Algae of the Pieniny National Park (S. Poland)

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1. INTRODUCTION

The first observations concerning algae from the Pieniny area were made by the Hungarian specialist FILARSZKY (1899, 1900). In his work he mentions about 400 species occurring in the Dunajec valley and mostly in the region of Slovakia.
In the thirties WOLOSZYNSKA (1936) published data from BURSA on the occurrence of *Rhodophyta* (*Batrachospermum anatinum* Sirodot, *B. ectocarpum* Sirodot and *B. boryanum* Sirodot) in the Pieniny Mts. (Pieninski torrent). After a break caused by World War II, algological studies in the Pieniny Mts. were resumed under the supervision of Prof. Dr. K. Starmach. Initial research only concerned the Dunajec river (CHUDYBA 1965, KAWECKA 1965, WASYLIK 1971), other biotopes in the Pieniny Mts. (TARNOWSKA 1971, MROZINSKA-WEBB 1975, STARMACH 1975) were later included. Further research from 1987 to 1988 provided full specification of algae in this area and of a number of species of great scientific interest worth to be protected.
All these data lead to further research dealing with a proper management of aquatic biotopes in this area and the creation of a protection zone for drinking water resources and for the Dunajec river. Part of the prior results was published (MROZINSKA 1982).

2. CHARACTERIZATION OF ALGAE

Abundance of water in the Pieniny Mts. in form of swamps, sources and tor-

rents as well as geological, morphological and climatic differences decided of rather rich algal flora, which assure stability of water ecosystems in this area. Therefore it is worthwhile to get acquainted with it.

165 species of algae have been found, belonging to six taxonomic groups: *Bacillariophyceae*, *Chrysophyceae*, *Charophyceae* (*Characeae* and *Zygnemophyceae*), *Chlorophyceae*, *Xanthophyceae* and *Rhodophyceae* and 18 species of *Cyanophyta* (Table 1).

The most numerous group is composed of *Chrysophyta*, especially *Bacillariophyceae*. Its share in algal flora of the Pieniny Mts. is as high as 74%. Beside small forms such as *Achnanthes minutissima, Achnanthes lanceolata, Achnanthes affinis*, usually escaping notice, there are also bigger and imposing forms such as *Campylodiscus hibernicus* (Figs. 3-4), *Cymatopleura solea, Cymbella aspera, Cymbella simonsenii* (Figs. 12-13), *Gyrosigma attenuatum, Melosira arenaria, Nitzschia sigmoidea* and others. Abundance of the last of the species mentioned above is one of the characteristic features of the flora of the Pieniny Mts. Most found diatoms are of cosmopolic character. They occur in nearly all parts of the world, both in the mountains and lowlands. However, some of them such as *Achnanthes flexella* (Fig. 11), *Anomoeoneis vitrea, Denticula tenuis, Mastogloia grevillei, Neidium binodis, Pinnularia interrupta, Rhopalodia rupestris, Surirella spiralis* (Figs. 5-7) are represented in greater abundance in the mountains (including the Tatras and the Alps). It is also confirmed in the Pieniny Mts. and in the type of mountains where specific relations of the amount of species are characteristic for this mountain range. A good example of such characteristic quantitative relations are two species of the genus *Gyrosigma*. *Gyrosigma attenuatum* is a dominating species in the Pieniny Mts. while *Gyrosigma acuminatum* is the most numerous species in the Alps (KRAMMER and LANGE-BERTALOT 1986, 1988) but very scarce in the Pieniny in some torrents. Similar occurrence is also characteristic for *Denticula tenuis, Rhopalodia rupestris* and others.

The calciphile species, *Cymbella simonsenii* is noteworthy (Figs. 1 and 12-13): It occurs in the Pieniny in waters rich in calcium carbonate of medium contents of electrolites and is characteristic for the limestone Alps. Usually it is accompanied by *Caloneis alpestris* and *Amphipleura pellucida*. *Neidium binodis* has an ecological requirement similar to *Cymbella simonsenii*. It was found in the Macelowy and Limbargowy torrents.

Table 1 (p. 220-225). List of algae and Cyanophyta from different localities of Pieniny National Park. A-Y see Fig. 2.

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
Bacillariophyceae																							
1. *Achnantes affinis* Grun.		+	+	+	+		+			+		+	+	+				+			+		
2. - *dispar* Cl.									+														
3. - *flexella* (Kuetz.) Brun.									+	+	+	+	+										
4. - *lanceolata* (Breb.) Grun.		+	+	+					+	+		+		+							+		
5. - - f. *ventricosa* Hust.												+						+					
6. - - var. *minuta* (Skv.) She.												+											
7. - *lapponica* Hust.									+			+											
8. - *linearis* (W. Sm.) Grun.									+														
9. - *microcephala* (Kuetz.) Grun.								+	+		+												
10. - *minutissima* Kuetz.	+	+	+	+	+	+	+		+	+	+	+	+	+	+			+	+		+		+
11. *Amphipleura pellucida* Kuetz.										+													
12. *Amphora libyca* Ehr.	+	+										+											
13. - *ovalis* (Kuetz.) Kuetz.			+				+		+	+		+	+	+									
14. - *pediculus* (Kuetz.) Grun.					+																		
15. *Anomoeoneis vitrea* (Grun.) Ross							+			+	+	+			+						+		
16. *Caloneis alpestris* (Grun.) Cl.									+	+													
17. - *silicula* (Ehr.) Cl.		+				+			+	+		+		+									
18. *Campylodiscus hibernicus* Ehr.		+	+					+				+											
19. *Cocconeis pediculus* Ehr.										+	+	+						+			+		
20. - *placentula* Ehr. var. *uglypta* (Ehr.) Cl.			+							+	+	+					+	+			+		
21. *Cyclotella comta* (Ehr.) Kuetz.											+												
22. - *kuetzingiana* Thwait.						+				+		+											
23. *Cymatopleura elliptica* (Br.) W.Sm.			+		+							+									+		
24. - *solea* (Breb.) W.Sm.		+			+		+			+		+											
25. *Cymbella aequalis* W.Sm.											+												
26. - *affinis* Kuetz.												+											
27. - *amphicephala* Nag.				+	+	+				+	+	+	+		+						+		
28. - *angustata* (W.Sm.) Cl.												+											
29. - *aspera* (Ehr.) Cl.		+	+		+					+	+	+											
30. - *cesatii* (Rab.) Grun.									+							+							
31. - *gracilis* (Ehr.) Kuetz.						+									+			+					

Table 1 (continued)

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
32. - *helvetica* Kuetz.								+		+		+	+		+						+		
33. - *hungarica* (Grun.) Pan.										+													
34. - *laevis* Naeg.									+														
35. - *lanceolata* (Ehr.) Kirchn.										+													
36. - *microcephala* Grun.										+		+											
37. - *silesiaca* Bleisch.			+						+	+		+			+			+			+		
38. - *simonensii* Kramm.		+	+		+				+	+													
39. - *sinuata* Greg.										+													
40. *Denticula tenuis* Kuetz.										+	+	+			+								+
41. *Diatoma mesodon* (Ehr.) Kuetz							+			+	+	+											
42. - *vulgaris* Bory										+												+	
43. - - var. *linearis* Grun.												+		+					+				
44. - - var. *producta* Grun.																				+			
45. *Diploneis ovalis* (Hilse) Cl.		+	+	+	+			+	+	+	+					+			+		+		+
46. - *blongella* (Naeg.) Cleve-Eul							+	+															
47. - *puella* (Schum.) Cl.										+												+	
48. *Epithemia adnata* (Kutz) Breb.				+																			+
49. *Eunotia arcus* Ehr.		+	+								+	+											
50. - var. *fallax* Grun.								+															
51. - *exigua* (Breb.) Rab.																+				+			
52. - *praerupta* Ehr.										+	+												
53. *Fragilaria intermedia* Grun.										+													
54. - *leptostauron* (Ehr.) Hust.												+											
55. - - var. *dubia* Grun.					+																		
56. - *pinnata* Ehr.												+											
57. *Frustulia vulgaris* Thw.			+							+													
58. *Gomphonema angustatum*(Kuetz.) Rab.	+	+	+				+			+	+	+	+					+	+				
59. - *angustum* Agardh	+		+					+		+	+		+		+				+		+		
60. - *acuminatum* Ehr.												+											
61. - *clavatum* Ehr.		+	+	+						+						+	+	+		+			
62. - *clevei* Fricke											+												
63. - *livaceum* (Lyngb.) Kutz.										+	+												+

Table 1 (continued)

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
64. - *parvulum* (Kuetz.) Grun.										+	+												
65. *Gyrosigma acuminatum* (Kutz.) Rab.					+																+		
66. - *attenuatum* (Kuetz.) Rab.		+		+	+						+	+	+										
67. - *scalproides* (Rab.) Cl.			+			+					+	+											
68. *Hantzschia amphioxys* (Ehr.) Grun.									+					+									
69. *Melosira arenaria* Moore					+						+									+			
70. - *varians* Ag.																							
71. *Meridion circulare* (Grev.) Ag.	+		+				+			+	+								+				
72. *Mastogloia grevillei* W. Sm.			+										+			+		+		+	+		
73. *Navicula cryptocephala* Kuetz.			+	+	+	+		+	+	+	+												
74. - *cryptotenella* Lange-Bert.							+						+	+	+			+			+		
75. - *cuspidata* (Kuetz.) Kuetz.												+		+				+			+	+	
76. - *elginensis* (Greg.) Ralfs	+																						
77. - *minima* Grun.										+			+										
78. - *mutica* Kuetz.										+													
79. - *rotracta* Grun.		+	+		+					+	+	+											
80. - *pupula* Kuetz.				+			+	+						+									
81. - *pygmaea* Kuetz.										+													
82. - *radiosa* Kuetz.			+	+	+			+		+	+	+											
83. - *subminuscula* Mang.													+								+		
84. - *ripunctata* (Muell.) Bory										+					+						+		
85. - *iridula* Kuetz.	+										+	+						+			+		+
86. - - var. linearis Hust.											+	+	+										
87. *Neidium affine* (Ehr.) Cl.		+																					
88. - *inodis* (Ehr.) Hust.												+											
89. - *isulcatum* (Lagerst.) Cl.										+											+		
90. - *dubium* (Ehr.) Cl.							+				+	+											
91. *Nitzschia dissipata* (Kuetz.) Grun.										+													
92. - *kuetzingiana* Hilse		+																					
93. - *inearis* W. Sm.										+													
94. - *alea* (Kuetz.) W.Sm.	+	+			+	+				+	+										+		
95. - *pura* Hust.											+		+	+		+		+		+	+		

Table 1 (continued)

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
96. - *sigma* (Kuetz.) W.Sm.					+																		
97. - *sigmoidea* (Ehr.) W.Sm.					+						+							+			+		
98. - *sinuata* (W.Sm.) Grun.		+						+	+		+	+		+									
99. - *umbonata*(Ehr.)Lange-Bert.						+								+									
100. - *sublinearis* Hust.						+								+									
101. *Pinnularia interrupta* W. Sm.											+												
102. - *maior* (Kuetz.) Rab.	+	+											+										
103. - *microstauron* (Ehr.) Cl. var. *brebissonii* (Kuetz.) Hust.							+			+	+			+									
104. - *iridis* (Nitzsch.) Ehr.							+				+	+			+								
105. *Rhopalodia gibba* (Ehr.) O.Muell.				+	+	+			+				+										
106. - - var. *parallela* (Grun.) H. et M. Perag.						+	+			+							+						
107. - *rupestris* (W.Sm.) Kramm.								+															
108. *Stauroneis pheonicenteron* (Nitzsch.) Ehr.	+	+		+							+												
109. - *smithii* Grun.					+					+			+	+									
110. *Surirella angusta* Kuetz.										+	+	+	+										
111. - *legans* Ehr.			+							+													
112. - *minuta* Breb.											+				+								
113. - *valis* Breb.										+								+					
114. - *spiralis* Kuetz.		+	+	+				+			+	+										+	+
115. - *tenera* Greg.	+		+			+							+	+									
116. *Synedra amphicephala* Kuetz. var.*austriaca* Grun.										+	+												
117. - *tabulata* (Ag.) Kuetz.										+			+										
118. - *vaucheriae* Kuetz.										+								+			+		
119. - *lna* (Nitzsch.) Ehr.								+		+	+		+	+				+					
120. - - var. *aequalis* (Kuetz.)Hust.											+	+	+		+								
121. - - var. *amphirhynchus* (Ehr.)			+		+								+					+					
Characeae																							
122. *Chara vulgaris* L.		+	+										+										
Zygnemaphyceae																							
123. *Actinotaenium cucurbita* (Breb.) Teil.							+		+	+				+									
124. *Closterium leibleinii* Kuetz.							+		+		+			+							+		+

Table 1 (continued)

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
125. - *ittorale* Gay							+			+				+									
126. - *unula* (Muell.) Nitzsch.				+			+																
127. - *moniliferum* (Bory) Ehr.														+									
128. - *ritchardianum* Archer												+		+									
129. - *setaceum* Ehr.				+																			
130. *Cosmarium crenatum* Ralfs							+						+	+	+								
131. - *didymochondrium* Nordst.							+				+	+		+									+
132. - *granatum* Breb.		+	+					+	+			+											+
133. - *holmiense* L. var.*integrum* L.									+					+									
134. - *laeve* Rab.	+													+									
135. - *obtusatum* (Schmid.) Schmid.							+					+	+	+							+		
136. - *ochtodes* Nordst.				+			+							+									
137. - - var. *amoebum* W.West														+									
138. - *pokornyanum*(Grun.)W. et G.S.W.							+						+										
139. - *egnelii* Wille												+											
140. - *subcrenatum* Hantzsch.							+		+				+	+	+						+		+
141. - *tetraophtalmum* Breb.								+	+			+	+										+
142. - *vexatum* West							+	+			+	+											
143. *Mougeotia* sp.								+				+									+		
144. *Oocardium stratum* Nag.								+	+		+												
145. *Spirogyra* sp.							+			+		+									+		+
146. *Staurastrum lapponicum* (Schm.) Gronbl.												+											
147. *Zygnema* sp.							+		+			+											
Chlorophyceae																							
148. *Bulbochaete mirabilis* Witrr	+																						
149. - *pseudoareolata* W.et O. Bock	+																						
150. *Chaetophora incrassata* (H.) H.										+													
151. - *elegans* (Roth.) Agardh				+								+									+		+
152. *Cladophora glomerata* (L.) Kuetz.										+		+				+					+		
153. *Gongrosira calcifera* Krieg.										+		+											
154. *Oedogonium crispum* (Hass.) Wittr.												+											
155. - *decipiens* Wittr. var.*africanum* Tiff.												+									+		

Table 1 (continued)

SPECIES/LOCALITIES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y
156. - *inversum* Witrr.		+																					
157. *Pediastrum integrum* Naeg.												+											
158. *Monoraphidium fontinale* Hind.														+									
159. *Scenedesmus armatus* Chod.							+																
160. *Stigeoclonium elongatum* (H.) K						+																	
Chrysophyceae																							
161. *Chrysonebula holmesii* Lund										+		+										+	
Xanthophyceae																							
162. *Tribonema vulgare* Pascher					+					+		+											
Rhodophyceae																							
163. *Batrachospermum boryanum* Sir.					+								+										
164. - *ectocarpum* Sirodot					+					+		+	+				+		+				
Cyanophyceae																							
165. *Calothrix fusca* (Kuetz.) B.et F.										+		+										+	
166. *Chamaesiphon incrustans* Grun.										+	+	+										+	
167. *Chamaesiphon polonicus* (R.) H.										+		+										+	
168. *Hydrococcus cesatii* Rab.										+												+	
169. *Homeothrix nordstedtii* (B.F.) K.et K.										+													
170. *Lyngbya amplivaginata* V.Goor										+													
171. - *martensiana* Menegh.										+		+											
172. *Merismopedia glauca* (Ehr.) N.												+			+								+
173. *Microcoleus lacustris* (R.) Farl.										+													
174. *Phormidium valderiae* (D.) G. f. *pseudovalderianum* (W.) Elenk.										+													
175. - *foveolarum* (Mont.) Gom.										+													
176. - *incrustatum* (Naeg.) Gom.										+													
177. - *favosum* (Bory) Gom.										+		+										+	
178. *Pseudanabaena constricta* (S.) L.										+													
179. *Schizothrix fasciculata* (N.) G.										+		+										+	
180. - *ulvinata* (Kuetz.) Gom.										+		+				+					+		
181. - *tenuis* Woron.										+													
182. *Synechocystis pevaleckii* Erc.										+													

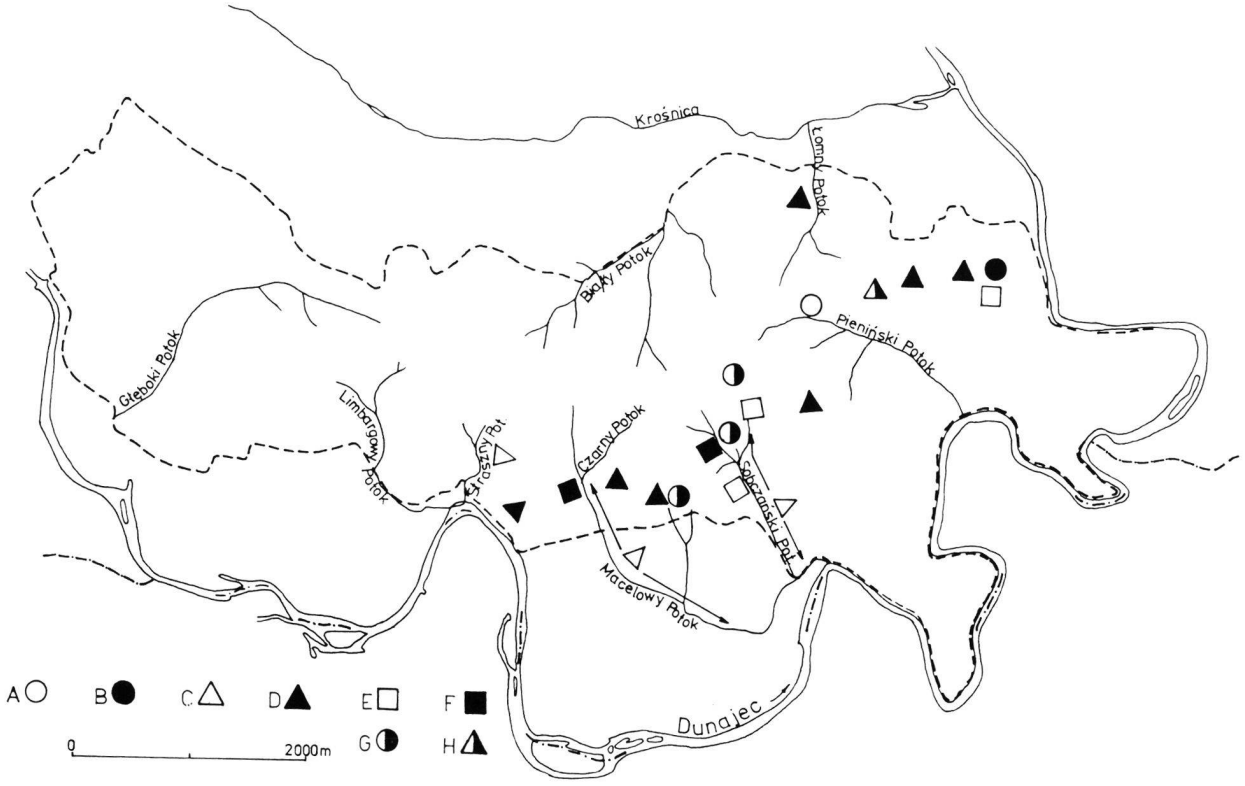


Fig. 1. Occurrence of algae species of great scientific value in Pieniny National Park.
A - *Batrachospermum boryanum* Sirodot, B - *Bulbochaete pseudoareolata* W. et O.Bock, C - *Chrysonebula holmesii* Lund, D- *Cosmarium didymochondrium* Nordst., E - *Cymbella simonsenii* Krammer, F - *Gongrosira calcifera* Krieger, G - *Oocardium stratum* Naeg., H - *Stigeoclonium elongatum* (Hass.) Kuetz.

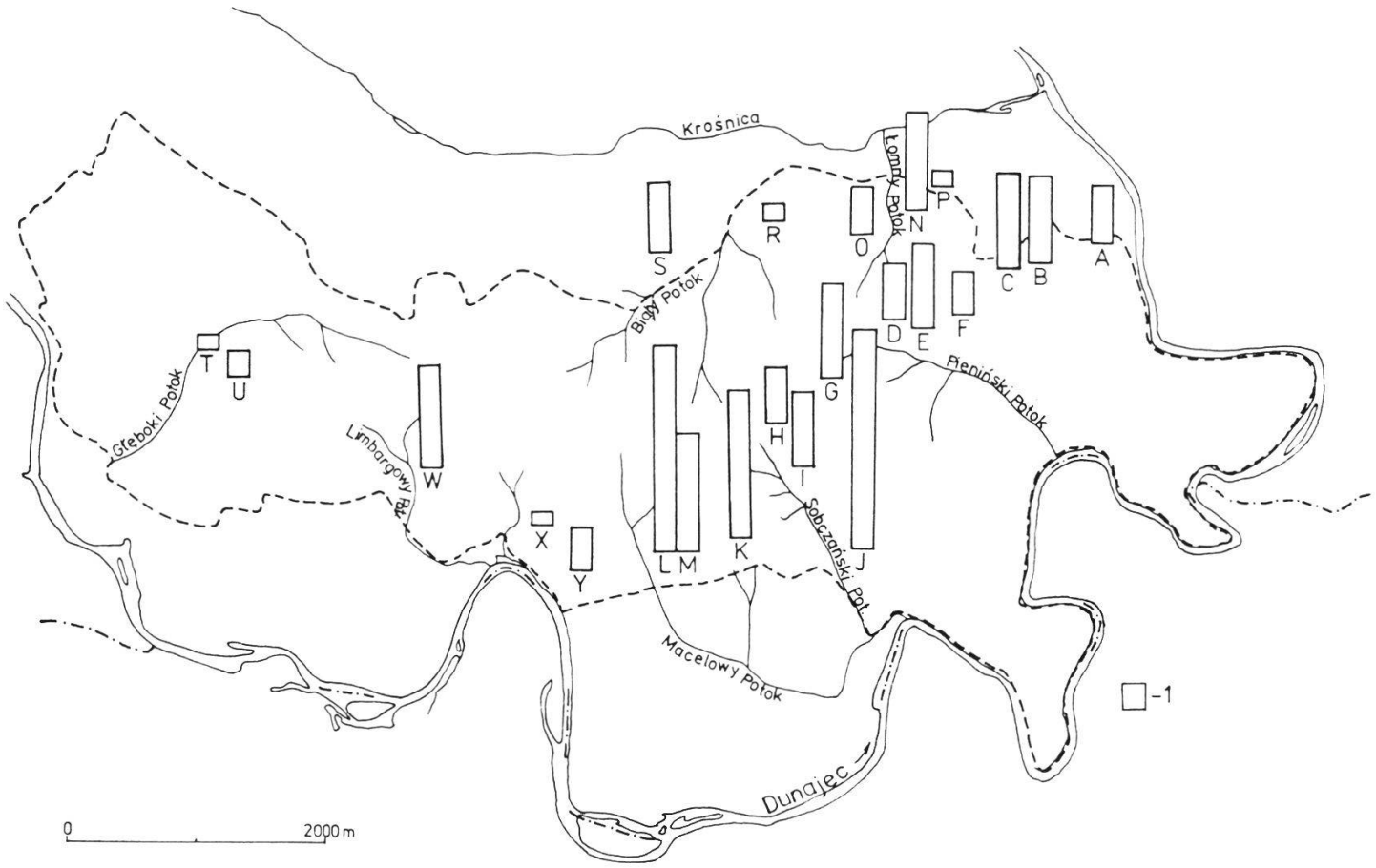


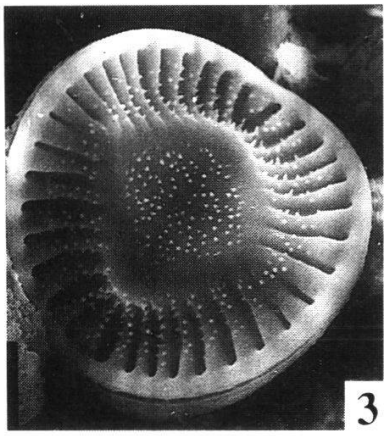
Fig. 2. Number of species of algae in different aquatic biotopes of Pieniny National Park.
1 - Number of 10 species.
A - Swamp along Ociemny Torrent, B - Swamp above Grodek (I), C - Swamp above Grodek (II), D - Swamp along Pieninski Torrent, E - Pieninski Torrent, F - Swamp on Toporzysko, G - Swamp below Szopka pass, H - Swamp under Szopka pass (above Sobczanski Valley), I - Swamp in fork of Sobczanski Torrent, J - Sobczanski Torrent, K - Source of Kotlowy Torrent, L - Macelowy Torrent, M - Swamp in the valley of Macelowy Torrent, N - Periodical stream in the valley of Lomny Torrent, O - Swamp along Lomny Torrent, P - Lomny Torrent, R - Torrent Pod Wysokim Dzialem, S - Bialy Torrent, T - Gleboki Torrent, U - Swamp below the road in Zaukier locality, W - Limbargowy Torrent, X - Straszny Torrent, Y - Swamp under the Macelowy Hill (Czerwone Skalki).

A group of diatoms quoted here contains species with strong bioindicator features. Most of them indicate that the water is clean, however, *Navicula cuspidata, Navicula cryptocephala, Nitzschia sigmoidea* and others indicate water pollution caused by the inflow of mineral substances (in swamps from accumulation of decaying leaves, tourist movement and in some torrents from fertilizers used in the neighbouring meadows and fields).

An interesting species of algae is *Chrysonebula holmesii* (*Chrysophyta*). Until recently it has been thought to occur only in Gardale Beck torrent in England (LUND 1953) thus separated by a large range disjunction. This circumstance entitles it to be considered an old species. It belongs, as well as *Hydrurus foetidus* to a group of stenothermic algae, accustomed to live in cold waters in narrow ranges of temperature.

Green algae should be mentioned next to the *Chrysophyta*. Its share in the Pieniny flora for all of them (*Charophyceae* and *Chlorophyceae*) amounts to 22% (e.g. *Bulbochaete pseudoareolata, Chaetophora elegans, Gongrosira calcifera, Monoraphidium fontinale, Pediastrum integrum* [Figs. 14-15] and *Stigeoclonium elongatum*). *Bulbochaete pseudoareolata* develops both in swamps near Grodek and in old river beds along the Dunajec (Sromowce Nizne and Srednie) (MROZINSKA-WEBB 1976). As an epiphytic alga it sticks to different water plants and is therefore most found on the surface of *Chara vulgaris* and on stems of *Carex* and *Equisetum*, where it creates together with *Bulbochaete mirabilis* a dense nap. Apart from the Pieniny this species is only known from Unterfranken (Germany). *Gongrosira calcifera* has a strongly encrusted thallus with calcium carbonate so that only the markedly swollen ends of threads can be seen from calcareous tufa (Figs. 18-19). It occurs in masses in the Macelowy and Sobczanski torrents and until recently it has been thought to occur in the Raba river. It was described by KRIEGER (1933) from Schildow Preserve (Germany). Short fibrous forms growing from the top of the cells and wide vegetative cells are the features that differentiate it from *Gongrosira incrustans* (Reinsch) Schmidle and *Gongrosira debaryana* Rabenh., met in the torrents in the Tatra Mts. (WASYLIK 1971).

Figs. 3-13 (p. 229)
Figs. 3-4. *Campylodiscus hibernicus* Ehr., SEM x 650.
Figs. 5-7. *Surirella spiralis* Kuetz., SEM x 500.
Fig. 8. *Stauroneis phoenicenteron* (Nitzsch) Ehr., SEM x 1000.
Fig. 9. *Navicula viridula* (Kuetz.) Ehr., SEM x 900.
Fig. 10. *Navicula elginensis* (Greg.) Ralfs, SEM x 1700.
Fig. 11. *Achnanthes flexella* (Kuetz.) Brun., SEM x 2000.
Figs. 12-13. *Cymbella simonsenii* Kramm., SEM x 1200, x 5000.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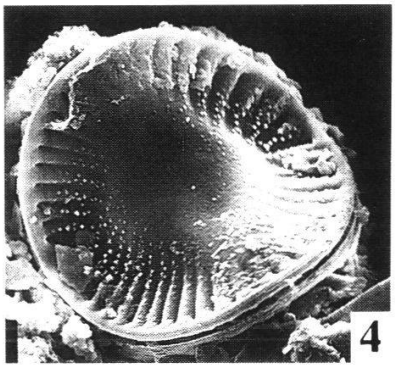
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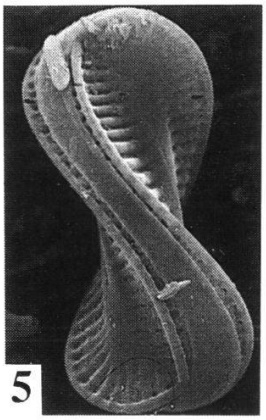
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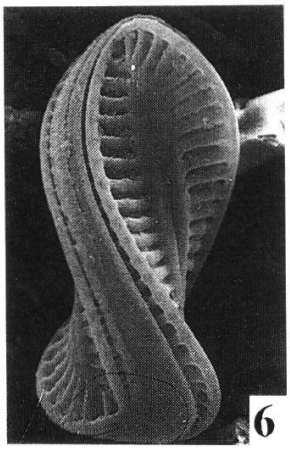
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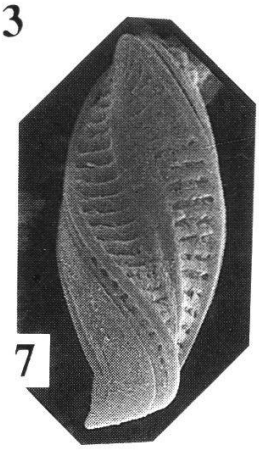
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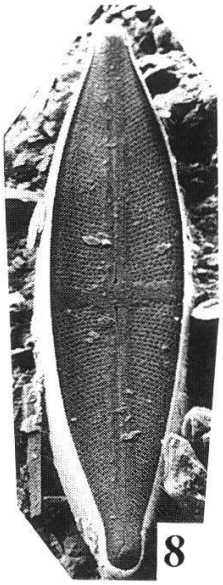
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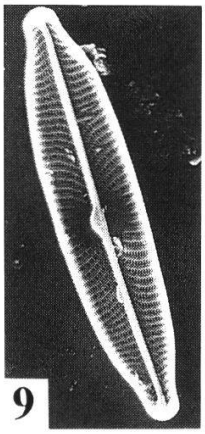
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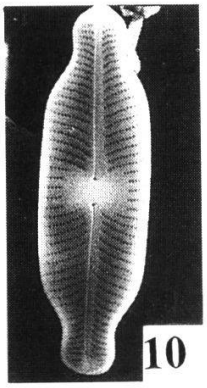
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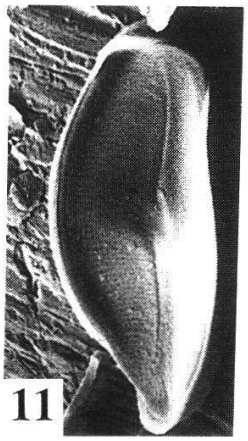
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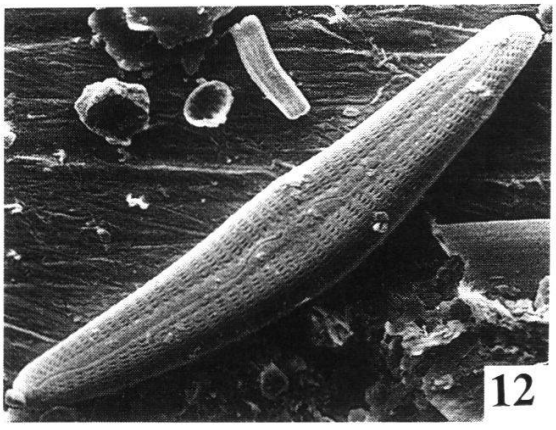
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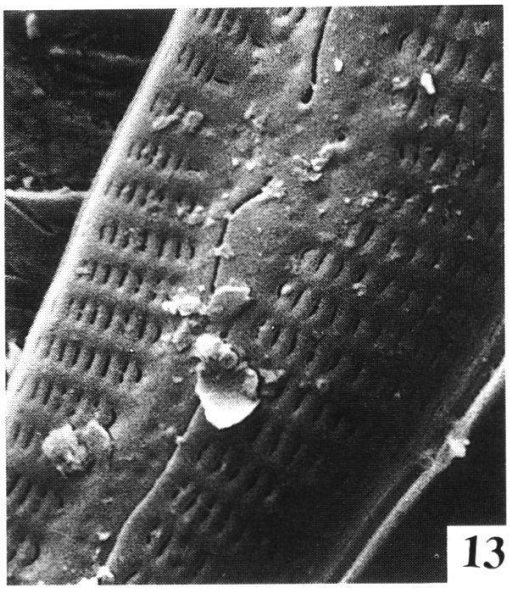
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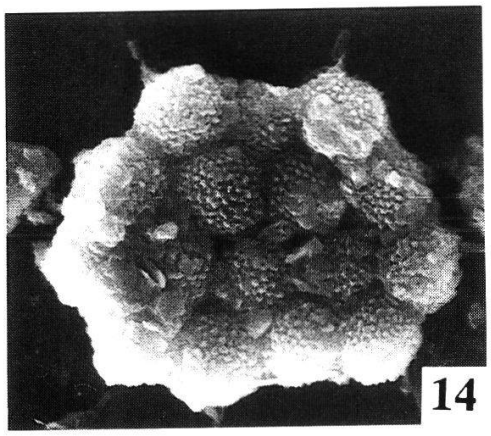

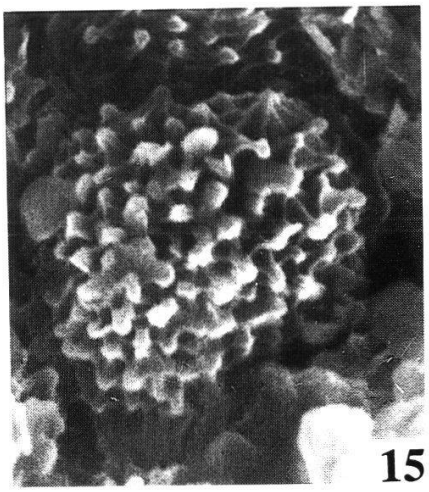

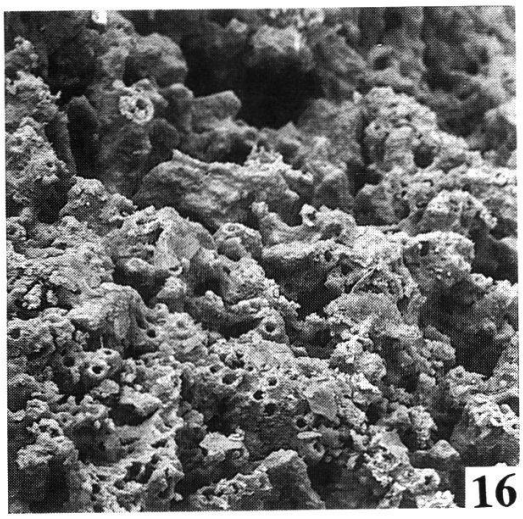

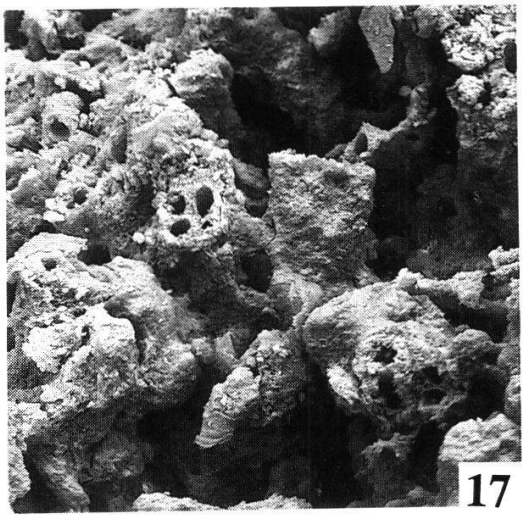

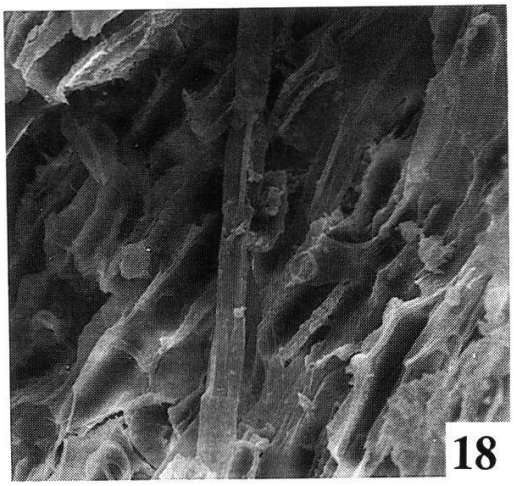

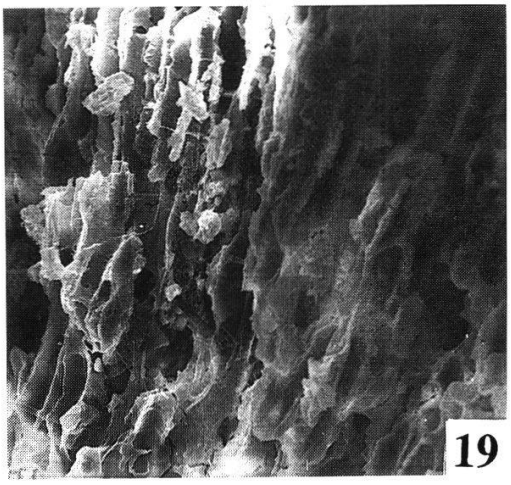

Figs. 14-15. *Pediastrum integrum* Naeg., SEM x 500, x 1500.
Figs. 16-17. Tufas of *Oocardium stratum* Naeg., SEM (from Dr. J. Szulc).
Figs. 18-19. Tufas of *Gongrosira calcifera* Krieger, SEM (from Dr. J. Szulc).

An interesting species of green alga, characteristic for the swamps on Toporzysko, is *Stigeoclonium elongatum*. It creates slippery, long thallus with sparse side branches, sometimes sharpened or passing into a long hair-like form. In Europe this alga is only found in a few places (mostly mineral water sources).

Chaetophora elegans is widespread in the Pieniny Mts. and of great importance for this region. It occurs both in swamps (swamps along the Pieninski torrent and the Macelowy torrent) and in torrents (Homole torrent). It creates spheric, green thallus embedded in jelly often settled near each other. They grow up to large jelly lumps that can be seen from a distance.

Beside these green algae desmids, the great algological curiosity of the Pieniny Mts., occur species such as *Actinotaenium cucurbita, Closterium leibleinii, Closterium littorale, Closterium lunula, Closterium pritchardianum, Cosmarium crenatum, Cosmarium didymochondrium* and others (Table 1). They are mostly found together with *Cratoneuron commutatum* in swamps, sources and torrents. Some of them (*Closterium moniliferum, Closterium leibleinii, Closterium pritchardianum* and others) occur in great mass on mud, too. In the Alps *Cosmarium crenatum, Cosmarium obtusatum, Cosmarium ochtodes* and *Cosmarium tetraophtalmum* grow in biotopes with pH 8.0 or even 9.0. *Cosmarium holmiense* var. *integrum*, *Cosmarium ochtodes* and others were found in calcareous parts of Tatra Mts. (WASYLIK 1971).

Oocardium stratum is much scarcer in this region. Due to its capabilities of calcium carbonate precipitation, it forms large calcareous tufa (Figs. 16-17) at some distance from the source that can mainly be observed on *Cratoneuron commutatum*. It is very abundant in the limestone Alps and in Southern Europe as opposed to the Pieniny Mts., where it is not abundant. In Poland it only occurs on the southern slopes of the Pieniny Mts.

The last group of algae, *Rhodophyta*, is only represented in the Pieniny Mts. by two species: *Batrachospermum boryanum* and *B. ectocarpum*. *B. ectocarpum* is most abundantly and frequently creates wide underwater meadows in torrents or swamps.

Cyanophyta are not very numerous (18 species), its share amounts only to 10% in the Pieniny flora. Special attention should be paid to *Schizothrix tenuis, Schizothrix calcicola* and *Schizothrix rubra*. Until recently these species have been known from Western and Southern Europe and the Caucasus. *Schizothrix tenuis* usually creates sod coating, sticking tightly to the stones, often in the neighbourhood of *Cladophora thallus*. It frequently forms small frayed tufa in the Sobczanski torrent, where *Schizothrix calcicola* grows

among calcite incrustations and creates a characteristic membranous thallus composed of unbranched threads. The most interesting species of the above blue-green is *Schizothrix rubra* which occurs in the Pieniny on damp rocks in the form of bunches of brownish-red and sometimes pink threads.
The species presented briefly here are of great scientific value and contribute to the specific character of water biotopes in the Pieniny region. They require with the whole biotope a special protection (Fig. 1). This is why they were included into the reservation and protection project.

3. ALGAE OCCURRING IN DIFFERENT AQUATIC BIOTOPES IN THE PIENINY NATIONAL PARK

Numerous and varied aquatic biotopes in the Pieniny Mts. usually have rather characteristic algal flora. In this work the algal flora of four biotopes will be considered.

3.1. ALGAE IN TORRENTS AND SOURCES

The torrents are a very characteristic and important element of the Pieniny landscape. They are characterized by a short course and a big decline, and in some cases a considerable degree of banks overgrowing and overshadowing of a torrent bed. The water level and current strength depend to a large extent on the amount of rainfall. Therefore the water level is very unstable in the stream. Its maximum is observed in spring and summer, its minimum in autumn and winter. Many of the torrents are karstic and exhibit low and stable temperature all year long, pH higher than 7 with a large concentration of calcium and magnesium salts (KOSTRAKIEWICZ 1982). Some torrents are good examples of calcareous, unpolluted waters with special types of algae worth to be protected.
On stones in the main „stream of the Sobczanski and the Macelowy torrents (the most interesting torrents), a characteristic crust can be seen created by different *Cyanophyta* and algae (*Schizothrix pulvinata, Schizothrix fasciculata, Lyngbya martensiana* f. *calcarea, Gongrosira calcifera*). In the same zone, *Chrysonebula holmesii* can be spotted, too. In the period of its main development, which lasts from autumn to spring, the stones are covered with thick brownish-grey mucilaginous coatings that can be seen from a distance. Here and there on the stones characteristic spots and thin crusts created by *Chamaesiphon incrustans* and *Chamaesiphon polonicus*, and blue-green

slices of *Phormidium* can also be seen. *Cladophora glomerata* which finds perfect conditions for development, especially in the Macelowy torrent, sticks with its basal part to the stones and creates thallus sometimes as long as 50 cm. This species is a perfect background for other epiphytic algae and is usually covered with small algae, especially diatoms (*Cocconeis pediculus, Cocconeis placentula* var. *euglypta, Achnanthes minutissima, Achnanthes microcephala, Gomphonema angustatum* and others). Diatoms play an important role, they grow as crustose masses usually covered by slippery mucous secretions.

In the littoral, in somewhat calmer places of the torrents, on stones or among mosses, the most frequent algae are *Batrachospermum ectocarpum* and *Batrachospermum boryanum*. All these algae are accompanied by groups of diatoms in the Pieninski torrent: *Nitzschia sigmoidea, Synedra ulna, Gyrosigma attenuatum, Navicula radiosa, Cymbella hungarica, Cymatopleura solea, Gomphonema angustatumm, Navicula cryptocephala, Diploneis ovalis, Caloneis silicula, Stauroneis phoenicenteron, Amphora lybica* and others. *Melosira arenaria, Campylodiscus hibernicus, Eunotia praerupta, Fragilaria leptostauron, Cymbella aspera, Pinnularia viridis* and others are important species in the Macelowy torrent; the majority of them are indicators of clean water. On the other hand, *Navicula cryptocephala, Navicula cuspidata* and *Nitzschia sigmoidea, Nitzschia palea* and others indicate water pollution caused by inflow of leaching agriculture fertilizers from the fields and meadows in the neighbourhood of the torrent and by the uncontrolled tourist movement. The situation looks much worse in the torrents on the northern and southern side of Pieniny due to intensive fertilizing of fields and meadows in private properties. Certain algae obviously benefit of the high nitrogen concentration whereas many others are completely eliminated, which is proved by the scarce and little diversified algal flora (Fig. 2).

Most species in the torrents are alkalophilous. They develop mainly in water very rich in soluble calcium and magnesium compounds, especially bicarbonate, the most noticeable biological phenomenon, seen especially in Sobczanski and Macelowy torrent, is incrustation of algal threads with precipitated calcium salts. The algae and Cyanophytes (*Gongrosira calcifera, Oocardium stratum, Homoeothrix nordstedtii, Phormidium incrustatum, Schizothrix pulvinata*) cause a precipitation of calcium and magnesium in form of an insoluble carbonate which secure them from tearing away. The amount of carbonates thus precipitated is so considerable that the material deposited (travertine) may attain a thickness of 1-2 mm during the course of week.

Differentiation of species inhabiting krenal results from different types of sources. The most interesting ones, from the point of view of algology, are the sources widely spread on the surface, with the bottom covered with mosses (mainly *Cratoneuron commutatum*) and vascular plants. In such sources, *Oocardium stratum* occurs together with *Homoeothrix crustacea* accompanied by *Cosmarium tetraophtalmum, Cosmarium granatum, Cosmarium didymochondrium, Calothrix fusca* and the numerous diatoms (*Diatoma mesodon* and *Diatoma vulgare*, in different morphological forms), which play an important role, and *Achnanthes flexella* as well as *Chaetophora incrassata* usually accompanied by blue-green algae (*Phormidium incrustatum, Calothrix fusca* and *Synechocystis pevaleckii*). Apart from the algae, diatoms also play an important role (*Diatoma mesodon, Diatoma vulgare, Achnanthes flexella, Surirella spiralis, Nitzschia sinuata, Achnanthes minutissima, Cymbella aspera, Gomphonema angustatum*).
The source in the upper part of Macelowy valley seems to be algologically interesting, too. In spring *Batrachospermum ectocarpum* tends to develop peculiar underwater meadows, by the end of spring, *Chaetophora elegans* appears. In summer *Oedogonium decipiens* var. *africanum* grows abundantly with numerous diatoms (*Campylodiscus hibernicus, Cymatopleura solea, Surirella spiralis, Melosira arenaria* and others). Desmids mentioned above are also found here.

3.2. ALGAE IN SWAMPS

Algae flora in swamps spread all over the Pieniny mountains is usually rich. The typical calcareous plants, *Chara vulgaris* and *Cladophora glomerata*, play an important role. Numerous epiphytic algae grow on them (e.g. *Oedogonium decipiens* var. *africanum*, *Oedogonium inversum*, *Bulbochaete pseudoareolata* and *Bulbochaete mirabilis*). *Gomphonema gracilis* var. *auritum* grows in great abundance; it can easily be distinguished from other epiphytic diatoms by their jelly-like, horny edges on the upper pole of the cell. The endophytic alga, *Coleochaete nitellarum*, typical for these reservoirs is growing inside *Chara vulgaris* tissues. Apart from the algae diatoms mentioned, *Cymbella aspera, Cymbella silesiaca, Diploneis ovalis, Epithemia argus, Epithemia adnata* and others are frequent. *Campylodiscus hibernicus, Cymatopleura elliptica, Surirella spiralis*, common in that region, occur in swamps in great abundance and variety.

3.3. ALGAE ON DAMP ROCKS

The rocks are usually overgrown with characteristic algae composed mainly of blue algae. They are visible as dark spots on light limestone. On dry rocks only periodically sprinkled with water *Gloeocapsa kuetzingiana, G. alpina, Nostoc microscopicum, Chroococcus minutus* and *Calothrix parietina* are found. They are also known from the limestone of the Tatras and from Ojcow. Part of these species, *Trentepohlia aurea*, common in some regions of the Tatras, occurs very rarely here. On rocky cliffs continually moistened by waterfalls grow the characteristic alga *Schizothrix rubra* with brownish-red, sometimes pink thallus, and *Homoeothrix nordstedtii, Schizothrix lardacea and Tolypothrix byssoidea* able to endure dry periods. During drought they stop growing and their mucilage becomes leathery. Watered, they immediately start dividing and growing.
In this work presenting important biocenosis in the Pieniny Mts. only the most characteristic species were taken into account.

4. DISCUSSION

The research carried out in recent years proved that the central area of the Pieniny National Park is algologically the most rich one (Fig. 2). It abounds in species which are elsewhere very rare or even unique, and represents a very specific algological flora, which can easily be destroyed but rather be recreated. The water objects located on the boundary of the Park testify this clearly.
Great pressure of urbanization around the Pieniny National Park brought changes inside the Park. Some swamps, especially in the Ociemny valley and in Grodek, were changed into drinking water resources. Therefore, interesting algae (e.g. *Chara vulgaris, Coleochaete nitellarum, Cymbella simonsenii, Campylodiscus hibernicus, Surirella spiralis* and *Cosmarium didymochondrium*) disappeared.
We may suppose that due to the leaching process of agriculture fertilizing from the surrounding fields and meadows, uncontrolled tourist movements and wild pasture the consequent impoverishment will continue. As no restrictions from the Planning Board exist concerning new houses, the pollution of the area close to the Park is increasing. At present, the houses only have in some places septic tanks connected to the sewer. This ultimately leads to the growth of unsightly algae piling up on the shore and decaying with an offensive odour (there should be public outcry that something should be done).

Advances should be made in sewage purification before the next stage will be reached, as this area should be of particular cared not only because of its natural values.

Some data concerning *Chlorella vulgaris* growth may be worth mentioning. The very high values are probably caused by intense fertilization of meadows and fields, illegal sheep pasture and rubbish dumps in torrent beds. These phenomena are of deep concern and have to be limited or even eliminated from the region, which should be a protection zone for the newly built drinking water reservoirs in the vicinity. This is why proper management is so necessary.

SUMMARY

From 1987 to 1988 aquatic algae of the Pieniny National Park were studied. 165 taxa belonging to six taxonomic groups (*Bacillariophyceae, Chrysophyceae, Charophyceae* [*Characeae* and *Zygnemophyceae*] *Chlorophyceae, Xanthophyceae* and *Rhodophyceae*) and 18 species of *Cyanophyta* were found. *Batrachospermum boryanum* Sirodot, *Bulbochaete pseudoareolata* W. et O. Bock, *Chrysonebula holmesii* Lund, *Cymbella simonsenii* Krammer, *Gongrosira calcifera* Krieger, *Oocardium stratum* Naeg. and other species of the order *Desmidiales* and *Stigeoclonium elongatum* (Hass.) Kütz were of scientific value.

The central area of the Pieniny National Park is algologically the most rich area which abounds in species elsewhere very rare or even unique.

Fertilizers from the surrounding fields and meadows, uncontrolled tourist movements and wild pasture) increase the impoverishment. These phenomena are of deep concern and have to be limited or even eliminated from the region, which should be a protection zone for the newly built drinking water reservoirs in the vicinity.

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