forms found in autumn probably hatch from eggs laid by females which begin their flight there or come from the Białka stream.

## 5. Polish summary

### Rozsiedlenie jętek (*Ephemeroptera*) w niektórych potokach Tatr i Podhala

W latach 1979 i 1980 przeprowadzono badania terenowe nad rozsiedleniem larw jętek w trzech głównych ciekach Podhala: Białce, Czarnym Dunajcu i Rogoźniku (z Bystrym) oraz w dwóch różnych typach potoków tatrzańskich: Waksmundzkim i Kościeliskim (z Pyszniańskim) (ryc. 1, 2).

Badania miały na celu poznanie ugrupowań larw jętek oraz określenia ewentualnych przekształceń tych ugrupowań pod wpływem działalności człowieka.

Stwierdzono, że zbiorowiska larw jętek w badanych ciekach Podhala są charakterystyczne dla 1—3 strefy zasiedlenia (S o w a 1975, 1980). Ze składu gatunkowego i struktury dominacji wynika, że są to ugrupowania jeszcze nie zmienione na skutek działalności człowieka (tabele I, II, III).

Potok Waksmundzki odznacza się wybitnie niekorzystnymi warunkami środowiskowymi dla jętek. Jętki dochodzą w tym potoku tylko do wysokości 1400 m n.p.m., podczas gdy w potoku Pyszniańskim — do 1700 m n.p.m. (tabela IV). Największą liczebność larw jętek stwierdzono w potoku Waksmundzkim w przedziale wysokości 1200—1300 m n.p.m., na tym też odcinku zaobserwowano wszystkie stadia rozwojowe larw jętek przez cały rok. Powyżej stanowiska 3 liczebność jętek spada, co jest związane z okresowym zanikaniem potoku.

## 6. References

- Ciszek H., E. Sosińska, 1965. Mayflies (*Ephemeroptera*) and beetles (*Coleoptera*) of the Dunajec River. In: E. Dratnal, B. Szczęsny (ed.), Benthic fauna of the Dunajec River. Kom. Zagosp. Ziem Górskich PAN, 11, 182—186.



- Illies J., L. Botosaneanu, 1963. Problèmes et méthodes de la classification et de la zonation écologique des eaux courantes considérées surtout du point de vue faunistique. *Int. Ver. theor. angew. Limnol. Mitt.*, 12, 1—57.
- Kamler E., 1960. Notes on the *Ephemeroptera* Fauna of Tatra streams. *Pol. Arch. Hydrobiol.*, 8, 107—127.
- Kawecka B., M. Kownacka, A. Kownacki, 1971. Ogólna charakterystyka biocenozy w potokach Polskich Tatr Wysokich — General characteristics of the biocoenosis in the streams of the Polish High Tatras. *Acta Hydrobiol.*, 13, 465—476.
- Kownacka M., A. Kownacki, 1965. The bottom fauna of the river Białka and its Tatra tributaries the Rybi Potok and Potok Roztoka. *Limnol. Invest. in the Tatra Mts and Dunajec River Basin. Kom. Zagosp. Ziem Górskich PAN*, 11, 129—151.
- Krzanowski W., E. Fiedor, T. Kuflikowski, 1965. Fauna denna kamienisto-prądowych siedlisk dolnych odcinków Białego Dunajca, Rogoźnika i Lepietnicy. *Zesz. Nauk. UJ, Prace Zool.*, 9, 43—60.
- Oleksynowa K., T. Komornicki, 1965. The chemical composition of water in the Polish Tatra Mountains and the problem its variation in time. *Kom. Zagosp. Ziem Górskich PAN*, 11, 91—111.
- Sowa R., 1975a. Ekologia i biogeografia jętek (*Ephemeroptera*) wód płynących w polskiej części Karpat. 1. Rozprzestrzenienie i analiza ilościowa — Ecology and biogeography of mayflies *Ephemeroptera* of running waters in the Polish part of the Carpathians. 1. Distribution and quantitative analysis. *Acta Hydrobiol.*, 17, 223—297.
- Sowa R., 1975b. Ekologia i biogeografia jętek (*Ephemeroptera*) wód płynących w polskiej części Karpat. 2. Cykle życiowe — Ecology and biogeography of mayflies *Ephemeroptera* of running waters in the Polish part of the Carpathians. 2. Life cycles. *Acta Hydrobiol.*, 17, 319—353.
- Sowa R., 1980. La zoogéographie, l'écologie et la protection des Epheméroptères en Pologne, et leur utilisation en tant qu'indicateurs de la pureté des eaux courantes. *Advances in Ephemeroptera Biology*. Ed. J. F. Flannagan and K. E. Marshall, Freshwater Institute, Winnipeg, Manitoba, Canada. Plenum Press. New York and London, 141—154.
- Wit-Jóźwik K., 1974. Hydrografia Tatr Wysokich. *Dok. Geogr. Zesz.* 5.