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Strefowe rozmieszczenie zbiorowisk glonów w potokach Polskich Tatr Wysokich

Zonal distribution of alga communities in streams of the Polish High Tatra Mts

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Abstract — On the basis of species occurring most numerously on limited sections of waters in streams of the High Tatra Mts, 3 zones can be distinguished. In zone I (alt. about 1550—1780 m) the predominant forms are blue-green algae with prevailing *Chamaesiphon polonicus*. Zone II (alt. about 890—1550 m) is characterized by a strong development of *Hydrurus foetidus* and *Homoeothrix janthina*, and of diatoms with the predominant species *Diatoma hiemale* with the variety *mesodon*. Zone III (alt. 540—890 m) is distinguished by a mass development of diatoms with the characteristic species *Diatoma vulgare* var. *Ehrenbergii*, *Cymbella affinis*, and *Synedra ulna*.

The present work gives a description of the character of communities of algae developing in streams of the High Tatra Mts.

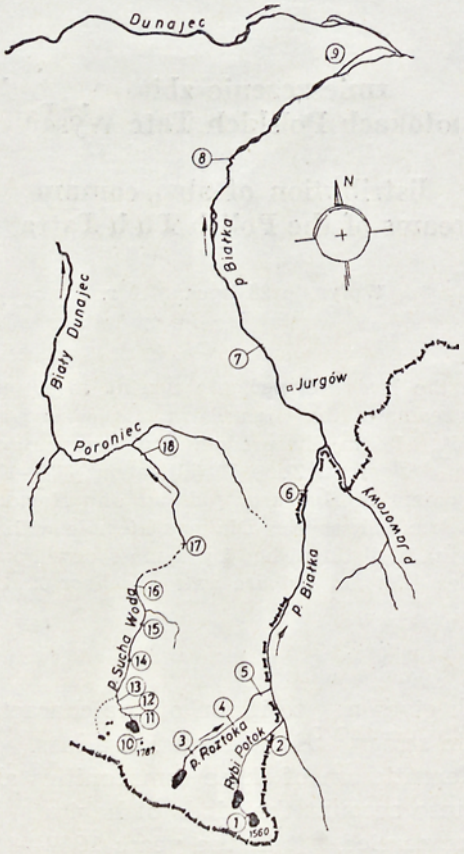
It shows the differentiation of these communities along the course of the streams, taking into account the kinds of habitat.

Observations were carried out in the years 1962—1966. In the course of two seasons in 1962 and 1963 they included the Polish part of the basin of Białka Tatrzańska, thus, the stream draining the Czarny Staw above the Morskie Oko, the Rybi Potok, the Potok Roztoka, and the Białka Tatrzańska. The materials have already been published (Kawecka 1965). In the years 1965/1966 the communities of algae were investigated in the stream system including the stream draining the Zmarły Staw, the Czarny Potok, and the Sucha Woda.

The geological characteristics of the investigated terrain are given by Pasternak (1971), and the chemical ones by Oleksynowa and Komornicki (1965, 1969) and Bombówna (1971).

Methods of investigations

The material for the investigations was collected from 18 sampling-points (fig. 1). Observations were carried out at monthly or two monthly intervals. The stream Sucha Woda with its tributaries was investigated throughout the year, including winter, and the others from spring to autumn. In the course of sampling the temperature of the water was measured and its pH determined on the spot. From each point at least



Ryc. 1. Lokalizacja stanowisk
Fig. 1. Localization of sampling stations

10 samples were collected, account being taken of the diversity of the habitats. The material obtained was preserved in 4 per cent formalin solution. The material was collected and the loricae of diatoms prepared according to the known methods (K a w e c k a 1965).

On a section of the stream of about 25 sq. m, regarded as typical of the locality, the size of the area occupied by macroscopic conglomerations of algae was estimated according to the 5-degree scale: 1 — species occurring

Tabela I. Lista gatunków glonów w potokach Tatr Wysokich
Table I. List of species of algae in the High Tatra Streams

(cyfry przedstawiają średnie ilości z całego okresu badań)
(Numbers denote the mean amounts from the whole period of investigations)

Stanowiska (Station)	Potok Stream								
	Potok ze Zmarzłego Stawu Stream from the Zmarzły Staw	Czarny Potok			Sucha Woda				
	10	11	12	13	14	15	16	17	18
Wysokość w m (Altitude m.)	1780 1620	1600	1530	1460	1280	1180	1100	890	800
Cyanophyta									
Gloeocapsa magna (Brébisson) Hollerbach	+	+							
* Scopulonema polonicum (Raciborskii) Geitler	3	2							
Chamaesiphon incrustans Grunow	1	2	2	1	1		+	1	
- - var. elongatus (Starmach) Hollerbach			+	+	+			+	
* - polonicus (Rostafiński) Hansgirg	4	4	2	3	2		3	2	1
- fuscus (Rostafiński) Hansgirg		+	1	+	1		1	2	
- carpaticus Starmach								1	
Phormidium uncinatum (Agardh) Gomont	+	1	1	2	2		2	2	2
- favosum (Bory) Gomont			+	+	+			2	2
* - inundatum Kützing	1	2							
Lyngbya Kützingii (Kützing) Schmidle		+		+					
* Schizothrix lacustris A. Braun		2							
- Braunii (A. Braun) Gomont	+								
Nostoc sp.				1	+				
Calothrix fusca (Kützing) Bornet et Flahault		+					2		
* Homoeothrix janthina (Bornet et Flahault) Starmach		1	4	4	4	4	4	4	1
- fusca Starmach	+								
* Ammatoidea Normannii W. et G.S. West	3	2							
Tolypothrix distorta (Fl.Dan.) Kützing f. penicillata (Agardh) Kossinskaja		+		1	2		+		
Hydrococcus rivularis (Kützing) Meneghini					+				
Chrysophyceae									
* Hydrurus foetidus (Villars) Trevisan			4	3	3	4	4	3	2
Bacillariophyceae									
Melosira distans (Ehr.) Kütz. var. alpigena Grun.	+								
- Roseana Rabh.		+							
- italica (Ehr.) Kütz. var.valida Grun. Hust.		+							
Cyclotella Meneghiniana Kütz.			+	+					
- comta (Ehr.) Kütz.			+						
Tabellaria flocculosa (Roth) Kütz.	+	+	+	+	+	+	+	+	+
Meridion circulare Ag.	+	+	+	+	+	+	+	+	+
- - var. constricta (Ralfs) V.H.	+		+		+	+	+		
Diatoma vulgare Bory	+	+	+		+		+	+	+
- - var. productum Grun.								+	+
- - var. capitulatum Grun.	+	+	+				+	+	} 3
- - var. Ehrenbergii (Kütz.) Grun.	+	+	+	+	+	+	+	+	
- hiemale (Lyngb.) Heib.	+	+	3	2	3	2	2	4	1
- - (Lyngb.) Heib. var. mesodon (Ehr.) Grun.	1	+	2	3	2	2	2	3	1
- anceps (Ehr.) Kirch.	+		+	+		+		+	+
Fragilaria crotonensis Kitt.	+								
- capucina Desm. var. lanceolata Grun.		+	1	1	+	+	+	+	+
- intermedia Grun.	+	+	+			+		+	+
- leptostauron (Ehr.) Hust.								1	+
- pinnata Ehr.	+	+	+	+	+	+	+	+	+
- - var. lancettula (Schum.) Hust.		+	+	+	+	+	+	+	+
Ceratoneis arcus (Ehr.) Kütz.	+	+	3	2	2	3	2	2	3
- - var. amphioxys (Rabh.) Grun.	+	+	+	+	+	+	+	+	+
Synedra Vaucheriae Kütz.			+	+				+	
- ulna (Nitzsch) Ehr.			+			+	+	+	+
- amphicephala Kütz.	+		+	+	+	+		+	3
- rumpens Kütz.	+	2	1	+	+	+	+	+	+
Synedra sp.		1	+	+	+				
Eunotia diodon Ehr.	+	+	+	+					
- diodon forma ?		+	+	+					
- bigibba Kütz	+								
- - var. pumila Grun.	+								
- praerupta Ehr.	+	+	+	1	+	+	+	+	+
- - var. bidens (W.Sm.) Grun.	+								
- - var. muscicola Petersen	+								
- arcus Ehr.	+			+					
- - var. fallax Hust.								+	
- exigua (Bréb.) Rabh.	1	+	+	+	+	+	+		
- - var. bidens Hust.	+								
- pectinalis (Dillw.? Kütz.) var. minor (Kütz.) Rabh.	+	+	+	+	+				

Stanowiska (Station)	Potok Stream								
	Potok ze Zmarzłego Stawu Stream from the Zmarzły Staw	Czarny Potok			Sucha Woda				
	10	11	12	13	14	15	16	17	18
Wysokość w m (Altitude m.)	1780 1620	1600	1530	1460	1280	1180	1100	890	800
Eunotia fallax Cl.	+								
- - var. gracillima Krasske	+								
- lunaris (Ehr.) Grun.	+								
- - var. subarcuata (Näg.) Grun.	+								
- sudetica O. Mull.		+							
Cocconeis disculus (Schum.) Cl.							+		
- diminuta Pant.							+		+
- placentula Ehr.			+	+	+	+	+	+	+
- - var. intermedia (Hérib. et Perag.) Cl.	+				+	+	+	+	+
- - var. klinoraphis Geit.			+				+		+
- - var. lineata (Ehr.) Cl.							+		
- - var. euglypta (Ehr.) Cl.	+		2	2	1	1	1	1	2
- pediculus Ehr.							+	+	+
Achnanthes microcephala (Kütz.) Grun.	+	2	2	1	1	+	1	+	+
- minutissima Kütz.	+	1	2	3	2	2	3	+	+
- austriaca Hust. var. helvetica Hust.	+								
- Clevei Grun.			+				+		
- laterostrata Hust.		+	+	+			+	+	
- lapidosa Krasske	+	2	2	2	2	+	+	+	+
- marginulata Grun.								+	
- amphicephala Hust.			+					+	+
- pyrenaica Hust.	+	+	+	+	2	2	2	3	2
- lanceolata (Bréb.) Grun.	+	1	1	+	1	+	1	+	+
- - var. ventricosa Hust.	+	+		+	+		+	+	+
- - f. capitata O. Müll.	+		+		+		+	+	+
- - var. rostrata (Østr.) Hust.							+	+	+
- - var. elliptica Cl.					+		+		+
- Peragallii Brun et Hérib.					+	+		+	+
- lapponica Hust.						+	+	+	+
- flexella (Kütz.) Brun		+	+	+	+		+		+
Rhoicosphenia curvata (Kütz.) Grun.					+		+	+	
Diploneis ovalis (Hilse) Cl.									+
Frustulia rhomboides (Ehr.) De Toni var. saxonica (Rabh.) De Toni		+			+				
- vulgaris (Thw.) De Toni							+		
Anomoeoneis serians (Bréb.) Cl. var. brachysira (Bréb.) Hust.	+			+	+				
- - var. brachysira (Bréb.) Hust. f. thermalis (Grun.) Hust.					+				
- exilis (Kütz.) Cl.		+		+			+		
Stauroneis phoenicentron Ehr.							+		
- anceps Ehr.	+	+		+					
- Smithii Grun.									+
Navicula gregaria Donk.				1	+			+	+
- minima Grun. var. atomoides (Grun.) Cl.	+	+		+	+	+	+	+	+
- Rotaeana (Rabh.) Grun.	3		+	+	+	+	+	+	+
- Hustedtii Krasske ?	+			+	+				
- mutica Kütz.	+								+
- - var. nivalis (Ehr.) Hust.		+							
- contenta Grun. f. biceps Arn.	+								
- perpusilla Grun.	+	+	+	+	+	+	+	+	+
- bacillum Ehr.							+		
- pupula Kütz.									+
- pseudoscutiformis Hust.	+					+			
- cryptocephala Kütz.		+	+	+	+	+	+	+	+
- - var. veneta (Kütz.) Grun.			+					+	+
- - var. intermedia Grun.	+		+		+	+	+	+	+
- rhynchocephala Kütz.									+
- viridula Kütz. var. avenacea (Bréb.) Grun.		+							
- hungarica Grun. var. capitata (Ehr.) Cl.		+		+					
- cincta (Ehr.) Kütz.									+
- radiosa Kütz.	+	+	+	+			+	+	+
- gracilis Ehr.	+						+	+	+
- menisculus Schum.					+	+	+	+	+
- Reinhardtii Grun.					+			+	+
- laterostrata Hust.								+	+
- exigua (Greg.) O. Müll.							+	+	
- levanderi Hust. var. tatrensis Bilý et Marvan	+	+	+	+	+				
Pinnularia appendiculata (Ag.) Cl.	+		+	+					
- subcapitata Greg.	+	+		+	+	+			+
- - var. Hilseana (Janisch) O. Müll.	+	+		+	+		+		+
- mesolepta (Ehr.) W. Sm.				+	+				

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	Potok ze Zmarzłego Stawu Stream from the Zmarzły Staw	Czarny Potok			Sucha Woda				
	10	11	12	13	14	15	16	17	18
Wysokość w m (Altitude m.)	1780 1620	1600	1530	1460	1280	1180	1100	890	800
Pinnularia microstauron (Ehr.) Cl.	+	+	+	+	+		+		+
- - var. brebissonii (Kütz.) Hust.				+	+				
- borealis Ehr.	+		+	+	+		+		
- Balfouriana Grun.	+								
- gibba Ehr.	+	+					+		
- viridis (Nitzsch) Ehr.			+					+	+
- - var. sudetica (Hilse) Hust.	+								+
Neidium bisulcatum (Lagerst.) Cl.	+	+		+					
- affine (Ehr.) Cl.	+	+		+				+	
- - var. amphirynchus (Ehr.) C									+
- - var. longiceps (Greg.) Cl.	+			+					
- dubium (Ehr.) Cl.	+								
Caloneis silicula (Ehr.) Cl.	+								
Cyrosigma acuminatum (Kütz.) Rabh.								+	+
Amphora ovalis Kütz.					+		+		+
- - var. pediculus Kütz.	+	+	+	+	+	+	+	+	+
- Normanii Rabh.					+				
Cymbella naviculiformis Auersw.			+						
- turgida (Greg.) Cl.	+	+	2	1	+	+		+	+
- ventricosa Kütz.	2	1	3	3	2	2	2	2	3
- hebridica (Greg.) Grun.	+								
- aequalis W. Sm.									+
- sinuata Greg.	+	+	+	+	+	+	+	+	+
- - f. ovata Hust.							+		
- affinis Kütz.	+							+	2
- cistula (Hemp.) Grun.								+	+
- lanceolata (Ehr.) V. H.									+
- helvetica Kütz.				+				+	+
- imitans Gutwiński var. striatior Kalbe	+								
Gomphonema parvulum (Kütz.) Grun.			+				+	+	+
- - var. subellipticum Cl.									+
- - var. micropus (Kütz.) Cl.	+	+		+	+	+	+	+	+
- angustatum (Kütz.) Rabh.	+	+	+	+	+	+		+	1
- - var. productum Grun.		+			+		+	+	+
- longiceps Ehr. var. montanum (Schum.) Cl.	+	+	+	1	+	+	+	+	+
- intricatum Kütz.								+	+
- - var. pumilum Grun.	+	+	1	+	2	1	2	2	3
- capitatum Ehr.	+								
- olivaceum (Lyngb.) Kütz.	+		+		+	+	+	+	1
- - var. calcareum Cl.	+	+	+					+	+
Denticula tenuis Kütz.		+							
- - var. crassula (Näg.) Hust.	+	+	+	+	+	+	+	+	+
Hantzschia amphioxys (Ehr.) Grun.				+			+	+	
Nitzschia hungarica Grun.				+					
- linearis W. Sm.	+		+					+	+
- recta Hantzsch								+	+
- sublinearis Hust.		+	+	+	+	+	+	+	+
- dissipata (Kütz.) Grun.		+	+	+	+	+	+	+	+
- Hantzschiana Rabh.	+		+		+		+	+	+
- fonticola Grun.				+	+		+		
- palea (Kütz.) W. Sm.	+	+		+	+			+	+
- Kützingiana Hilse						+	+		
- acicularis W. Sm.	+								
Cymatopleura ellip a (Bréb.) W. Sm.									+
Surirella linearis W. Sm.	+								+
- - var. helvetica (Brun) Meist.							+		
- angustata Kütz.							+	+	+
- ovata Kütz.	+		+	+					+
Xanthophyceae									
* Vaucheria sp.					2				
Chlorophyta									
Ulothrix zonata Kütz.			+	+	+			+	1*
* Chlorhormidium flaccidum A. Br.		1		2	1		1		
* - rivulare Kütz.	2	2	1	2	1		1		
Prasiola fluviatilis Aresch.					1		1		
Trentepohlia aurea (L.) Mertius							1		
* Spirogyra sp.			3						
Penium sp.									+
Closterium acerosum (Schrank) Ehr			+						+
- Leibleinii Kütz.	+								
Cosmarium Holmiense Lund.									+
- subcrenatum Hantzsch.			+	+					+
- subcucumis Schmidle							+		+
- hornavanense Gutw.		+							

Stanowiska (Station)	Potok Stream								
	Potok ze Zmarzłego Stawu Stream from the Zmarzły Staw	Czarny Potok			Sucha Woda				
	10	11	12	13	14	15	16	17	18
Wysokość w m (Altitude m.)	1760 1620	1600	1530	1460	1280	1180	1100	890	800
Staurastrum orbiculare Ralfs var. hibernicum W. West et G.S. West			1						
- punctulatum Bréb.			+	+			+		
- polytrichum (Perty) Rab.			+						
Chantransja pygmea Kütz.				+	+				
* Lemanea fluviatilis C. Ag.					1		1		

Uwaga: * oznacza gatunki glonów tworzące makroskopowe skupienia
Notice: * denotes algae species forming macroscopic concentrations - "flock"

sparingly or very sparingly, 2 — covering less than 25 per cent of the area, 3 — covering 25—50 per cent of the area, 4 — covering 50—75 per cent of the area, 5 — covering 75—100 per cent of the area.

The quantitative analysis of the material was carried out by means of the methods applied by the Department of Hydrobiology of the Jagiellonian University in investigations of river algae (S t a r m a c h 1962).

The number of microscopic species of diatoms was reckoned using the estimation method on the basis of several preparations, according to the 6-degree scale (K a w e c k a 1964, 1965). The area occupied by the particular species of diatoms was determined from the magnitude of the

Tabela II. Spektrum florystyczne (skład gatunkowy)
Table II. Floristic spectrum (Number of species)

Stanowiska Station	Potok - Stream								
	Potok ze Zmarzłego Stawu Stream from the Zmarzły Staw	Czarny Potok			Sucha Woda				
	10	11	12	13	14	15	16	17	18
Cyanophyta	9	13	7	10	10	1	7	8	4
Chrysophyceae	1	1	1	1	1	1	1	1	1
Bacillariophyceae	88	63	68	72	69	49	76	81	94
Xantophyceae	-	-	-	-	1	-	-	-	-
Chlorophyta	2	3	9	5	4	-	6	1	6
Rhodophyta	-	-	-	1	2	-	1	-	-
Suma Total	100	80	87	89	87	51	91	91	105

coefficient of coverage and the degree of relation of the species to the environment, on the basis of V classes of stability.

The results of these calculation were based on about 950 samples. 312 species and varieties belonging to 32 genera were determined, the share of *Bacillariophyceae* amounting here to 75.8 per cent, that of *Chlorophyta* to 14 per cent, of *Cyanophyta* to 9 per cent, of *Rhodophyta* to 0.6 per cent, of *Chrysophyceae* to 0.3 per cent, and of *Xantophyceae* to 0.3 per cent. The list of species is assembled in Table I, their quantitative composition being represented by the floristic spectrum (Table II).

Lithorheophilous communities of algae

On account of the strong current of the Tatra streams, the chief habitat of algae is the stony substratum, the lithorheophilous community being the dominant type here.

The algae overgrow stones and boulders, forming crusts (*Chamaesiphon, Scopulonema*), skinlike coatings (*Phormidium*), sod (*Schizothrix, Chaetophora, Draparnaldia, Calothrix),* bushy and setaceous thalli (*Cladophora, Lemanea, Vaucheria, Ulothrix, Prasiola, Microspora*), and gelatinous colonies (*Hydrurus,* diatoms).

Sucha Woda with its tributaries: the stream taking its rise in the Zmarzły Staw and the Czarny Potok

In the outflows of streams from lakes (altitude about 1550—1780 m, stations 10 and 11) chiefly blue-green algae developed, forming dark spots, and crusts on stones. They were represented by *Chamaesiphon polonicus, Schizothrix lacustris, Ammatoidea Normanii* and *Scopulonema polonicum. Chamaesiphon polonicus* prevailed over the other blue-green algae. The green algae growing here were *Chlorhormidium flaccidium* and *Ch. rivulare.*

Lower (altitute 890—1550 m, stations 12—17) a different type of algae community developed. *Hydrurus foetidus* and *Homoeothrix janthina* together with diatoms prevailed everywhere. The bottom of the stream during the period of strong development of these algae took on a brownish-orange colour.

The development of these algae was greatest in places of gushing springs in the bed of the stream (stations 12 and 15), investigated in winter. Moreover, the blue-green algae *Phormidium unicinatum, Ph. favosum,* and *Chamaesiphon polonicus* were fairly often encountered in this section, especially at station 16. *Tolypothrix distorta* f. *penicillata, Calothrix fusca,* and others occurred less frequently. The green algae represented here

were *Chlorhormidium flaccidium* and *Ch. rivulare, Prasiola fluviatilis, Ulothrix zonata, Trentepohlia aurea,* and others.

The communities of algae in the stream flowing in the Podhale region (altitude about 800 m, station 18) were of different character. The species *Hydrurus foetidus* and *Homoeothrix janthina* disappeared. Diatoms played the most important part in the community, enveloping stones with a yellowish-brown mucilage or forming filamentous conglomerations. They also occurred together with *Ulothrix zonata, Phormidium uncinatum,* and *Ph. favosum,* which were fairly common here. *Chamaesiphon polonicus* occurred in very small numbers.

Pelorheophilous communities of algae

In shallow places along the whole length of the streams, mostly near the bank, a delicate silt settled, being very readily washed out, especially in the Tatra part of the streams. In the Podhale region it was less subject to outwashing and occurred abundantly, especially in the lower sections of the Białka Tatrzańska, and was, apart from stones, the chief habitat of algae.

Rich and interesting communities of algae developed in this silt. Diatoms prevailed here, desmids, threads of green algae, as, e. g., *Spirogyra* sp., *Zygnema* sp., or *Mougeotia* sp., being also encountered, as well as fragments of other filamentous algae torn off from stones. In the silty shallows in the Białka Tatrzańska *Merismopedia glauca* continued to occur.

Phytorheophilous communities of algae

Depending on the overgrowth of moss these communities developed in the upper courses of streams. Braids of threads of algae, such as *Phormidium, Ulothrix zonata,* and *Homoeothrix janthina,* or thalli of *Hydrurus foetidus* formed a related habitat. In both cases diatoms were almost exlusively encountered.

Diatom communities

The richest in species and very numerous group of diatoms formed characteristic communities in some water areas. These communities showed a considerable stability, the annual variations concerning the number of species, while the typical configuration in the pattern of dominant species remained unchanged. Particular attention was paid to this group.

The diatoms occurred along the whole length of the streams, in every

habitat. The question arose whether they form different groups according to the kind of habitat, such as stones, moss, slime, and the kind of alga accompany.

Observations showed that at a given height one community developed with the species characteristic of it, irrespective of the kind of habitat. The influence of the latter proved to be of little significance.

It was found that in a lithorheophilous community diatoms forming filamentous, colonial conglomerations showed a tendency to form monospecies groups, in which species of the genus *Diatoma*, e.g. *Diatoma hiemale* with the variety *mesodon*, or else varieties of *D. vulgare*, always prevailled. In mucilaginous conglomerations species of the genus *Cymbella* and *Achnanthes* occurred in a large number of specimens.

In the pelorheophilous community a marked increase in the diversity of species was observed, as well as an increase in the number of specimens of the genus *Navicula*, *Nitzschia*, and *Gomphonema*.

In the phytorheophilous community of mosses many individuals of the genus *Fragilaria*, *Eunotia*, *Navicula*, and *Pinnularia* were encountered. In conglomerations of threads of *Homoeothrix janthina* specimens of *Gomphonema intricatum* var. *pumilum* were more frequently found. The community of diatoms in gelatinous *Hydrurus foetidus* thalli was always qualitatively less differentiated. The dominant forms here were chiefly *Ceratoneis arcus*, *Diatoma hiemale* with its variety, *Cymbella ventricosa*, species of the genus *Achnanthes*, and others, according to the local conditions.

In the course of investigating communities of diatoms along the streams those typical of the particular stations or of their groups were represented, the possible habitat differences being pointed out.

Diatom communities in the stream Sucha Woda with its tributaries: the stream taking its rise in the Zmarzły Staw and the Czarny Potok

In the outflows of streams from lakes (altitude about 1550—1780 m, stations 10 and 11) moss was the chief habitat of diatoms.

The phytorheophilous communities of diatoms were highly differentiated qualitatively. The species occurring most numerously are forms widely distributed and encountered along the whole length of the streams.

The species characteristic of the stream rising in the Zmarzły Staw are north-Alpine and mountain species which, in spite of their small coefficient of coverage, are very stable here. They are represented by *Tabellaria flocculosa*, *Neidium affine* var. *longiceps*, *Melosira distans* var. *alpigena* from the group of dominants, and by *Anomoeoneis serians* var. *brachysira*, *Cymbella hebridica*, *Eunotia bigibba*, *E. bigibba* var. *pumila*, and *Pinnularia borealis* from the group of subdominants.

Below, at station 12, altitude about 1530 m, diatoms formed groups of a different type.

During the winter season the diatoms lived outside the moss, chiefly in *Hydrurus foetidus* thalli and between threads of *Homoeothrix janthina*. *Ceratoneis arcus, Diatoma hiemale* with the variety *mesodon, Cymbella ventricosa, Achnanthes minutissima,* and *Achnanthes microcephala* developed in large numbers here. Other highly stable forms, though occurring in small numbers, were *Cocconeis placentula* var. *euglypta, Gomphonema longiceps* var. *montanum, Cymbella turgida, Achnanthes lapidosa, Gomphonema intricatum* var. *pumilum, Eunotia praerupta,* and *Achnanthes lanceolata.*

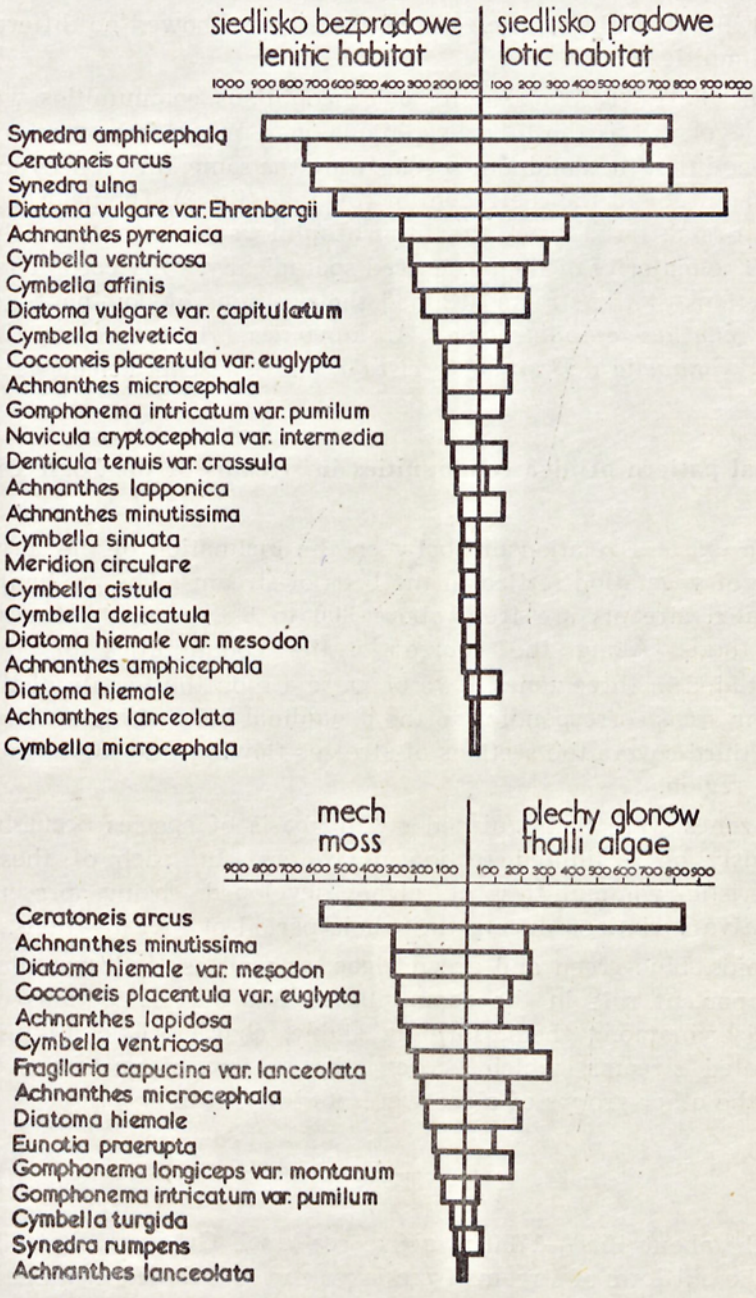
In the forest zone (altitude about 890—1460 m, stations 13—17) the most numerously developing were *Ceratoneis arcus, Diatoma hiemale* with the variety *mesodon,* and species of the genus *Achnanthes, Cymbella ventricosa,* and *Cocconeis placentula* var. *euglypta.*

At station 13 *Fragilaria capucina* var. *lanceolata* developed fairly well locally. *Gomphonema longiceps* var. *montanum, Eunotia praerupta,* Achnanthes *lapidosa, Synedra rumpens, Achnanthes lanceolata, Cymbella turgida,* and *Gomphonema intricatum* var. *pumilum* occurred in small numbers but throughout the whole period of investigations.

Beginning from station 14 quantitative changes took place in the diatom communities, this being a visible reaction of the organisms to changes of the substratum passing from granite to limestone and Flysch. In the group of dominants *Achnanthes pyrenaica* appeared, encountered sporadically at station 13. Moreover, the value of the coefficient of coverage of the species *Gomphonema intricatum* var. *pumilum* markedly increased. On the other hand, *Gomphonema longiceps* var. *montanum* fell to the positions of adominant, and *Eunotia praerupta* and *Synedra rumpens* to the role of subdominants of a low coefficient of coverage, or of adominants. At station 17 *Synedra ulna* entered the group of dominants and *Diatoma vulgare* var. *Ehrenbergii* and *Cymbella affinis* that of subdominants. These species developed in small numbers.

Diatoms developing on moss formed groups similar to those occurring in the neighbouring habitats (fig. 2), with a tendency to a stronger development of *Achnanthes lapidosa, A. lanceolata,* and *Cocconeis placentula* var. *euglypta.* This community was distinguished by an immense diversity of forms encountered, which, however, occurred in single specimens. They were mostly represented by individuals of the genus *Fragilaria, Eunotia, Achnanthes, Navicula,* and *Pinnularia.*

In the community of diatoms in the Podhale section of the stream (altitude about 800 m, station 18) *Diatoma vulgare* var. *Ehrenbergii, D. vulgare* var. *capitulatum, Synedra amphicephala, S. ulna,* and *Cymbella affinis* attained the highest coefficient of coverage. *Diatoma hiemale* with the variety *mesodon* became less numerous here. *Gomphonema olivaceum,*



Ryc. 2. Porównanie zbiorowisk okrzemek w różnych siedliskach na podstawie gatunków dominujących ułożonych wg wielkości współczynnika pokrycia.

Fig. 2. Comparison of the diatom communities in the different habitats on the basis of dominant species arranged according to the value of coefficient of coverage

G. angustatum, Diatoma vulgare, and individuals of the genus *Navicula, Nitzschia,* and *Cymbella* were more frequently encountered. Samples collected in silt in the lenitic zone of the stream showed no differences in the communities.

In the Białka Tatrzańska the pelorheophilous communities were just as well developed as the lithorheophilous ones. When they were compared it was found that the dominant species were the same, differences appearing in the magnitude of the coefficient of coverage (fig. 2), The pelorheophilous communities differed from the lithorheophilous ones in the richness of species. The majority of them occurred sporadically. Only certain species in some sections of the stream attained the positions of dominants, such as, e.g., *Achnanthes amphicephala, A. lapponica, A. lanceolata, Meridion circulare, Cymbella delicatula, C. cistula,* and *Nitzschia acicularis.*

The zonal pattern of alga communities in streams of the High Tatra Mts

There exists a relationship between the inclination of the terrain and the type of vegetation settled in the beds of streams. The gradients in the investigated streams are from about 300 to 8‰, hence microphytes are settled there. Along the course of the communities of algae are differentiated in three zones. Two of these are on the terrain of the Tatra Mts, their areas corresponding to the altitudinal belts of higher vegetation, and the third covers the sections of streams flowing into the terrain of the Podhale region.

The zones were distinguished on the basis of species occurring most numerously on a limited section of waters. In each of these zones characteristic communities of algae developed, being present with quantitative variations during the whole period of investigations.

Diatoms, blue-green and green algae, as well as *Hydrurus* played the most important role in the communities. A group of diatoms could be distinguished among them, forming stable, characteristic groups in the investigated streams, which became the subject of particular interest, though the other groups of algae were not left out of account.

Zone I

Height about 1550—1780 m above sea-level. Gradient about 300‰. It covers the outflows of streams from lakes and is included in the mountain--pine zone, extending to the upper timber line. A very important and characteristic feature is the short vegetation season in this section of the streams. Thus, for example, in the stream draining the Zmarzły Staw and in the upper section of the Czarny Potok there is no flow from

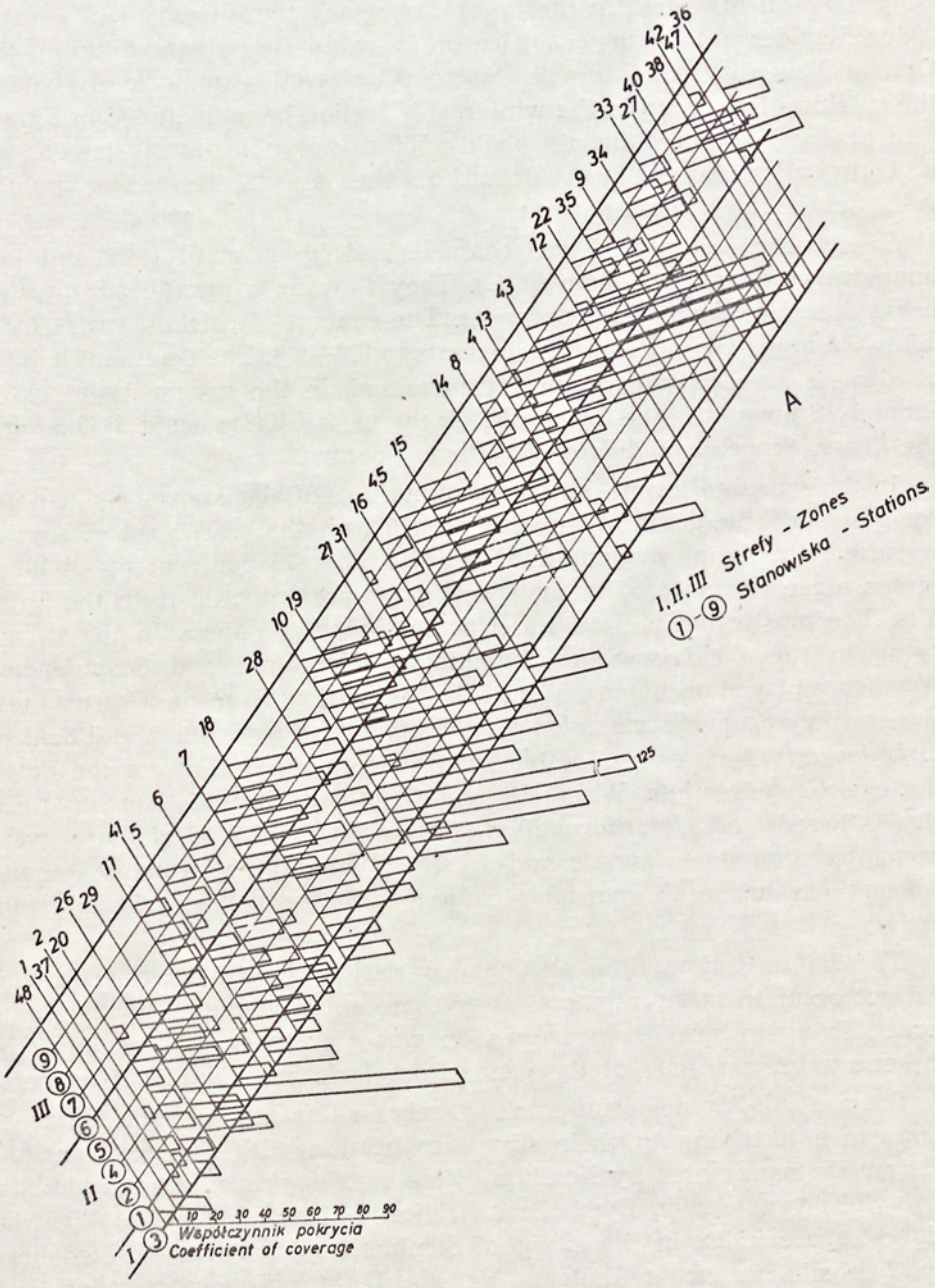
November till May, and in the Potok Roztoka if there is any it is greatly reduced under a thick layer of ice or snow. In the stream draining the Czarny Staw above the Morskie Oko the short section immediately behind the outflows freezes up in the winter, this section being included in zone I. The observed station 1 (height about 1560 m above sea-level) lies outside it. Observations should be continued in this stream, the winter months being taken into account as well.

The streams of zone I are characterized by a small flow and low temperature of water (0,5 to 11°C). They flow on a granite substratum, being therefore poor in mineral salts. The content of calcium varies from 2.5 to 3.8 mg/l. The pH of water amounts to 6.2—6.8. The dominant habitat of algae is a rocky substratum and moss sod. In the stream draining the Zmarzły Staw and in the Czarny Potok the moss *Blindia acuta,* B.G.S., and the lichen *Scapania undulata* (L.) D u m. occur.

In the zone under consideration communities of algae developed, chiefly composed of blue-green algae with dark brown thalli. The set of species is varied, this being evidenced by the fact that 75 per cent of all blue--green algae encountered in the investigated area proceed from the Tatra Mts. The most often noticed was *Chamaesiphon polonicus.* In the stream rising in the Zmarzły Staw *Ammatoidea Normanni* and *Scopulonema polonicum* played an important part. In the outflow from the Czarny Staw Gąsienicowy *Scopulonema polonicum, Ammatoidea Normannii,* and *Schizothrix lacustris* had a considerable share, and in the outflow of the Potok Roztoka *Coelodesmium Wrangelii* and *Calothrix Braunii.* Among green algae threads of *Chlorhormidium flaccidium* and *Ch. rivulare* were encountered on stones and desmids in silt. North-Alpine forms were found among them, such as *Cosmarium caelatum, C. hornavanense,* and *Closterium exile.*

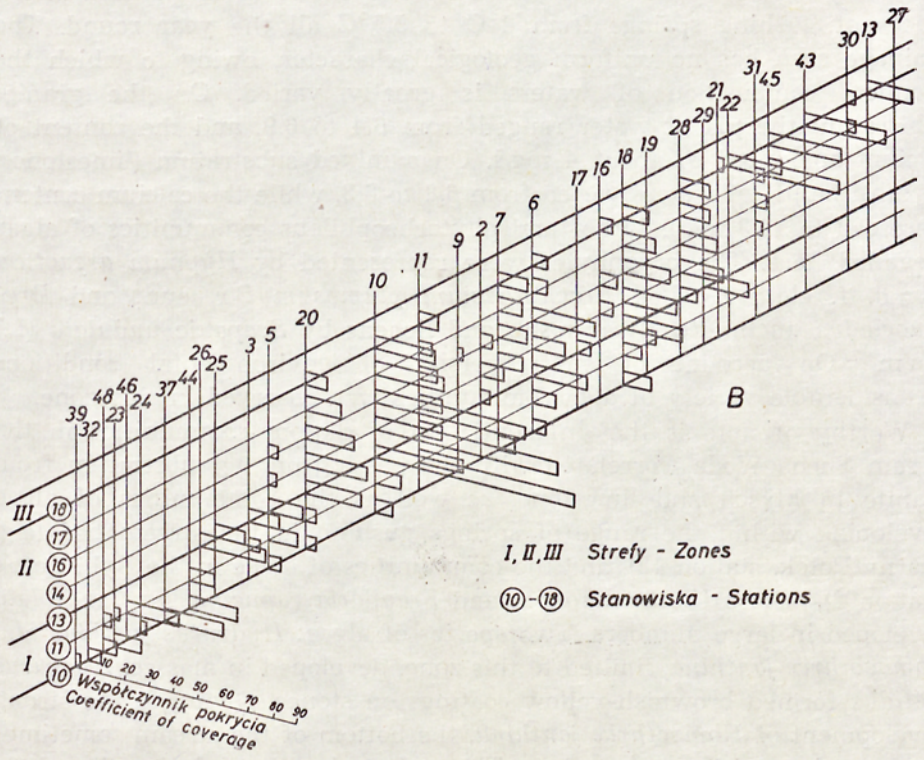
The diatom communities abounded in various species which, however, did not occur in large numbers. They represented montane, north-Alpine forms, living in springs on mosses on wet rock walls. The majority of the encountered species of the genus *Pinnularia* and *Eunotia* lived here.

Some north-Alpine forms attained only in this zone a high degree of dominance testifying to their strong connection with the environment. They were represented by *Neidium affine* var. *longiceps, Eunotia bigibba, E. bigibba* var. *pumila, Cymbella hebridica,* and *Anomoeoneis exilis.* The highest space index in the group of dominant species was attained here by *Cymbella ventricosa, Diatoma hiemale, D. hiemale* var. *mesodon,* and species of the genus *Achnanthes* and *Gomphonema longiceps* var. *montanum,* in the outflow from the Zmarzły Staw by *Navicula rotaeana,* and in the stream Roztoka by *Synedra amphicephala* and *Cymbella helvetica* (fig. 3 A, B).



Zone II

Height about 890—1550 m above sea-level, gradient about 60—100 (300) ‰. It includes the sections of streams lying in the forest zone, up to the upper timber line. These streams are characterised by an abundant



Ryc. 3. Strefowe rozmieszczenie zbiorowisk okrzemek w Białce Tatrzańskiej (A) i Suchej Wodzie (B) z dopływami. Zgrupowano gatunki o podobnym współczynniku pokrycia

Fig. 3. Zonal distribution of the diatom communities in the stream Białka Tatrzańska (A) and Sucha Woda (B) and its tributaries. The species of the similar coefficient of coverage are grouped together. 1. *Achnanthes flexella*, 2. *A. lanceolata*, 3. *A. lapidosa*, 4. *A. lapponica*, 5. *A. microcephala*, 6. *A. minutissima*, 7. *A. pyrenaica*, 8. *A. amphicephala*, *Cymbella delicatula*, 9. *Amphora ovalis* var. *pediculus*, 10. *Ceratoneis arcus*, 11. *Cocconeis placentula* var. *euglypta*, 12. *Cymbella aequalis*, *Fragilaria pinnata*, *Nitschia palea*, *Surirella ovata*, 13. *Cymbella affinis*, 14. *C. cistula*, 15. *C. helvetica*, 16. *C. sinuata*, 17. *C. turgida*, 18. *C. ventricosa*, 19. *Denticula tenuis* var. *crassula*, 20. *Diatoma hiemale*, *D. hiemale* var. *mesodon*, 21. *D. vulgare*, 22. *D. vulgare* var. *Ehrenbergii*, *D. vulgare var. capitulatum*, 23. *Eunotia exigua*, 24. *E. diodon*, *E. pectinalis* var. *minor*, 25. *E. praerupta*, 26. *Fragilaria capucina* var. *lanceolata*, 27. *Gomphonema angustatum*, 28. *G. intricatum* var. *pumilum*, 29. *G. longiceps* var. *montanum*, 30. *G. olivaceum*, 31. *Meridion circulare*, 32. *Melosira distans* var. *alpigena*, 33. *Navicula cryptocephala*, *N. exigua*, 34. *N. cryptocephala var. intermedia*, 35. *N. gracilis*, 36. *N. radiosa*, 37. *N. rotaeana*, 38. *N. viridula*, *Cymbella lanceolata*, 39. *Neidium affine var. longiceps*, 40. *Nitzschia acicularis*, 41. *N. Hantzchiana*, 42. *N. sigmoidea*, 43. *Synedra amphicephala*, 44. *S. rumpens*, 45. *S. ulna*, 46. *Synedra sp.*, 47. *S. Vaucheriae*, *Ceratoneis arcus var. amphioxys*, 48. *Tabellaria flocculosa*.

flow of water throughout the year and in winter are supplied by springs. The temperature of the water varies here from 0.4 to 12.5°C and at the places of gushing springs from 4°C to 5.5°C all the year round. The drainage area has no uniform geological character, owing to which the chemical composition of waters is greatly varied. On the granite substratum the pH of water ranged from 6.4 to 6.9, and the content of calcium amounted to about 4 mg/l. On a mixed substratum (limestones, Flysch) the pH of waters varied from 6,8 to 8,3, while the calcium content increased to 14.3 mg/l. Litho- and phytorheophilous communities of algae prevailed here. The bryophytes were represented by *Hypnum arcuatum* Lind. f. *elata* Podp., *Brachythecium plumosum* Br. eur., and *Drepanocladus uncinnatus* Warnst., and lichens by *Scapania undulata* (L.) Dum. On account of the diversity of environmental conditions a considerable variety of alga communities was observed in this zone.

Worthy of note is the differentiation of diatom communities in the stream Sucha Woda, correlated with the passing of the substratum from granite to Flysch and limestone, as well as the communities of algae developing within the range of springs gushing in the stream bed (e.g. Czarny Potok, station 12), and the communities of algae in the Rybi Potok (station 2), where *Ulothrix zonata* and *Fragilaria capucina* var. *lanceolata* developed in large numbers. Two species of algae: *Hydrurus foetidus* and *Homoeothrix janthina,* limited to this zone, developed in masses. *Hydrurus foetidus* formed brownish-yellow coatings on stones. Owing to the strong development of *Homoethrix janthina,* the bottom of the stream sometimes took on a brownish-orange colour. These algae developed during the whole period of investigations, greatly varying in number. *Phormidium uncinatum, Chamaesiphon polonicus, Ch. fuscus, Chlorhormidium flaccidium, Lemanea fluviatilis,* and *Chantransia pygmea* were fairly often encountered in the streams of this zone.

Diatoms occurred in very large numbers in the conglomerations of algae. The most numerous here were *Diatoma hiemale* with variety, especially in the stream Sucha Woda and its tributaries, *Cymbella ventricosa, Ceratoneis arcus,* the genus *Achnanthes,* chiefly *A. microcephala* and *A. minutissima,* and *Cocconeis placentula* var. *euglypta* (fig. 3 A, B). The species *Diatoma hiemale* with the variety *mesodon* attained only in this section of the streams such a high stability with at the same time a high coefficient of coverage. They can therefore be regarded as characteristic of this section of waters.

Zone III

Height about 540—890 m above sea level. Gradient about 8—20‰. It includes the sections of the longest streams flowing outside the Tatra Mts, in the Podhale region. The streams flow throughout the year,

carrying a large amount of water. The temperature of the water varies from 0.3 to 16.5°C. The bed of the streams is cut in Flysch and limestone rock. The pH of water amounts to 7.0—8.5, and the calcium content to 22.2—32.9 mg/l.

Both litho- and pelorheophilous communities of algae developed well here.

Diatoms and green algae played the most important part in these communities. The diatom communities are rich in taxons and very numerous. There occur here forms characteristic of stagnant waters, living in the littoral zone and on the bottom of water bodies, as e.g. *Amphipleura pellucida*, varieties of *Caloneis silicula*, species of the genus *Cymatopleura*, *Gyrosigma attenuatum*, *Campylodiscus noricus* var. *hibernica*, and others. The dominant species were *Diatoma vulgare* var. *Ehrenbergii*, *D. vulgare* var. *capitulatum*, *Cymbella ventricosa*, *C. affinis*, and of the genus *Achnanthes chiefly A. pyrenaica*, *Synedra amphicephala*, *S. ulna*, and *Ceratoneis arcus*. The species *Diatoma vulgare* var. *Ehrenbergii* together with *D. vulgare* var. *capitulatum*, *Cymbella affinis*, and *Synedra ulna* were regarded as characteristic of this section of waters, since they attained here the degree of dominance and at the same time a high coefficient of coverage (fig. 3 A, B).

Of the green algae occuring here *Ulothrix zonata* played the most important role, strongly developing in the Białka Tatrzańska. *Chaetophora elegans*, *Draparnaldia* sp., *Cladophora glomerata*, and *Prasiola fluviatilis* also grew here. *Chamaesiphon polonicus* and *Ch. fuscus* were encountered everywhere, and *Ch. carpaticus* was noted in the stream Sucha Woda. *Hydrurus foetidus* grew in abundance during the autumn — winter — spring season. *Homoeothrix janthina* was only sporadically encountered in this zone.

Comparison of the investigated streams with other algological studies of Carpathian rivers showed that *Diatoma vulgare* var. *Ehrenbergii* and *Cymbella affinis* also characterized the river Soła (W a s y l i k 1965). On the other hand, *Synedra ulna* attained in this river a much lower coefficient of coverage than in the Podhale section of the streams. *Diatoma hiemale*, *D. vulgare* var. *Ehrenbergii*, and *Meridion circulare* also characterized the upper section of the Dunajec, while *Cymbella affinis* and *Synedra ulna* occurred very numerously along the whole length of river (C h u d y b a 1965).

In the lower course of the stream Lepietnica (C h u d y b a 1964) and in the stream Rogoźnik (K a w e c k a 1964) other communities of diatoms developed with dominant species of the genus *Navicula*.

Algological studies of Carpathian rivers at yet scarce, but they are indispensable, since on this basis it will be possible to determine in future the stability and recurrence of alga communities.

Observations on the species

Of the determined species and varieties 8 are new for the Tatra Mts. They are represented by *Phormidium inundatum*, *Tolypothrix distorta* f.*penicillata*, *Eunotia lunaris* var. *subarcuata*, *Achnanthes Clevei*, *Navicula contenta* f. *biceps*, N. *hungarica* var. *capitata*, *Nitzschia hungarica*, and *Surirella linearis* var. *helvetica*. These forms are widely distributed and common in inland waters, *N. hungarica* var. *capitata* and *Nitzschia hungarica* also occuring in saline waters.

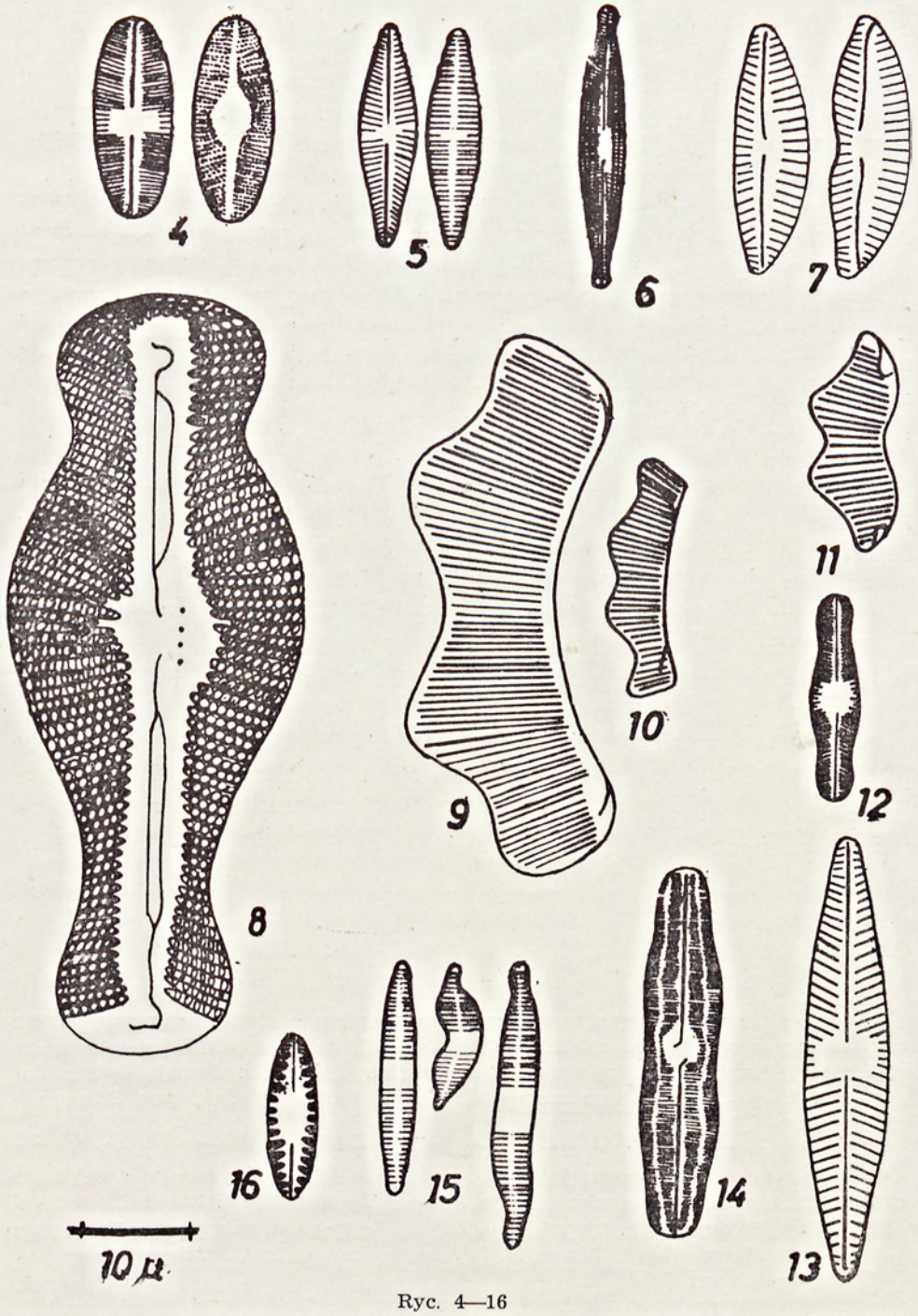
Worthy of note are forms regarded by Hustedt (1938, 1942, 1943), West (1908), and Krasske (1949) as north-Alpine. They occurred in small numbers, but sometimes attained in zone I high degrees of stability. E.g. in the stream taking its rise in the Zmarzły Staw (alt. 1620—1780 m, pH 6.2—6.4; water temperature 1.5—6.4°C). *Neidium affine* var. *longiceps* (fig. 14) was in the group of dominants, and *E. bigibba* (fig. 9), *E. bigibba* var. *pumila* (fig. 10), and *Cymbella hebridica* (fig. 7) in that of subdominants. *Anomoeoneis exilis* (fig. 6) in the stream Roztoka (alt. about 1560 m, pH 6.5; water temperature 5.5—11°C) occurred as subdominant. *Didymosphaenia geminata* (fig. 8) in the Rybi Potok (alt. about 1140 m, pH 6.4—6.9; water temperature 1.9—9.8°C) was also one of the subdominants. Interesting is the occurrence of this species in the Białka Tatrzańska (Kawecka 1965), where it seasonally attained high degrees of stability. It is a species known from arctic and subarctic mountain regions, rarely encountered in the Alps and Pyrenees (Hustedt 1938).

The other species: *Achnanthes laterostrata*, *Navicula Levanderi* var. *tatrensis*, *Pinnularia Balfouriana*, *Cymbella Cesatii*, as well as those of the group of desmids: *Cosmarium caelatum*, and *C. hornavanense*, occurred sporadically.

Also worthy of note is the species *Achnanthes pyrenaica* (fig. 5) described by Hustedt (1938) from the Pyrenees. It was also reported from the Swedish Lapland and mountains of the Balkan Peninsula (Hustedt 1942, 1943), as well as from Czechoslovakia (Bilý, Hanuška, Winkler 1952). A hitherto known locality of this species are the Tatra streams. It attained a high space index in zone III (alt. about 540—850 m, pH 7—8.5; 22.2—32.9 Ca mg/l, water temperature 0.3—16.5°C).

An interesting fact are the decreasing dimensions of cells in some species encountered at the highest lying stations, the other features concordant with the diagnosis being retained. This was observed in *Achnanthes austriaca* var. *helvetica* (fig. 4. 15—20×5—7.5; 30 ribs in 10 μ), *Navicula viridula* var. *avenacea* (fig. 13. 37.5—43.75×6.25—7.5); 11 ribs in 10 μ), *Cymbella hebridica* (fig. 7. 21—25×6.25; 10 ribs in 10 μ), and in *Synedra rumpens* (fig. 15. 16—30×2.5—3.75; about 20 ribs in 10 μ).

Conversely, in the species *Navicula Hustedtii* (fig. 12. 16.25—18.75× ×3.75—4.5; about 30 ribs in 10 μ) and *Pinnularia Balfouriana* (fig. 16.



Ryc. 4—16

Figs. 4—16. 4. *Achnanthes austriaca* var. *helvetica*, 5. *A. pyrenaica*, 6. *Anomoeoneis exilis*, 7. *Cymbella hebridica*, 8. *Didymosphaenia geminata*, 9. *Eunotia bigibba*, 10. *E. bigibba* var. *pumila*, 11. *E. diodon* fo. ?, 12. *Navicula Hustedtii*, 13. *N. viridula* var. *avenacea*, 14. *Neidium affine* var. *longiceps*, 15. *Synedra rumpens*, 16. *Pinnularia Balfouriana*

8.8—16.25×3.75; 9—10 ribs in 10 μ) longer cells in relation to the accepted diagnosis were noted. Moreover, in the species *Eunotia praerupta* and *Gomphonema intricatum* var. *pumilum* an increase in the number of ribs in 10 μ was observed as the dimensions of the cell decreased.

Another observation should still be noted concerning the diatom *Eunotia diodon* form? (fig. 11. 21.25—22.5×7.5; 15—17 ribs in 10 μ). It occurred in the material together with *Eunotia diodon*, corresponding to the latter in dimensions. The similar in shape (Cleve-Euler I. II, p. 129, fig. 470 a-c) *Eunotia gibbosa* Grun. *a constricta* (Font. A. Bg.). syn.: *E. diodon* var. *minor* f. *constricta* Fontell., does not correspond in dimensions to the examined form.

In Kawecka's (1965) work the following forms were erroneously determined:
Phormidium ambiguum Gom. var. *novae—semliae* (Schirsch.) Elenk., which belong to the species *P. uncinatum*. The majority of cells determined as *Synedra amphicephala* var. *austriaca* belong to the species *S. amphicephala*. Since between the species and the variety there are many transitional forms, there may occur here cells belonging to the variety, though not in their extreme cases. Moreover, the determination of *Eunotia valida* was reconsidered, these cells being included in the species *E. praerupta*.

The present work was carried out in the Laboratory of Water Biology of the Polish Academy of Sciences under the direction of Prof. K. Starmach, to whom I wish to express my sincere gratitude for suggesting me its theme, and for his help and valuable advice in the course of preparing the material for publication.

STRESZCZENIE

W niniejszym opracowaniu przeprowadzono ogólną charakterystykę zbiorowisk glonów w potokach północnej strony Tatr Wysokich na tle szczegółowej ich analizy w Bialce Tatrzańskiej z dopływami (Kawecka 1965) oraz Suchej Wody z dopływami. Stosowano przy tym metodę do badań glonów rzecznych wg Starmacha (1962).

Potoki zasiedlane są przez: *Bacillariophyceae* (75,8%), *Chlorophyta* (14%), *Cyanophyta* (9%), *Rhodophyta* (0,6%). *Chrysophyceae* i *Xantophyceae* po 0,3%. Z 312 oznaczonych gatunków i odmian glonów 8 jest nowych dla Tatr: *Phormidium inundatum, Tolypothrix distorta* f. *penicillata, Eunotia lunaris* var. *subarcuata, Achnanthes Clevei, Navicula contenta* f. *biceps, N. hungarica* var. *capitata, Nitzschia hungarica, Surirella linearis* var. *helvetica*.

Zbiorowiska glonów wzdłuż biegów potoków różnicują się w trzech strefach, które charakteryzują gatunki najliczniejsze ograniczone występowaniem. W obrębie stref, siedliska życia (kamienie, muł, mech, plechy glonów) nie mają większego wpływu na dalsze różnicowanie grupy okrzemek. Na terenie Tatr przebieg stref koreluje się z piętrami roślin wyższych: kosodrzewiny i regla.

Strefa I. wys. ok. 1550—1780 m n.pm., spadek 200—600‰, obejmuje wypływy

potoków z jezior. Temperatura waha się od 0,5—11°C, odczyn wody 6,2—6,8 pH, zawartość wapnia ok. 4 mg/l, okres wegetacyjny trwa 6 miesięcy (V—XI). Żyją tu głównie sinice. Wśród nich dominuje *Chamaesiphon polonicus*, a towarzyszą mu lokalnie *Coelodesmium Wrangelii, Calothrix Braunii, Scopulonema polonicum, Ammatoidea Normannii*. Zbiorowiska okrzemek są różnorodne, a taksony nie osiągają wysokich liczebności. W grupie gatunków dominujących najliczniejsze są formy szeroko rozprzestrzenione (ryc. 3 A, B). Obok nich występują formy północnoalpejskie charakterystyczne dla innych masywów górskich Europy, np. *Neidium affine* var. *longiceps, Eunotia bigibba, E. bigibba var. pumila, Cymbella hebridica* itd. Z zielenic żyją tu desmidie, a także często spotyka się *Chlorhormidium rivulare* i *Ch. flaccidium*.

Strefa II. wys. ok. 890—1550 m n.p.m., spadek ok. 60—100 — (300)‰, temperatura wody waha się od 0,4—12,5°C, w miejscach bijących źródeł ok. 5°C, na granicie odczyn wody wynosi 6,4—6,9 pH, ok. 4 mg/l Ca, na wapieniu i fliszu 8,3 pH i 14,3 mg/l Ca. Wegetacja trwa cały rok. W strefie tej istnieje duża różnorodność zbiorowisk glonów.

Masowo rozwija się *Hydrurus foetidus, Homoeothrix janthina* i okrzemki. Najwyższe liczebności osiągają tu szeroko rozprzestrzenione gatunki okrzemek (ryc. 3 A, B). Gatunek *Diatoma hiemale* z odmianą mesodon uznano za charakterystyczny dla tej partii wód, zaś *Fragilaria capucina* var. *lanceolata* wyróżniający zbiorowisko w Rybim Potoku. W strefie tej spotyka się ponadto liczne zielenice, sinice, a także krasnorosty.

Strefa III. wys. ok. 540—850 m n.p.m., spadek ok. 8—20%, temperatura wody waha się od 0,3—16,5°C, odczyn wody 7,2—8,2 pH, zawartość wapnia 22,2—32,9 mg/l. Strefą tą objęte są odcinki potoków najdłuższych, przepływających przez teren Podhala. Główną rolę w zbiorowiskach glonów odgrywają okrzemki, a z nich gatunki: *Diatoma vulgare* var. *Ehrenbergii* wraz z *D. vulgare* var. *capitulatum, Cymbella affinis, Synedra ulna* uznano za charakterystyczne dla tej strefy (ryc. 3 A, B). Z licznych zielenic najlepiej rozwija się *Ulothrix zonata, Chaetophora elegans*, gatunki z rodziny *Zygnemataceae*.

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