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Zbiorowiska planktonowe w stawach rybnych Zespołu Ochaby

Plankton communities in the Ochaby Complex of Experimental Fishery Farms

Wpłynęło dnia 22 lutego 1966 r.

In the year 1961 investigations were started on the plankton of ponds belonging to the fishery farms of Gołysz in the district of Cieszyn and of Landek in the district of Bielsko, forming part of the complex of experimental farms of the Laboratory of Water Biology of the Polish Academy of Sciences.

To characterize plankton communities the author applied by way of experiment the sociological method based on dominant species, which was suggested by Professor Starmach.

The first to undertake sociological investigations of algae communities were: Steinecke, Allorge, Kurz, Denis, Messikommer (Starmach 1963); these investigations were later continued by Fott (1948), Hadač (1948), Margalef (1949), Symoens (1951), and Fetzmann (1956).

The sociological method was applied by Starmach (1961, 1964), Bohr (1962), Kawecka (1964), Chudybowa (1964), Chudyba (1965), Wasylik (1965), Kyselowa, and Kysela (1966) in investigations which were chiefly concerned with attached algae. To characterize plankton communities it was applied by Starmach (1962), Szklarczyk-Gazdowa (1965), and Kyselowa (1966). The last two works were based on investigations of plankton biocoenoses, carried out several times in a large number of ponds and at a chosen time, most propitious to the development of plankton. Thus, they were of a different character from that of the present work.

When dealing with sociological investigations on animal plankton one cannot disregard the contribution of Polish scientists, such as: Lityński (1922, 1925, 1938), Bowkiewicz (1934 a, b, 1935), or Patalas (1954); among foreign authors Šrámek-Hušek (1941, 1962) approaches this problem in an interesting though rather specific way.

It should be mentioned that the plankton of ponds belonging to the Ochaby complex has already been the subject of investigation by a number of authors (Sosnowska 1956, Czapik 1957, Jasiński et al. 1957, Klimczyk 1957, 1958, 1964, Siemińska, Bucka 1959,

Characteristics of ponds

Ponds		Wyszni VI	Księżok Mały III	Wyszni II
Soil a) of the bottom of ponds b) of the adjacent areas	at Gołysz - ponds supplied with water of the Vistula by the right-bank mill race Kiczyce	a) parent rock horizon: silt loams of water origin, differing by a smaller content of sand and a gre b) soils formed from silt loams of water origin of podsol type		
	at Landek - ponds supplied with water from the river Iłownica	a) parent rock horizon: heavy loams or silty clay deposited in b) brown soils, formed from loess covering the hills of Rudzica with soils formed on silt loams of water origin (podsols)		
Productivity area in ha		5.7	3.0	8.3
Degree of overgrowth of the pond area	soft vegetation %	10	20	5
	hard vegetation %	20	50	15
Predominant plants		Typha latifolia Typha angustifolia Phragmites communis Glyceria aquatica Carex sp. div.	Phragmites communis Glyceria aquatica Typha latifolia Carex sp. div.	Typha latifolia Glyceria aquatica Phragmites communis
Kind of fertilization	N P_2O_5 kg/ha	not fertilized	not fertilized	urea 70 superphosphate 45
Fish stock	K_1/ha K_2/ha	300 -	220 -	1300 -
Natural yield of fish	kg/ha	126	155	426
Total production (glucose kg/ha)		1470	1910	4550
Plankton communities in seasons	spring	Spirogyra sp. Daphnia longispina	Ceratium hirundinella Synedra acus Diaptomidae	Spirogyra sp. Cyclopidae
	summer	Dinobryon divergens Cyclopidae	Volvox aureus Cyclopidae	Microcystis aeruginosa Ceriodaphnia quadrangula
	autumn	Dinobryon divergens Asplanchna priodonta	×	Euglena acus Cyclopidae
General character of plankton communities during the whole period of investigations		Dinobryon divergens Cyclopidae	Volvox aureus Diaptomidae Cyclopidae	Pediastrum Boryanum Cyclopidae
Sum of coverage indices	phytoplankton	1197.0	801.0	1195.5
	zooplankton	2275.5	1408.0	2761.5
Quotients of trophism	Nygaard compound	2.50	2.75	3.84
	Thunmark chlorophycean	1.62	1.43	2.63

$$\text{the Nygaard compound quotient} = \frac{\text{Myxophyceae + Chlorococcales + Centrales + Euglenineae}}{\text{Desmidieae}}$$

$$\text{the Thunmark chlorophycean quotient} = \frac{\text{Chlorococcales}}{\text{Desmidieae}}$$

B u c k a 1960, 1964, K r z e c z k o w s k a 1961, 1964, B o m b ó w n a et al. 1962, K y s e l o w a 1964, 1965, 1966, F e r e ń s k a 1965, S z k l a r-c z y k - G a z d o w a 1965, F e r e ń s k a, L e w k o w i c z 1966, K r z e c z-k o w s k a - W o ł o s z y n 1966).

My grateful acknowledgements are due to Professor K a r o l S t a r-m a c h for entrusting me with this work and for his valuable advice in the course of its realization. I also wish to thank Docent J a d w i g a

Table I

Księżok Środkowy	Wyszni III	Księżok Rudzicki	Wyszni IV
from slime layers apart from organic matter ater amount of silt and clay (particle diameter 0.02 mm)			
6.4	6.9	5.5	6.0
10	40	15	single specimens
15	20	30	10
Typha latifolia Glyceria aquatica Phragmites communis	Heleocharis acicularis Batrachium aquatile Glyceria aquatica Typha latifolia Phragmites communis	Phragmites communis Glyceria aquatica Typha latifolia Potamogeton lucens Potamogeton natans Potamogeton sp.	Phragmites communis Glyceria aquatica Typha latifolia Carex sp. div.
urea 70 superphosphate 22	25 % ammonia water 77 superphosphate 45	25 % ammonia water 60 superphosphate 36	ammonium sulphate 84 superphosphate 50
1300 -	1298 -	727 254	1300 -
357	250	387	513
3450	4160	5990	4740
Asterionella formosa Diaptomidae	Eudorina elegans Daphnia longispina	Bacillariophyceae sp. div. Diaptomidae	Pediastrum duplex Diaptomidae
Aphanizomenon flos aquae Daphnia longispina	Microcystis aeruginosa Daphnia longispina	Volvox aureus Daphnia longispina	Dictyosphaerium pulchellum Daphnia longispina
Closterium gracile Bosmina longirostris	*	Synura uvella Asplanchna priodonta	Euglena spirogyra Asplanchna priodonta
Pediastrum boryanum Daphnia longispina	Eudorina elegans Daphnia longispina	Eudorina elegans Daphnia longispina	Pediastrum duplex Daphnia longispina
935.0 1538.0	838.5 1524.5	876.5 1400.5	830.0 2232.0
3.78 2.21	3.55 2.55	4.07 2.22	4.64 3.28

quotients of trophism	oligo-	meso-	eu-
Nygaard compound	0-1	1-5	5-20
Thunmark chlorophycean	0-1	1-5	5-15

x = single sampling in this season
* = caught towards the end of August

Siemińska for her help in determining some species, and Docent Stanisław Wróbel for his suggestions in preparing the illustrations. I am also very grateful to my colleagues Mrs Maria Szumiec for the data concerning the temperature of water and to Dr Łucja Krzeczkowska-Wołoszynowa for those regarding flowering plants. I also wish to thank Mr. Jan Broda, Director of the Ochaby complex, for facilitating my field researches.

Methods

The investigations were carried out in the ponds of Gołysz from the 13th of April to the 17th of October 1961, and in those of Landek from the 12th of April to the 18th of October 1961. Five of these ponds were fertilized while two remained unfertilized (Table I). Samples were taken at various dates, according to the application of fertilizers, 14 times on the average from each pond in the course of the vegetation season. Simultaneously with investigations of plankton, chemical investigations were carried out in these ponds (Wróbel 1962). Some data on the ponds under consideration together with the characteristics of their plankton communities are presented in Table I. The kind of soil occurring in the bottom is given after Pasternak (1959).

The present investigations were carried out on samples of plankton taken always from 50 l. of water through a plankton net of No 25 bolting cloth at one point in the pond, from a stage situated at a distance of 15 to 20 m. from the outlet box. The samples were fixed with 4 per cent formalin and placed in titrated conic tubes for 24 hours, in order to measure the volume of the sediment. The relationship between the amount of sediment and productivity of the investigated ponds is shown in fig. 1.

From each sample 3 slides were examined, the surface of the coverglass being 20×20 mm., magnification 100 × for zooplankton and 200 × for phytoplankton. Three or more bands of slide were examined according to the magnification, the density of the sediment being always kept in the ratio of 1 : 3. Each sample and slide prepared from it were treated as a stand of association corresponding to the phytosociological record (French relevé). In the course of microscopic examinations the species as well as their quantitative relations and size were determined according to the 6-degree scales.

Scale of amount:

+ — very rarely. The given organism occurs singly not in each slide. The total is 1—6 specimens in the examined slides.

1 — single. The given organism is encountered to the number of 1—6 individuals in one slide. The total is about 10 individuals in 100 fields of vision.

2 — few. The given organism occurs to the number of 7—16 individuals in the slide. The total is about 50 specimens in 100 fields of vision.
3 — moderately. The given organism occurs to the number of 1—3 specimens in almost all fields of vision. The total is about 100—150 specimens in 100 fields of vision.
4 — many. The given organism occurs to the number of 4—5 individuals in almost all fields of vision. The total is about 250 specimens in 100 fields of vision.
5 — very many. The given organism is positively predominant, occurring in a number greater than 5 individuals in each field of vision. In sum total more than 250 specimens in 100 fields of vision.

Scale of size (Table II).

Table II

Scale of size

Value of the scale	Average size μ	Coefficient of calculation of size
+	0- 4	0.1
1	5- 40	1
2	41-100	3
3	101-200	7
4	201-300	11
5	over 300	16

For filamentous algae it was accepted that a filament of length equal to the diameter of the field of vision in the microscope corresponds:

at a width of 1— 5 μ to the scale of size 1
„ „ „ „ 5—20 „ „ „ „ „ „ 2
„ „ „ „ 20—40 „ „ „ „ „ „ 3
„ „ „ „ 40—60 „ „ „ „ „ „ 4
„ „ „ „ 60—80 „ „ „ „ „ „ 5

However, the estimation of the size of the given specimen was dependent on its stage of development, e. g.:

juvenile stages of *Volvox aureus* size 2—3
mature specimens of *Volvox aureus* „ 4—5
juvenile stages of *Copepoda* „ 2—3
mature individuals of *Copepoda* „ 5

To determine the size of a colony various values of the scale of size were taken into account, according to the quantity of cells, as for instance, for genus *Dinobryon* (size 3—4). In the case of its disintegration single cells were counted, taking into consideration their mean numbers in the colony. Subsequently, the shape of the colony was reproduced and estimated according to the corresponding value of the scale of size.

The coverage index (space index) was obtained by multiplying the quantity determined according to the accepted scale by the coefficient of calculation corresponding to the particular values of the scale of size.

The elaboration of the above analytic features served as basis for making up tables, which in turn presented the following synthetic features: the frequency expressed in degrees of constancy, the dominance, the floristic and faunistic spectrum, the coefficient of coverage, and the quotients of trophism. As concerns the frequency:

degree V denotes that the given species occurs in 80—100% of the examined samples

degree IV denotes that the given species occurs in 60—80% of the examined samples

degree III denotes that the given species occurs in 40—60% of the examined samples

degree II denotes that the given species occurs in 20—40% of the examined samples

degree I denotes that the given species occurs in 1—20% of the examined samples.

The first two degrees include the dominant species (dominants) the next two the accompanying species (subdominants), while the last degree includes occasional species (adominants).

To illustrate the occurrence of all species the latter were divided into groups, according to the magnitude of their coefficients of coverage:

1. species of coefficient of coverage smaller than 100
2. „ „ „ „ „ from 100 to 500
3. „ „ „ „ „ „ 500 to 1000
4. „ „ „ „ „ „ 1000 to 2500
5. „ „ „ „ „ above 2500

The last value refers exclusively to some dominants from among zooplankton. Table III illustrates graphically in systematic order species and higher taxonomic units in the particular seasons and during the whole period of investigations, account being taken of their coefficient of coverage (P) and frequency, expressed in degrees of constancy.

The coefficient of coverage (P) was calculated according to the formula:

$P = \frac{s \cdot 100}{n}$, where s = sum of the mean coverage indices from all samples, n = numbers of samples. It gives an idea of the sociological role of the given species in the community.

When calculating the degree of constancy it was accepted that 100 per cent or „n" samples stands for all samples taken from the given pond during the whole investigated period.

The floristic and faunistic spectra were made (Table IV) by summing up the coverage indices of the particular vegetal and animal organisms. They allowed the determination of the relation of phyto- to zooplankton, account being taken of the space (coverage) occupied by its representatives, to compare the size of the groups belonging to it, and to establish the character of the plankton of the investigated ponds.

The quotients of trophism: the Thunmark (1945) chlorophycean and the Nygaard (1949) compound quotients were calculated as well (Table I). Consequently, the order *Conjugales* was excepted from the class of *Chlorophyceae* and dealt with separately (Table IV).

It should still be noted that the present investigations were based exclusively on net plankton; the nannoplankton was omitted and taken into account only in later investigations carried out in the same ponds (unpublished materials of the author from the year 1962).

Since in some cases it was impossible to determine a form as to species the author gave only the genus or the higher taxonomic unit so as to avoid, in accordance with Thunmark's (1945) recommendations, a distortion of the picture of the community.

To characterize the investigated pond environment plankton communities were discriminated for the season of spring, summer, and autumn, as well as for the whole investigated period. As criterion of the division into seasons the mean monthly temperature of water in the ponds was accepted, assigning to the spring: April and May at a maximum temperature to about 15 °C, to the summer: June, July, and August (temperature 19—21 °C), to autumn: September and October (temperature 17 °C and below).

Some difficulties in the description of communities arose owing to filamentous algae (*Spirogyra sp.*) and certain diatoms (*Pinnularia sp.*, *Amphora sp.*), and euglenins (*Euglena spirogyra*), growing usually as epiphytes or on the bottom of water-bodies, and hence not constituting a typical component of plankton. In some seasons they reached the highest coefficients of coverage, qualifying them to give their name to the community. However, it is known that filamentous algae are a characteristic phenomenon in all shallow water-bodies and cannot therefore be disregarded. It should also be noted that heleoplankton and euplankton have a different composition, the former being a mixture of pelagic and benthic forms. Taking this into account, as well as the specific character of this type of water-bodies, marked by shallowness and small mass of water and an inconstant thermal bedding, it seems justified to reckon among planktons the particular components, both seasonal and constant.

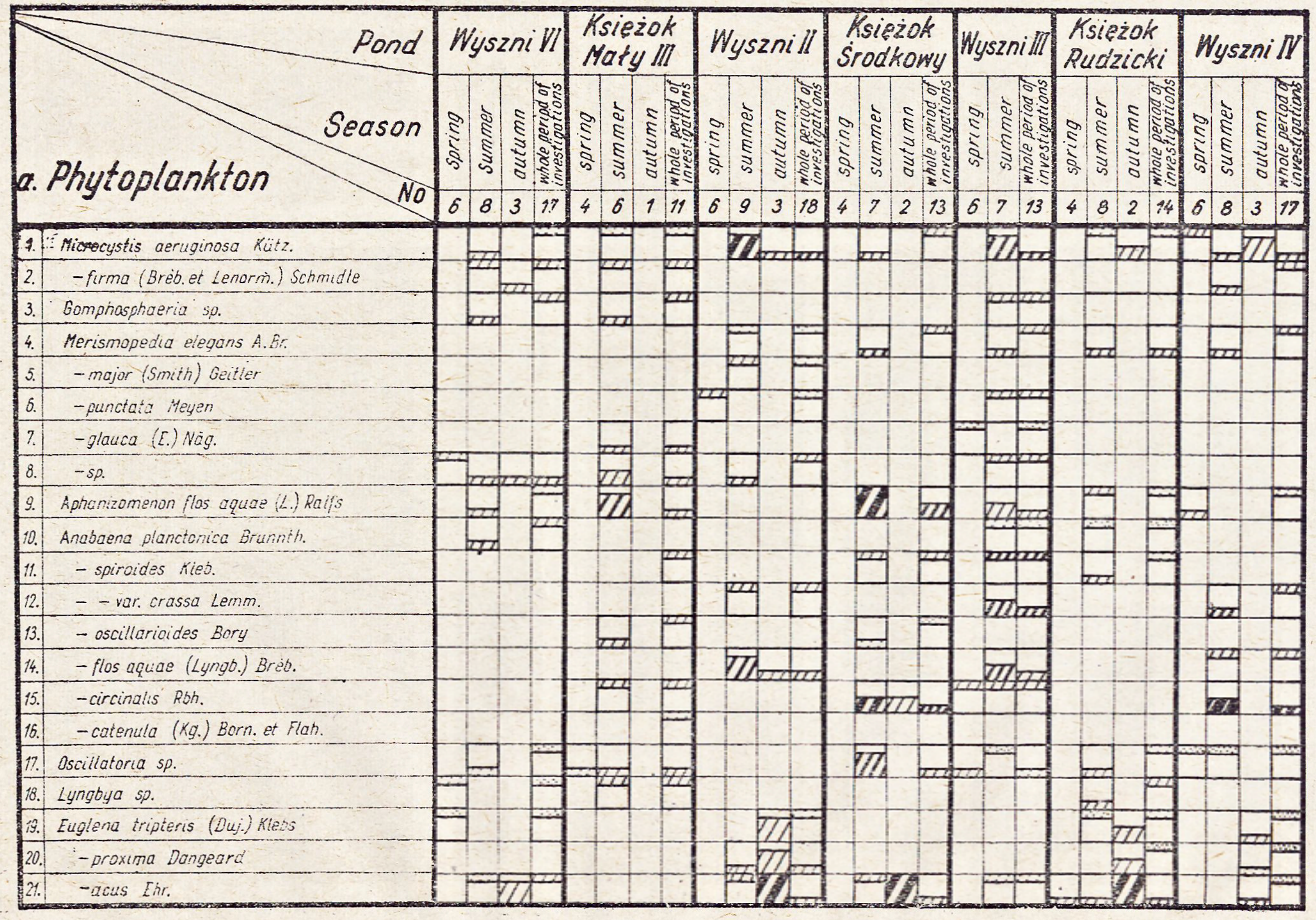
General Characteristics of the Plankton

The phytoplankton

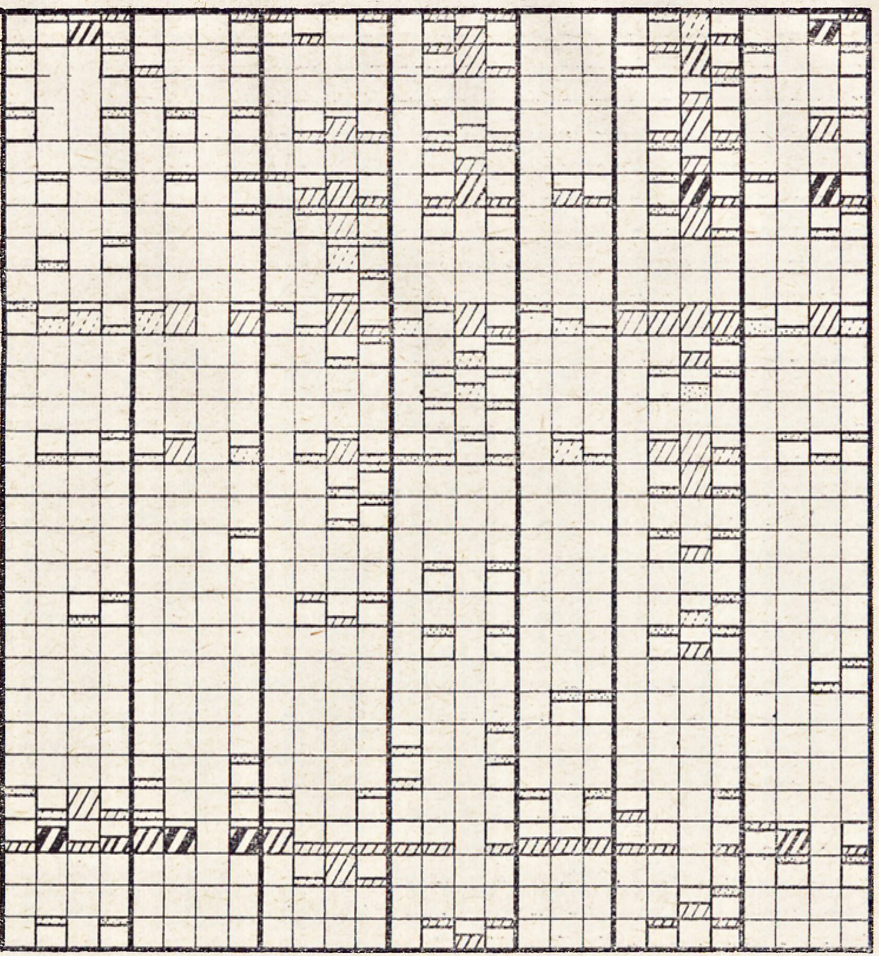
Altogether 152 species from 79 genera and 12 varieties (Table III) were determined. The greatest number and variety of species were observed in the pond Wyszni II. In the other ponds there appeared no marked differences in the qualitative composition. All systematic groups reached the greatest sum of coverage indices and the greatest number of species

Graphical interpretation of the plancton compositions

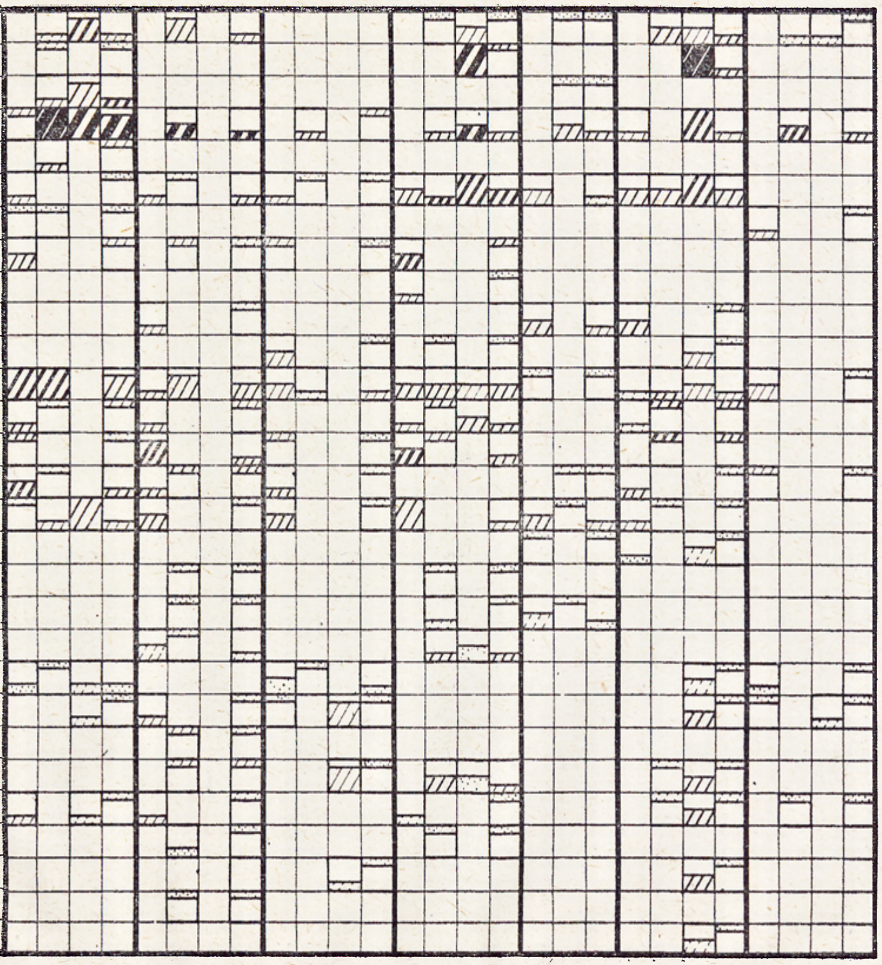
Table III



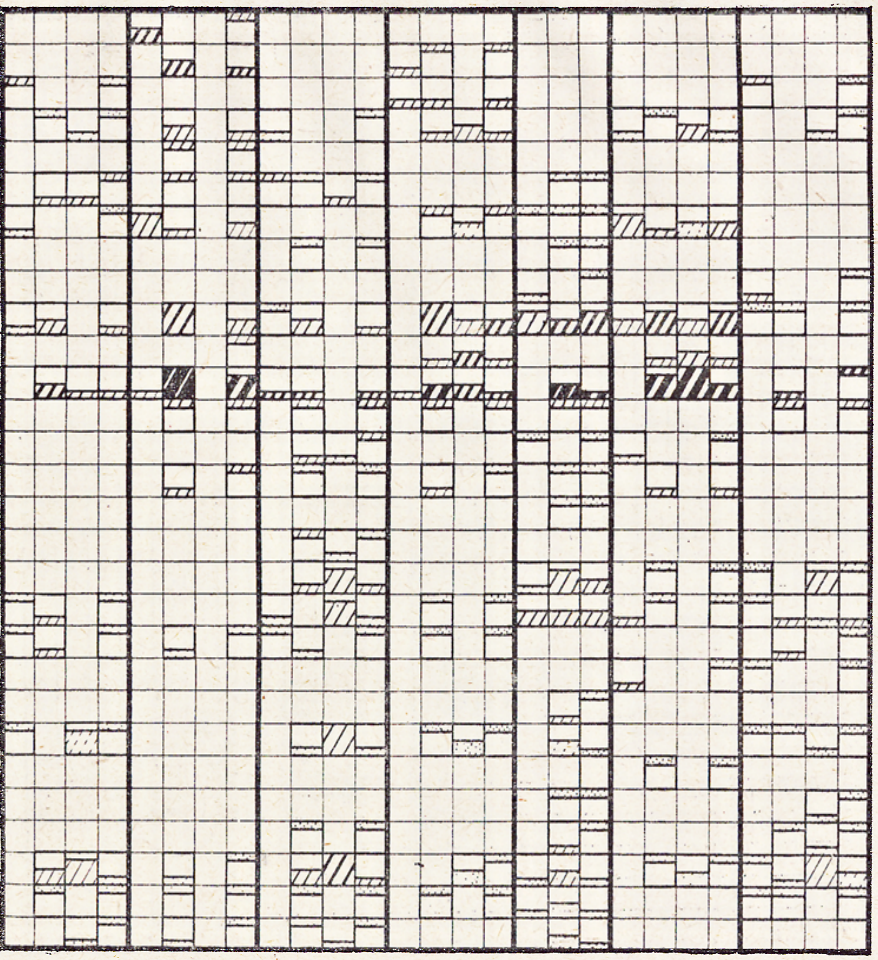
22.	– spirogyra Ehr.
23.	– sp.
24.	Phacus Lemmermannii (Swir.) Skvortzow
25.	– pleuronectes (O.F.M.) Dujardin
26.	– triqueter (E.) Dujardin
27.	– longicauda (E.) Dujardin
28.	– helicoides Pochm.
29.	– suecicus Lemm.
30.	– hispidulus (Eichwald) Lemm.
31.	Trachelomonas volvocina Ehr.
32.	– – var. derephora Conrad
33.	– lacustris Dreż.
34.	– conica Playf. fa. punctata Defl.
35.	– hispida (Perty) Stein
36.	– – var. coronata Lemm.
37.	– Kelloggii (Skv.) Deflandre
38.	– armata (E.) Stein
39.	– planctonica Swir. var. oblonga Dreż.
40.	– sp. div.
41.	Strombomonas verrucosa (v Daday) Defl. var. zmiewika (Swir.) Defl.
42.	Gymnodinium sp.
43.	Glenodinium sp.
44.	Peridinium cinctum (Müller) Ehr.
45.	– bipes Stein
46.	– sp.
47.	Ceratium hirundinella (O.F.M.) Schrank
48.	Ophiocytium capitatum Wolle
49.	Mallomonas producta Jwanoff
50.	– caudata Jwanoff



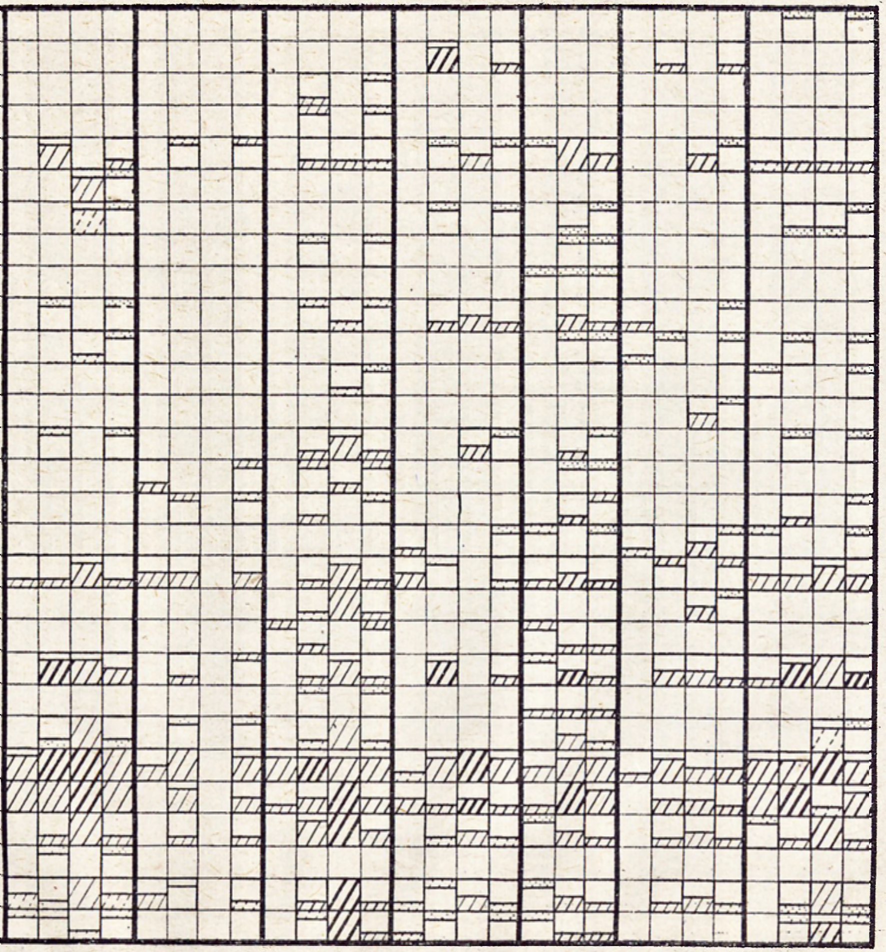
51.	– sp.
52.	Synura uvella Ehr.
53.	Dinobryon bavaricum Imhof
54.	– divergens Imhof
55.	Melosira varians Ag.
56.	– granulata (Ehr.) Ralfs
57.	– sp.
58.	Tabellaria flocculosa (Roth.) Kütz.
59.	Diatoma vulgare Bory
60.	– elongatum (Lyngb.) Ag.
61.	Fragilaria crotonensis Kitt.
62.	– capucina Desm.
63.	Synedra ulna (Nitzsch) Ehr.
64.	– acus Kütz.
65.	– sp.
66.	Asterionella formosa Hass.
67.	Achnanthes sp.
68.	Navicula cuspidata Kütz.
69.	– cryptocephala Kütz.
70.	– radiosa Kütz.
71.	– sp. div.
72.	Pinnularia sp.
73.	Pleurosigma sp.
74.	Amphora sp.
75.	Cymbella ventricosa Kütz.
76.	Gomphonema acuminatum Ehr.
77.	– constrictum Ehr.
78.	Epithemia ocellata Kütz.
79.	– sp.



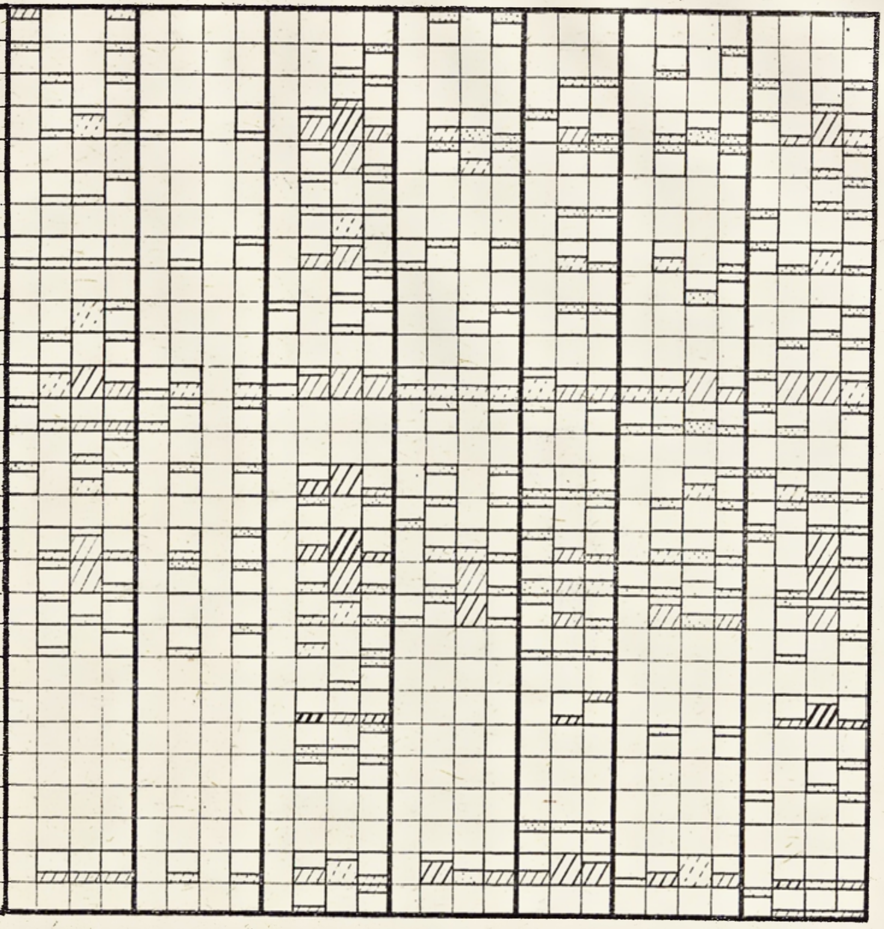
80. Hantzschia amphioxys (Ehr.) Grun.
81. Nitzschia vermicularis (Kütz.) Grun.
82. – sp.
83. Cymatopleura solea (Bréb.) W. Sm.
84. Surirella elegans Ehr.
85. – sp.
86. Bacillariophyceae sp. div.
87. Chlamydomonas sp.
88. Gonium pectorale Müller
89. Eudorina elegans Ehr.
90. Pandorina morum (Müller) Bory
91. Volvox aureus Ehr.
92. – globator Linnaeus
93. Sphaerocystis Schroeteri Chodat
94. Asterococcus superbus (Cienk.) Scherffel
95. Dispora sp.
96. Elakatothrix lacustris Korschik.
97. – gelatinosa Wille
98. Characium gracilipes Lambert
99. – limneticum Lemm.
100. – sp.
101. Tetraëdron arthrodesmiforme (G.S. West) Wołosz.
102. – caudatum (Corda) Hansg.
103. – gracile (Reinsch) Hansg.
104. – hastatum (Reinsch) Hansg.
105. – limneticum Borge
106. – minimum (A. Braun) Hansg.
107. – regulare Kütz. var. incus Teiling
108. – trigonum (Näg.) Hansg.

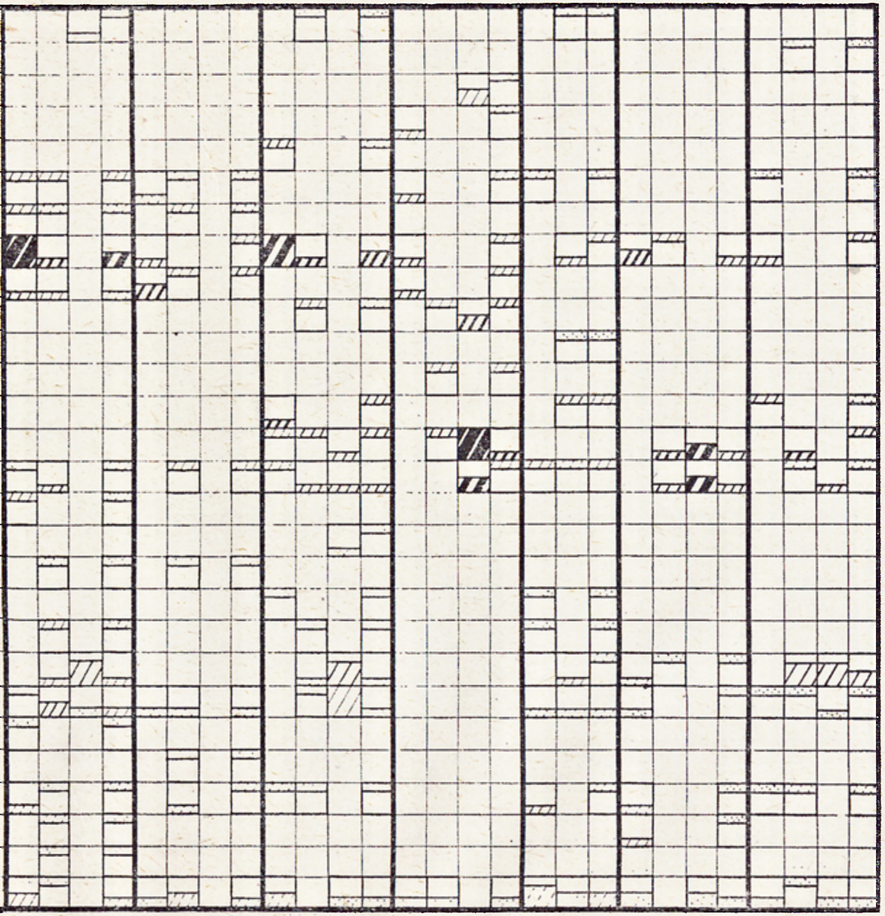


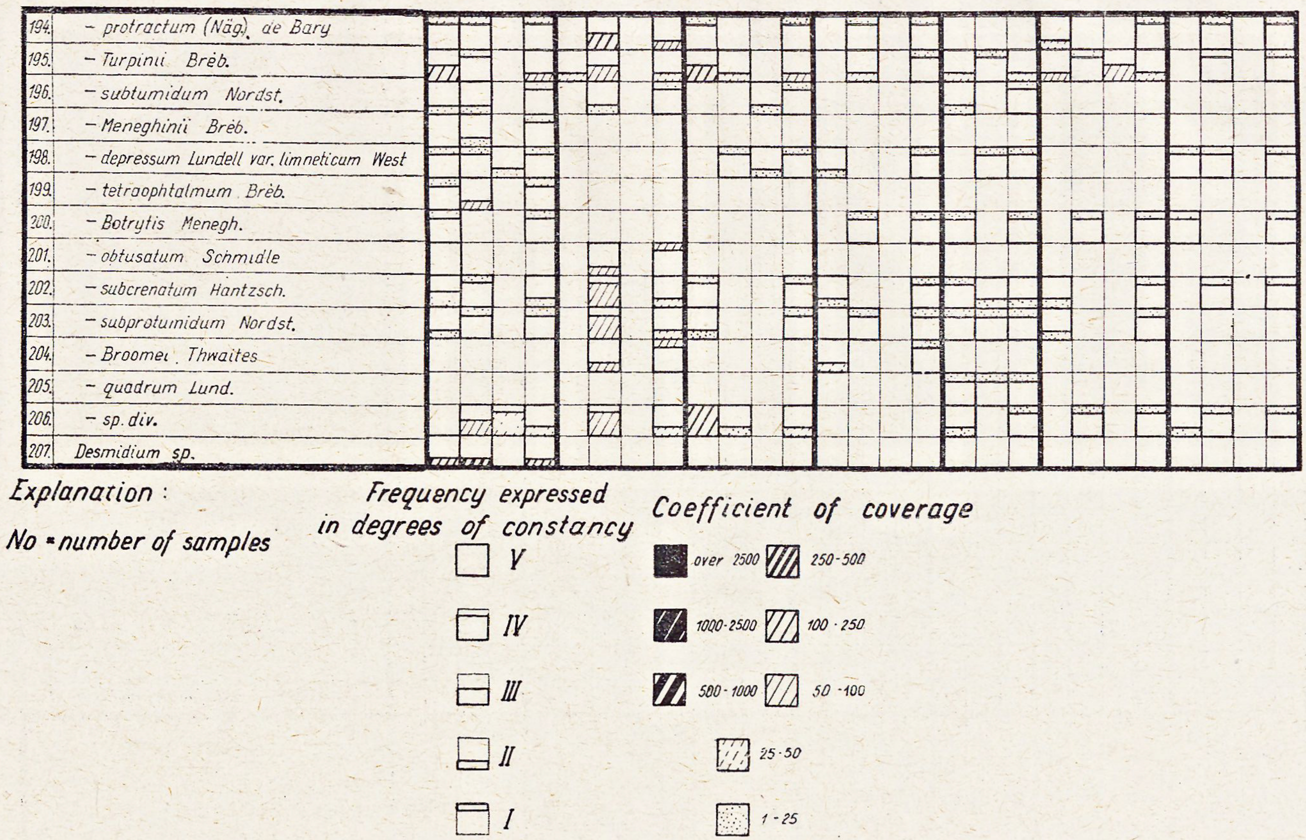
109.	— sp.
110.	Oocystis Borgei Snow
111.	— elliptica W. West
112.	— parva West and West
113.	— sp. div.
114.	Lagerheimia Chodatii Bern.
115.	— wratislaviensis Schroed.
116.	— genevensis Chodat
117.	— citriformis (Snow) G. M. Smith
118.	Botryococcus Braunii Kütz.
119.	Selenastrum gracile Reinsch
120.	— sp.
121.	Kirchneriella lunaris (Kirch) Moebius
122.	— sp.
123.	Ankistrodesmus longissimus (Lemm) Wille
124.	— acicularis (A. Br.) Korschik.
125.	— pseudomirabilis Korschik.
126.	— falcatus (Corda) Ralfs
127.	— sp. div.
128.	Schroederia sp.
129.	Dictyosphaerium pulchellum Wood
130.	— Ehrenbergianum Näg.
131.	Pediastrum tetras (Ehr.) Ralfs
132.	— Boryanum (Turp.) Menegh.
133.	— duplex Meyen
134.	— biradiatum Meyen
135.	Sorastrum spinulosum Naeg.
136.	Scenedesmus acuminatus (Lagerh.) Chodat
137.	— — var. biseriatus Reinsch

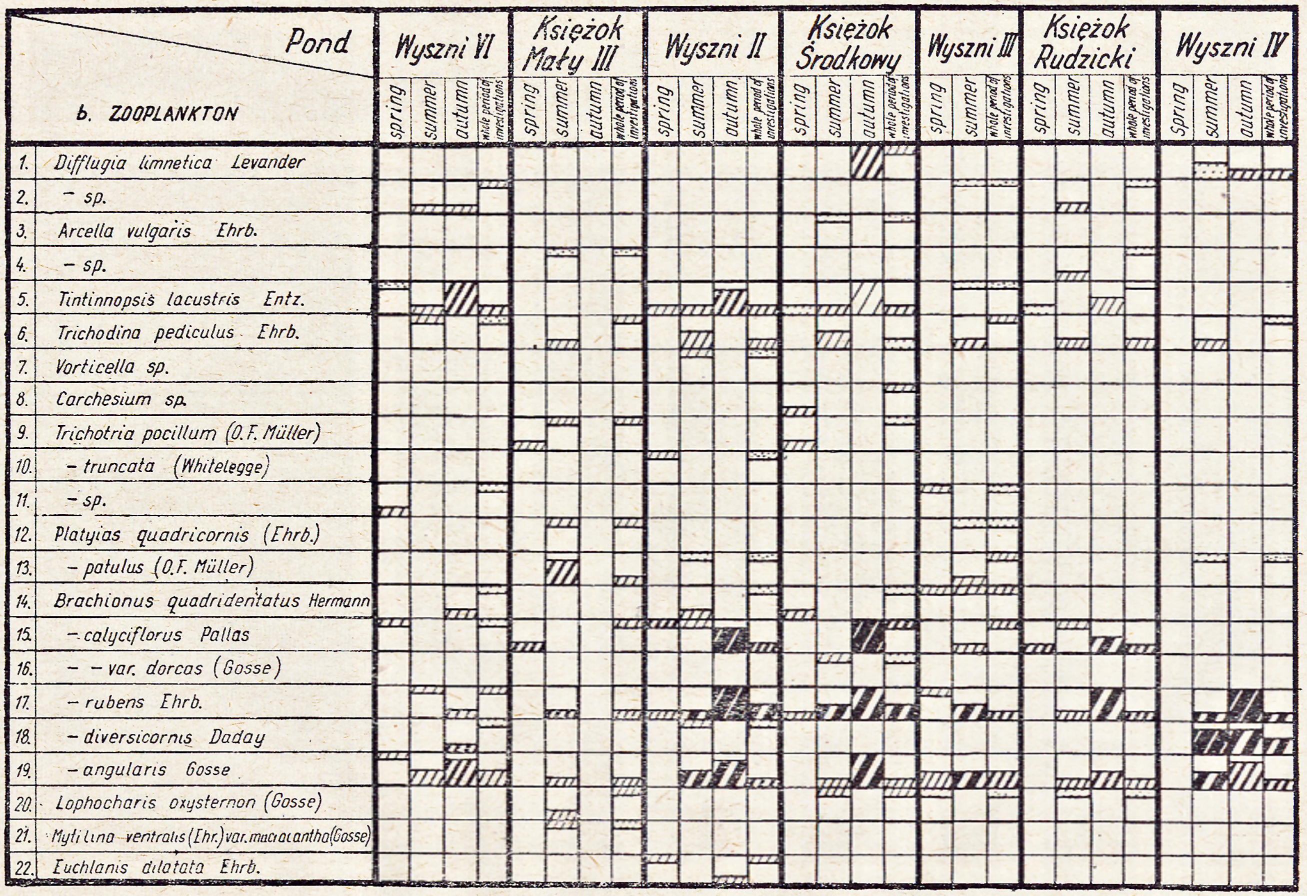


138.	– *falcatus* Chodat
139.	– *antennatus* Bréb.
140.	– *bijuga* (Turp.) Lagerh.
141.	– *arcuatus* Lemm.
142.	– *denticulatus* Lagerh.
143.	– *granulatus* W. et W. var. *verrucosus* (Roll) Deduss.
144.	– *acutiformis* Schroeder
145.	– *ecornis* (Ralfs) Chodat
146.	– *tennuispina* Chodat
147.	– *rostrato-spinosus* Chodat
148.	– *longus* Meyen var. *Naegelii* (Bréb.) G. M. Smith
149.	– *quadricauda* (Turp.) Bréb.
150.	– *Westii* (G. M. Smith) Chodat
151.	– *protuberans* Fritsch
152.	– sp. div.
153.	*Actinastrum Hantzschii* Lagerh.
154.	*Crucigenia apiculata* (Lemm.) Schmidle
155.	– *tetrapedia* (Kirch.) W. et W.
156.	– *gadrata* Morren
157.	– *rectangularis* (A. Braun) Gay
158.	– sp.
159.	*Westella botryoides* (W. West) de Wildemann
160.	*Tetrastrum staurogeniaeforme* (Schroed.) Lemm.
161.	– *heteracanthum* (Nordst.) Chodat
162.	– *elegans* Playfair
163.	– *glabrum* (Roll) Ahlstr. et Tiff.
164.	*Coelastrum microporum* Näg.
165.	– *proboscideum* Bohlin

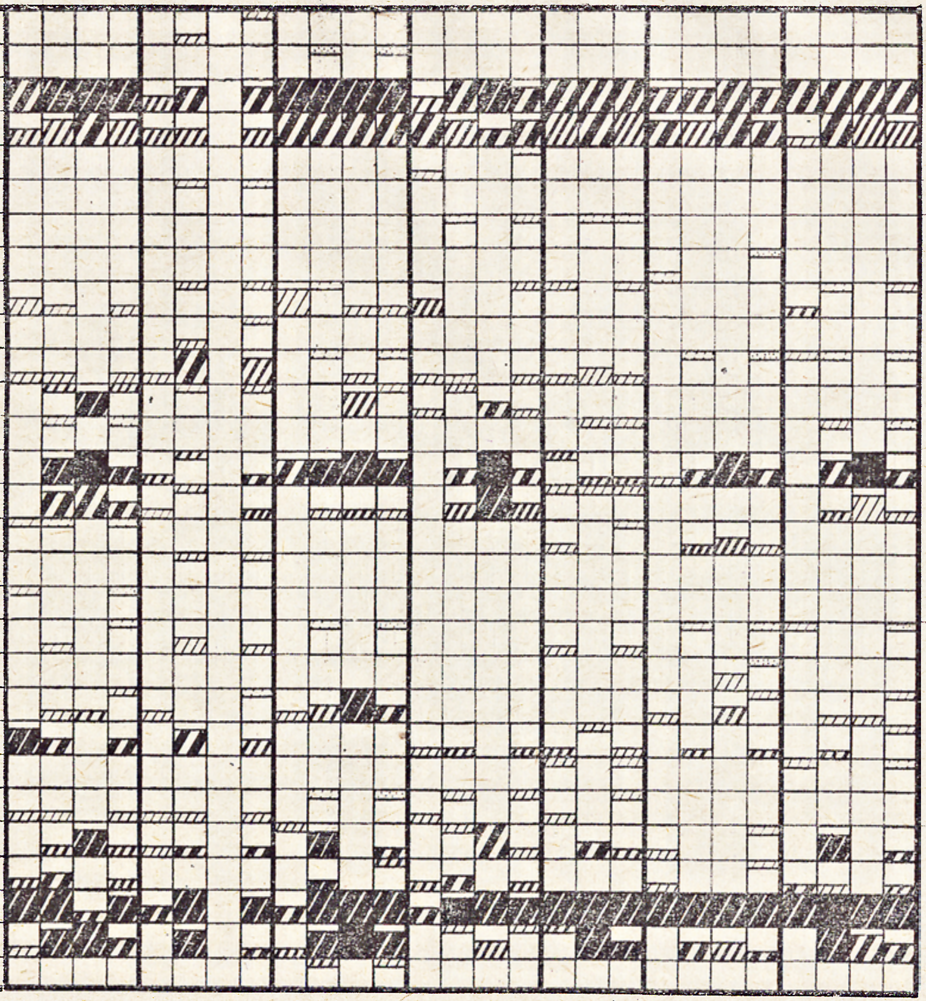


166.	– cambricum Archer	
167.	– sp.	
168.	Microspora sp.	
169.	Stigeoclonium lubricum (Dillw.) Kütz.	
170.	– sp.	
171.	Oedogonium sp.	
172.	Bulbochaete sp.	
173.	Spirogyra sp.	
174.	Zygnema sp.	
175.	Closterium acutum Bréb. var. variabile Krieger	
176.	– venus Kütz.	
177.	– malinvernianiforme Gronblad	
178.	– Pritchardianum Archer	
179.	– gracile Bréb.	
180.	– sp.	
181.	Pleurotaenium trabecula (Ehr.) Näg	
182.	Arthrodesmus incus (Bréb.) Hass.	
183.	Xanthidium antilopaeum (Bréb.) Kütz.	
184.	Staurastrum alternans Bréb.	
185.	– gracile Ralfs	
186.	– tetracerum Ralfs	
187.	– sp. div.	
188.	Euastrum dubium Näg.	
189.	– germanicum (Schm.) Krieger	
190.	– verrucosum Ehr. var. alatum Wolle	
191.	Micrasterias americana (Ehr.) Ralfs	
192.	– truncata (Corda) Bréb.	
193.	Cosmarium granatum Bréb.	

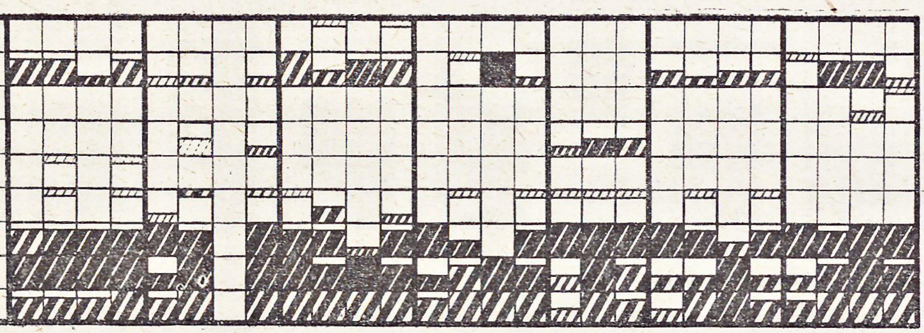

194. – protractum (Näg). de Bary
195. – Turpinii Bréb.
196. – subtumidum Nordst.
197. – Meneghinii Bréb.
198. – depressum Lundell var. limneticum West
199. – tetraophtalmum Bréb.
200. – Botrytis Menegh.
201. – obtusatum Schmidle
202. – subcrenatum Hantzsch.
203. – subprotumidum Nordst.
204. – Broomei Thwaites
205. – quadrum Lund.
206. – sp. div.
207. Desmidium sp.
Explanation :
No = number of samples
Frequency expressed in degrees of constancy
V
IV
III
II
I
Coefficient of coverage
over 2500
250-500
1000-2500
100 - 250
500 - 1000
50 - 100
25 - 50
1 - 25


Pond
b. ZOOPLANKTON
Wyszni VI
Księżok Mały III
Wyszni II
Księżok Środkowy
Wyszni III
Księżok Rudzicki
Wyszni IV
spring
summer
autumn
whole period of investigations
1. Difflugia limnetica Levander
2. – sp.
3. Arcella vulgaris Ehrb.
4. – sp.
5. Tintinnopsis lacustris Entz.
6. Trichodina pediculus Ehrb.
7. Vorticella sp.
8. Carchesium sp.
9. Trichotria pocillum (O.F. Müller)
10. – truncata (Whitelegge)
11. – sp.
12. Platyias quadricornis (Ehrb.)
13. – patulus (O.F. Müller)
14. Brachionus quadridentatus Hermann
15. – calyciflorus Pallas
16. – – var. dorcas (Gosse)
17. – rubens Ehrb.
18. – diversicornis Daday
19. – angularis Gosse
20. Lophocharis oxysternon (Gosse)
21. Mytilina ventralis (Ehr.) var. macracantha (Gosse)
22. Euchlanis dilatata Ehrb.

23.	– sp.
24.	Anureopsis fissa Gosse
25.	Keratella cochlearis Gosse
26.	– quadrata O.F. Müller
27.	Notholca squamula (O.F. Müller)
28.	Lepadella patella (O.F. Müller)
29.	– sp.
30.	Colurella uncinata (O.F. Müller)
31.	Lecane luna (O.F. Müller)
32.	– flexilis (Gosse)
33.	– lunaris (Ehrb.)
34.	Trichocerca cylindrica (Imhof)
35.	– sp.
36.	Asplanchna priodonta Gosse
37.	Polyarthra vulgaris Carlin
38.	– sp.
39.	Synchaeta sp.
40.	Testudinella parva (Ternetz)
41.	– patina (Hermann)
42.	Pedalia mira (Hudson)
43.	Filinia longiseta (Ehrb.)
44.	Conochilus unicornis Rousselet
45.	– sp.
46.	Rotatoria n. det.
47.	Diaphanosoma brachyurum Liéven
48.	Daphnia pulex de Geer
49.	– longispina O.F. Müller
50.	Ceriodaphnia quadrangula O.F. Müller
51.	– sp.



52. *Moina sp.*
53. *Bosmina longirostris O.F. Müller*
54. — *coregoni Baird*
55. — *sp.*
56. *Alonella sp.*
57. *Polyphemus pediculus Linne*
58. *Diaptomidae*
59. *Cyclopidae*
60. *Nauplii*



in the ponds Wyszni II and Wyszni VI and the smallest in the pond Księżok Mały III (Table III). Out of phytoplankton forms encountered during the investigated period *Chlorophyceae* reached the greatest sum of coverage indices and were represented by the largest number of species in all ponds (especially in the pond Wyszni II). The most numerous among them were species of the order *Protococcales* belonging chiefly to the genera *Pediastrum, Scenedesmus, Tetraëdron*, and *Crucigenia*. The next forms observed in the floristic spectrum of the ponds were represented successively according to the magnitude of the sum of coverage indices by *Chrysophyceae* and *Conjugales* — pond Wyszni VI, *Bacillariophyceae* — pond Księżok Środkowy, *Cyanophyceae* — pond Wyszni III, and *Euglenophyceae* — pond Księżok Rudzicki.

The peak development of phytoplankton occurred in the summertime (end of July and second decade of August). On some dates (especially on the 24th of August) some species also produced water-blooms, as for instance, *Eudorina elegans, Volvox aureus, Dinobryon divergens, Synura uvella, Mallomonas caudata*, or *Anabaena* sp. div. In the pond Wyszni III (on the 6th of August) the genus *Anabaena* was accompanied by *Brachionus angularis*, occurring in great numbers. This is interesting in so far as generally no mass appearance of zooplankton was observed with simultaneous bloom of phytoplankton.

As concerns the raw contents of plankton, it was found that the composition of the measured sediment had an effect on its consistence and volume (fig. 1). The greatest amount of sediment (10 ml.) was noted on the 23rd of June in the pond Wyszni IV and the least (0.2 ml.) several times in different ponds and on various dates. No correlation was observed between the raw contents of sediment and the amount of plankton in the periods of its most abundant occurrence. Nevertheless, their greatest values were noted as a rule in the summertime, especially in fertilized ponds. Thus, the amount of sediment may help to estimate approximatively the productivity of ponds, not, however, being a sure indicator.

In the investigated phytoplankton species were distinguished occurring in one or several ponds exclusively in the spring, summer, or autumn, or else during the whole period of investigations (Table III). In each season a more important share of some of them could be observed, e. g. the greatest number of diatoms appeared in the spring; they were accompanied by filamentous green algae and desmids. In summer green algae, chiefly chlorococcous, and blue-green algae were mostly noted, while in the autumn euglenins occurred in the greatest numbers. On the whole, the largest number of species was observed in the summertime. All the mentioned species formed the most numerous group and occurred irregularly; they can be determined as seasonal. The second group was represented by species occurring during the whole period of investigations (constant):

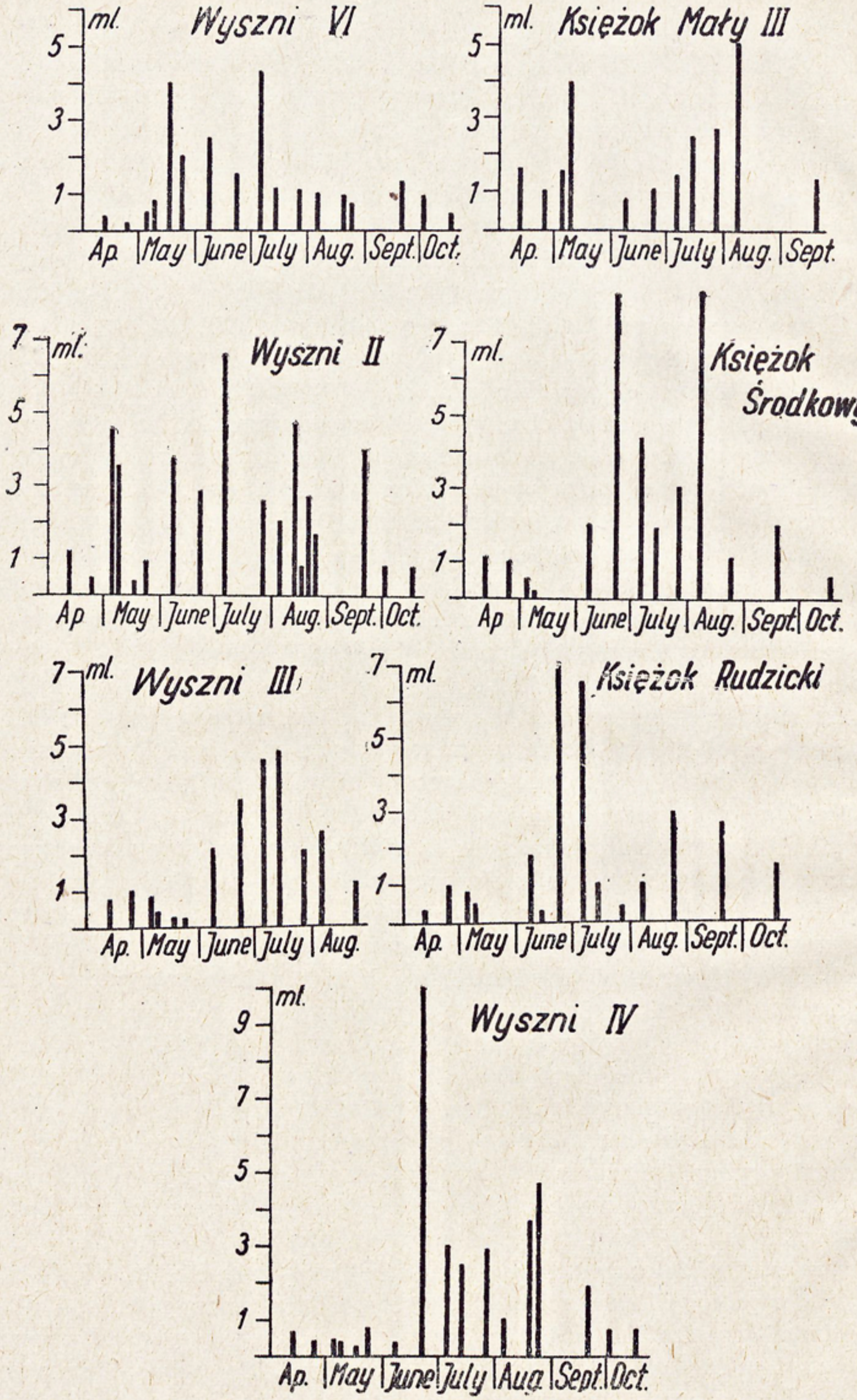


Fig. 1. Raw volume of plankton in ml. per 50 l. of water

A. in all ponds (*Trachelomonas volvocina, Pediastrum Boryanum,* and *Scenedesmus quadricauda*)

B. in the majority of ponds (*Ceratium hirundinella* and *Pediastrum duplex*)

C. only in one pond (*Lagerheimia citriformis, Tetrastrum glabrum, Cosmarium quadrum*).

The species given in points A and B were frequently noted as dominants of the degree of constancy IV and V, of high coefficient of coverage, those given in point C as adominants.

The spring, summer and autumn aspects of plankton are presented in Table I on the basis of species prevailing in the given season; the floristic and faunistic composition is shown in Table III.

Taking into consideration publications concerning the investigated area the existing systematic lists were complemented with the following species of plant plankton: *Merismopedia elegans, Anabaena spiroides* var. *crassa, A. oscillarioides, Phacus Lemmermannii, Trachelomonas volvocina* var. *derephora, Tr. conica* fa. *punctata, Tr. Kelloggii, Strombomonas verrucosa* var. *zmiewika, Peridinium bipes, Navicula cuspidata, Nitzschia vermicularis, Hantzschia amphioxys, Gomphonema acuminatum, Surirella elegans, Lagerheimia Chodatii, L. citriformis, Scenedesmus tennuispina, S. protuberans, Tetrastrum elegans, Closterium Pritchardianum, Micrasterias truncata, Cosmarium depressum* var. *limneticum.* The sociological role of these species was of no great importance on account of their scanty occurrence, low degree of constancy, and small coefficient of coverage (Table III).

The zooplankton

Altogether 39 species from 33 genera, and 2 varieties were distinguished, and among copepods 2 families and their juvenile form nauplius. The greatest number and variety of species were observed in the pond Wyszni II.

All systematic groups discriminated in the zooplankton reached the greatest sum of coverage indices in the pond Wyszni II and the smallest in the ponds Księżok Mały III and Księżok Rudzicki (Table IV). A comparison of the sum of coverage indices of phyto- and zooplankton shows that this sum is for algae half that for animals, although the number of species and higher systematic units of the former is more than three times as large as that of the latter.

The forms which, during the whole investigated period, reached in most ponds the greatest sum of coverage indices and the greatest number of species were represented by *Rotatoria* (chiefly *Keratella cochlearis, K. quadrata,* and *Asplanchna priodonta,* and species of the genus *Brachio-*

Table IV

Floristic and faunistic spectrum

A = Number of species and higher systematic units
B = Sum of coverage indices

Pond	Wyszni VI		Księżok Mały III		Wyszni II		Księżok Srodkowy		Wyszni III		Księżok Rudzicki		Wyszni IV		General	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Cyanophyceae	8	72.5	12	120.0	7	138.5	7	154.0	13	192.5	7	55.0	8	181.0	18	913.5
Euglenophyceae	10	44.0	8	39.0	15	135.5	14	94.0	4	19.0	18	142.0	10	66.5	23	540.0
Dinophyceae	2	66.5	3	59.0	2	33.0	3	24.0	3	31.5	2	24.0	2	33.0	6	271.0
Heterokontae					1	10.5							1	1.5	1	12.0
Chrysophyceae	5	232.5	2	77.0	1	10.5	4	54.5	3	20.5	5	61.5	2	36.0	6	492.5
Bacillariophyceae	16	166.0	23	171.0	13	74.0	18	198.5	9	43.0	17	149.5	8	25.0	31	827.0
Chlorophyceae (excl. Conjugales)	43	340.0	30	249.0	59	597.5	39	309.0	56	474.0	37	339.0	52	397.5	86	2706.0
Conjugales	24	275.5	16	86.0	19	196.0	14	101.0	18	58.0	14	105.5	14	89.5	35	911.5
Total	108	1197.0	94	801.0	117	1195.5	99	935.0	106	838.5	100	876.5	97	830.0	206	6673.5
Protozoa	3	30.0	2	7.5	3	42.0	5	52.0	3	13.5	4	24.0	2	25.5	8	194.5
Rotatoria	20	936.0	23	526.5	19	1083.0	18	627.0	21	499.0	14	477.5	15	760.5	37	4909.5
Cladocera	7	702.0	6	392.0	8	936.0	6	435.5	5	568.0	6	484.0	6	816.0	10	4333.5
Copepoda	3	607.5	3	482.0	3	700.5	3	423.5	3	444.0	3	415.0	3	630.0	3	3702.5
Total	33	2275.5	34	1408.0	33	2761.5	32	1538.0	32	1524.5	27	1400.5	26	2232.0	58	13140.0

nus). Then came *Cladocera* (especially *Daphnia longispina, Bosmina longirostris*, and *Ceriodaphnia quadrangula*), relatively *Copepoda*, while the last in this respect were *Protozoa* (Table IV). All the mentioned groups, with the exception of *Protozoa*, were noted most numerously in the pond Wyszni II. On the whole, rotifers prevailed over the other groups as regards the number and variety of species. However, on account of their smaller dimensions, they did not equal cladocerans or copepods in the magnitude of the coefficient of coverage (Table III). For this reason they were often disregarded in the final naming of the community. The quantitative relationships between the groups were not the same in the particular ponds, but these differences were of no great significance (Table IV). In the initial period of investigations animal individuals (especially from among cladocerans and copepods) were found more numerously than plant specimens. The greatest amounts of zooplankton were noted towards the end of July and in October.

Similarly as in the case of plants, species were found in one or several ponds, being characteristic exclusively for the particular seasons and for the whole investigated period (Table III). Taking the latter into account they can be divided into species occurring:

A. in all ponds (*Keratella cochlearis, K. quadrata, Daphnia longispina, Cyclopidae*, and their juvenile forms)

B. in the majority of ponds (*Diaptomidae, Asplanchna priodonta, Bosmina longirostris*)

C. and showing a continuity of occurrence in some ponds, while seasonally appearing in others (*Brachionus quadridentatus, Lecane luna, Trichocerca cylindrica, Filinia longiseta, Polyphemus pediculus*).

The species mentioned in points A and B usually represented dominants of a very high coefficient of coverage, those referred to in point C were more rarely dominants, being rather sub- or adominants.

Such species as: *Platyias quadricornis, Brachionus calyciflorus* var. *dorcas, Mytilina ventralis* var. *macracantha, Notholca squamula, Lecane flexilis*, or *Testudinella parva*, being most frequently typical adominants (Table III), enlarged the list of rotifers hitherto reported from these ponds.

Remarks on the Distinguished Plankton Communities

Some communities were discriminated in the plankton of the investigated ponds. Their differentiation was based on dominant species of the greatest coefficient of coverage, giving a notion of their position within these communities. As is known, many dominants are ubiquists, so that it was not purely accidental that they recurred in all ponds. To be exact, accessory species were sometimes found, being related to one pond, but they occurred as single specimens so that it would have been difficult to base on them the discrimination of communities.

Mention should be made here of M i z u n o's (1954, 1955, 1956) works, in which this author discriminated plankton communities on the basis of characteristic species. Among others, he reports, for instance, the following composition of a community of *Protozoa: Arcella vulgaris, Difflugia corona, Euglena acus, Ceratium hirundinella, Eudorina elegans, Volvox aureus*, and others. The quoted author carried out these investigations in numerous ponds in Japan, of varying geological substratum and variously cultivated. He also paid attention to some species present in almost all ponds, or else occurring only in some of them. This, in his opinion, was related to the intensity of the pollution of water, determining the degree of its trophism, and not only to the sole amount of salts dissolved in it. According to this author, the values of the latter were not so extremely high as to have an effect on the development of plankton communities.

To characterize the pond environment on the basis of communities discriminated in them a comparison was made in the present work of ponds cultivated in the same way. It was found that during the investigated period in the non fertilized ponds Wyszni VI and Księżok Mały III there developed communities composed of *Dinobryon divergens* + *Cyclopidae* in the former and of *Volvox aureus* + *Diaptomidae* + *Cyclopidae* in the latter. In the other fertilized ponds, such as Wyszni II and Księżok Środkowy, the communities distinguished were composed of *Pediastrum Boryanum* + *Cyclopidae* and *Pediastrum Boryanum* + *Daphnia longispina*, in the ponds Wyszni III and Księżok Rudzicki of *Eudorina elegans* + *Daphnia longispina*, and in the pond Wyszni IV of *Pediastrum duplex* + *Daphnia longispina* (Table I). As can be seen, it is only in ponds Wyszni III and Księżok Rudzicki (equally fertilized) that there developed plankton communities of analogous pattern of dominant species throughout the whole investigated period.

The plankton communities discriminated in the particular ponds showed a certain seasonal variability. A decrease or increase in the number of their particular components was often noted in the different seasons and ponds, which brought about a change in their qualitative composition (Table III).

The names of communities were determined according to the dominant species of the greatest coefficient of coverage. Some of the characteristic plants reached the highest values of the coefficient of coverage during the summer or autumn as, for instance, *Dinobryon divergens* in summer in the pond Wyszni VI, and *Synura uvella* in autumn in the pond Księżok Rudzicki; as concerns the animal plankton this usually occurred during the season of autumn, e. g. *Bosmina longirostris* in the pond Księżok Środkowy (Table I). On the whole, the greatest numbers of dominants, of sub- and adominants, as well as the greatest sums of their coverage indices were noted in the summertime, and the smallest in the spring, this referring both to plants and animals. In three fertilized ponds: Wyszni II, Księżok Środkowy, and Wyszni III it was at this season that blue-green algae and cladocerans were the dominant forms in the communities, while in the other ponds green algae prevailed as a rule with cladocerans in the fertilized ponds and with copepods in those not being fertilized (Table I). It follows from the above data that fully developed communities are related to this period, this being also observed by Szklarczyk-Gazdowa (1965). This author investigated various ponds in the basin of the Upper Vistula including those belonging to three experimental fishery farms of the Ochaby complex, of which the pond Wyszni II is also dealt with in the present work. She reported from these ponds for the season of summer a fully developed community, naming it *Dinobryon divergens* + *Copepoda*.

Thus, all plant communities of the investigated ponds should, after Symoens (1951), be assigned to the *Cyano-Bacillariophycion planctonicum eutroficum* alliance, composed of blue-green algae, diatoms, and protococcous algae. On the other hand, animal communities should be related (according to Šrámek-Hušek, 1962) to the association *Daphnio-Bosminetum longirostris*. This association includes plankton communities of highly eutrophic waters with predominance of heleoplankton components, chiefly from *Cladocera*, *Copepoda*, and *Rotatoria*. It corresponds to the complex E-H in Bowkiewicz's (1935) system and, according to Šrámek-Hušek's assumption, occurs in Czechoslovakia in strongly fertilized fish-ponds.

On the basis of the composition of plankton communities, it can be presumed that their character was determined on the one hand chiefly by green algae of the order *Chlorococcales*, and in a certain period also by blue-green algae, and on the other, by representatives of *Cladocera*, sometimes of *Copepoda* (especially in the spring), and *Rotatoria* (most often in the autumn) (Table I).

Some authors relate the mass appearances of chlorococcous algae to fertilization with nitrogen (Movčan 1955, Gajevskaja quoted by Vinberg 1952, Pidgaiko, Radzimovskij 1959, Veltiščeva quoted by Žadin 1959, Krzeczkowska 1963), and that of blue-green algae to phosphatic fertilization (Wunder et al. 1935, Langhans 1936, Vinberg 1952, Sosnowska 1956, Schäperclaus 1957, Müller 1958, Krzeczkowska 1961).

According to Klimczyk (1964), fertilization with superphosphate favours the development of copepods, while the use of organic fertilizers that of cladocerans. Langhans (1936), Weimann (1938), and Klimczyk (1964) consider some cladocerans (especially *Daphnia longispina*) to be typical of fertile ponds. In the opinion of other authors

(Kulamowicz 1956, Pejler 1961) this refers to rotifers (particularly to the genera *Brachionus* and *Keratella*).

It should be noted that it was just the above mentioned species, regarded by some authors as indicators of fertile waters, which were most frequently and most numerously found in the investigated ponds.

As concerns the opinion of the quoted authors, it would hardly be possible in the case of these ponds to attribute the strong development of the given groups of plant or animal plankton to the effect of one or other kind of fertilization on account of mixed fertilizers being applied here. For this reason, in accordance with such authors as Pauly (1919), Smith and Swingle (1939), Rodina et al. (1954), Rodina (1958), Movčan (1955), Starmach (1958), Ozereckovskaja and Smirnova (1959), Žadin (1959), and Wróbel (1959, 1962) it seems more justified to regard the mixed N+P fertilization as the most propitious for the development of plankton.

Taking this into account as well as the highest value of the summarized coverage index reached by green algae, rotifers, cladocerans, and copepods in the pond Wyszni II one may conclude that it is in this very pond that the action of N+P fertilization is most strongly marked as compared with the other, likewise fertilized ponds. Wróbel (1962) established in them a very strong effect of this kind of fertilization on the primary production of phytoplankton and on the yield of fish, especially in the ponds Księżok Rudzicki, Wyszni IV, Wyszni II, and others (Table I). The present investigations showed no such marked effect of N+P fertilization in the first two ponds as compared with the pond Wyszni II, this being apparent in the summarized coverage index, especially with regard to plants (Table I). On the other hand, in the pond Wyszni VI (not fertilized) the value of the index was very high, which did not agree with the estimation of the ponds based on chemical investigations. It should be added that in some periods there appeared in the phytoplankton of this pond a predominance of *Spirogyra* sp. (in the spring) and of *Dinobryon divergens* (in summer), which indubitably had an effect on the shaping of the magnitude of the sum of coverage indices (Table III).

An attempt was also made to determine the degree of trophism in the investigated ponds with the aid of the Thunmark (1945) chlorophycean and the Nygaard (1949) compound quotients. However, it should be noted that the values of both quotients were higher in fertilized ponds than in the non-fertilized ones, though in both cases they lay within the limits of medium eutrophy. This is therefore partly in agreement with the results of chemical investigations (Table I), which always showed a strong eutrophy in fertilized ponds (Wróbel 1962). As is known, the value of the above quotients is determined by the number of desmid species increasing, according to Nygaard (1949), in oligotrophic waters. Thus, the estimation of the degree of trophism of ponds on this basis has rather an indicatory character, as was already observed by the author in an earlier work (Bucka 1960). This is also the opinion of Szklarczyk-Gazdowa (1965), who considers that these quotients are more appropriate for distinguishing the type of investigated waters than for determining the degree of their fertility.

The results of the present investigations confirm the possibility of characterizing the water environment on the basis of the plankton communities distinguished in it. The knowledge of their specific composition also makes it possible in some measure to determine the character of the habitat in which they develop.

Results

1. The greatest sum of coverage indices and the greatest number of species was reached in phytoplankton by *Chlorophyceae*, (chiefly of the order *Chlorococcales*), and in zooplankton by *Rotatoria*.

2. The greatest number and variety of plant and animal species was observed in the pond Wyszni II.

3. A comparison of the sum of coverage indices of all the mentioned groups of plant and animal plankton shows that this sum is for plant organisms half that for the animal ones, which should to be explained by the difference in their dimensions.

4. Among dominant species of high coefficient of coverage some were found to occur in all ponds or in most of them during the whole investigated period, as for instance, *Trachelomonas volvocina*, *Scenedesmus quadricauda*, *Ceratium hirundinella*, *Pediastrum Boryanum*, *P. duplex*, *Keratella cochlearis*, *K. quadrata*, *Daphnia longispina*, *Asplanchna priodonta*, and others.

5. The above-mentioned were constant species and quantitatively formed a much smaller group than seasonal species, occurring irregularly.

6. In certain periods (chiefly towards the end of August) some species, as for instance, *Eudorina elegans*, *Volvox aureus*, *Dinobryon divergens*, *Synura uvella*, *Mallomonas caudata*, or *Anabaena* sp. div. produced water blooms.

7. When determining the name of the community, rotifers were often disregarded on account of their smaller dimensions as compared with cladocerans and copepods which, in spite of their quantitative and qualitative predominance they did not equal as a rule in the magnitude of the coefficient of coverage.

8. The plankton communities discriminated on the basis of dominant species of the greatest coefficient of coverage were characterized by a certain seasonal variability.

9. On the basis of the composition of plankton communities it was found that their character is determined chiefly by species of the order *Chlorococcales* and by representatives of *Cladocera* and *Copepoda*, which would point to a similarity between the ponds.

10. The greatest numbers of dominants, of sub- and adominants as well as the greatest sums of their coverage indices were noted in the season of summer, both within plant and animal plankton, which would indicate that fully developed communities are related to this period.

11. All plant communities of the investigated ponds were assigned after Symoens (1951) to the alliance of plankton associations of eutrophic waters called *Cyano-Bacillariophycion planctonicum eutroficum*, the animal communities being included in accordance with Šrámek-Hušek (1962) in the association *Daphnio-Bosminetum longirostris*.

12. The investigations confirmed the possibility of characterizing the water environment on the basis of the knowledge of the specific composition of plankton communities discriminated in it.

13. The degree of trophism of the investigated ponds, determined by means of the Thunmark (1945) chlorophycean and the Nygaard (1949) compound quotients, reached higher values in fertilized ponds and smaller ones in those which were not fertilized, this being corroborated by the results of chemical investigations (Wróbel 1962). In both cases the values of the quotiens lay within the limits of medium eutrophy and thus were not entirely in agreement with the chemical data, which showed a strong eutrophy in fertilized ponds.

14. The application of these quotients to determine the degree of the trophism of water has therefore an indicatory character, since their value is decidedly influenced by the number of desmid species, being much larger in oligotrophic waters (Nygaard 1949).

15. The investigations showed that the amount of plankton sediment is no exact indicator of the productivity of ponds and can only serve for their approximate estimation.

16. In the fertilized ponds a more numerous occurrence of protococcous algae was noted as a rule, many authors considering these forms to be indicators of fertile waters. Also higher total coverage indices for plant and animal groups were recorded in these ponds.

17. On the basis of the present work and of chemical investigations carried out simultaneously, as well as of data from the literature, it was established that mixed N+P fertilization is the most propitious for the development of plankton, the strongest effect of this kind of fertilization being observed in the pond Wyszni II.

STRESZCZENIE

W 1961 r. z inicjatywy Prof. dr Karola Starmacha podjęto badania planktonu stawów rybnych w Zespole Ochaby.

Do scharakteryzowania zbiorowisk planktonowych zastosowano tytułem próby metodę socjologiczną, zaproponowaną przez Profesora Starmacha.

Badaniami objęto dwa stawy nie nawożone oraz pięć nawożonych nawozami azotowo-fosforowymi (Tabela I). Próby planktonu pobierano z 50 l wody siatką nr 25. W trakcie badań mikroskopowych określano gatunki oraz ich stosunki ilościowe i wielkość według 6-stopniowych skali (Starmach 1962). Opracowanie cech analitycznych było podstawą do sporządzenia tabel, ujmujących z kolei następujące cechy syntetyczne: frekwencję wyrażoną w stopniach stałości, dominację, spektrum florystyczne i faunistyczne, współczynnik pokrycia, współczynniki troficzności.

Przy charakteryzowaniu badanego środowiska stawowego wyróżniono zbiorowiska planktonowe dla sezonu wiosennego, letniego, jesiennego oraz dla całego badanego okresu. Za kryterium podziału na sezony przyjęto średnią miesięczną temperaturę wody.

Ogółem w fitoplanktonie oznaczono 152 gatunki, z 79 rodzajów i 12 odmian (Tabela III). W badanym okresie największą sumę wskaźników pokrycia oraz największą liczbę gatunków we wszystkich stawach uzyskały *Chlorophyceae* (szczególnie w stawie Wyszni II). Dalsze pozycje w spektrum florystycznym zajmowały kolejno według wielkości sumy wskaźników pokrycia *Chrysophyceae* i *Conjugales* w stawie Wyszni VI, *Euglenophyceae* w stawie Księżok Rudzicki (Tabela IV).

Największe nasilenie występowania fitoplanktonu przypadło na sezon letni (koniec lipca i druga dekada sierpnia). W pewnych terminach (głównie 24. VIII.) dochodziło do zakwitów niektórych gatunków, jak np.: *Eudorina elegans, Volvox aureus, Dinobryon divergens, Synura uvella* i innych.

W obrębie fitoplanktonu wyróżniono gatunki sezonowe oraz trwałe, notowane przez cały okres badań we wszystkich stawach lub w większości z nich, np.: *Trachelomonas volvocina, Pediastrum Boryanum, P. duplex, Scenedesmus quadricauda, Ceratium hirundinella.* Występowały one najczęściej jako dominanty IV i V stopnia stałości, o dużym współczynniku pokrycia (Tabela III).

Rzadko natomiast znajdowano takie gatunki, jak np.: *Lagerheimia citriformis, Tetrastrum glabrum,* które stanowiły typowe adominanty.

Wśród zooplanktonu wyróżniono 39 gatunków, z 33 rodzajów, 2 odmiany, z widłonogów 2 rodziny oraz ich formę młodocianą (Tabela III). W całym badanym okresie największą sumę wskaźników pokrycia oraz największą liczbę gatunków uzyskały *Rotatoria*, następnie *Cladocera* oraz *Copepoda*, najmniejszą *Protozoa* (Tabela IV).

Na ogół wrotki przewyższały inne grupy liczebnością i różnorodnością gatunków, jednak ze względu na mniejsze wymiary nie dorównywały wioślarkom i widłonogom wielkością współczynnika pokrycia, zatem często nie uwzględniano ich przy ustalaniu nazwy zbiorowiska.

Największe ilości zooplanktonu obserwowano z końcem lipca i w październiku.

W zooplanktonie, analogicznie jak w fitoplanktonie, we wszystkich stawach lub w ich większości występowały gatunki sezonowe oraz trwałe. Do tych ostatnich należały: *Keratella cochlearis, K. quadrata, Daphnia longispina, Asplanchna priodonta, Bosmina longirostris* i inne. Zazwyczaj były to dominanty IV i V stopnia stałości, o dużym współczynniku pokrycia (Tabela III).

Oprócz nich znajdowano sporadycznie takie gatunki, jak: *Platyias quadricornis, Anureopsis fissa, Lepadella patella,* będące typowymi adominantami.

W oparciu o poprzednie publikacje, odnośnie do badanego terenu, uzupełniono dotychczasowe listy systematyczne 28 gatunkami roślin i zwierząt planktonowych.

Z porównania sumy wskaźników pokrycia wymienionych grup planktonu wynika, że jest ona dwukrotnie mniejsza dla organizmów roślinnych niż dla zwierzęcych, co należy tłumaczyć różnicą ich wymiarów (Tabela IV).

W planktonie badanych stawów wyróżniono zbiorowiska roślinne i zwierzęce. Opis zbiorowisk wykonano w oparciu o gatunki dominujące, o największym współczynniku pokrycia, co daje pogląd na ich rolę w zbiorowisku. Biorąc pod uwagę, że heleoplankton jest mieszaniną form pelagiczno-dennych, potraktowano jako planktonty poszczególne jego składniki zarówno okresowe, jak i stałe. Niejednokrotnie wskutek niemożliwości oznaczenia do gatunku, poprzestawano na podaniu rodzaju lub wyższej jednostki taksonomicznej, by zgodnie z zaleceniem Thunmarka (1945) nie wypaczać obrazu zbiorowiska.

Największe liczby dominantów, sub- i adominantów oraz największe sumy ich wskaźników pokrycia notowano w lecie, zarówno w obrębie planktonu roślinnego, jak i zwierzęcego, co potwierdzałoby, że z tym okresem wiążą się w pełni wykształcone zbiorowiska (Tabela III). Te ostatnie wykazywały pewną zmienność sezonową (Tabela I).

Na podstawie składu zbiorowisk planktonowych stwierdzono, że o ich charakterze decydowały na ogół gatunki *Chlorophyta* oraz *Cladocera* lub *Copepoda*, co wskazywałoby na podobieństwo między stawami.

Wszystkie zbiorowiska roślinne badanych stawów zaliczono za Symoensem (1951) do związku zespołów planktonowych wód eutroficznych o nazwie *Cyano-Bacillariophycion planctonicum eutroficum*, a zwierzęce według Šrámka-Huška (1962) do asocjacji *Daphnio-Bosminetum longirostris*.

Badania potwierdziły możliwość scharakteryzowania środowiska wodnego, w oparciu o znajomość składu gatunkowego wyróżnionych w nim zbiorowisk planktonowych.

Stopień troficzności badanych stawów określony za pomocą współczynników zielenicowego Thunmarka (1945) i złożonego Nygaarda (1949) osiągnął większe wartości w stawach nawożonych, niż w nie nawożonych, co potwierdziły też wyniki badań chemicznych (Wróbel 1962). W obu przypadkach wartości współczynników mieściły się w granicach umiarkowanej eutrofii, a zatem nie były zupełnie zgodne z danymi chemicznymi, które wykazywały w stawach nawożonych silną eutrofię (Tabela I). Zastosowanie powyższych współczynników do określenia stopnia troficzności wody ma więc charakter orientacyjny, gdyż na ich wartość wpływa decydująco zmienna liczba gatunków desmidii, znacznie większa w wodach oligotroficznych (Nygaard 1949).

Badania wykazały, że ilość osadu nie jest dokładnym wskaźnikiem produkcyjności stawów, a może służyć tylko do orientacyjnej ich oceny (ryc. 1).

W stawach nawożonych notowano z reguły liczniejsze występowanie glonów protokokkowych, które wielu autorów uważa za wskaźniki wód żyznych oraz większe sumaryczne wskaźniki pokrycia dla grup roślinnych i zwierzęcych.

Na podstawie niniejszej pracy i równolegle z nią prowadzonych badań chemicznych oraz danych z literatury (Pauly 1919, Smith i Swingle 1939, Rodina i inni 1954, Rodina 1958, Movčan 1955, Starmach 1958, Ozereckovskaja i Smirnova 1959, Žadin 1959, Wróbel 1959, 1962) uznano nawożenie azotowo-fosforowe za najbardziej korzystne dla rozwoju planktonu, przy czym najsilniejszy wpływ tego nawożenia obserwowano w stawie Wyszni II.

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