ACTA HYDROBIOL. | 6 | 1 | 1—11 | KRAKOW 1964

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Wymoczki występujące wśród skoszonej roślinności w stawach — Infusoria appearing on the mowed plants in ponds

Mémoire présenté le 4 février 1963 dans la séance de la Commission Biologique de l'Académie Polonaise des Sciences, Cracovie

Mowing the solid vegetation overgrowing the ponds is one of the first economic operations in fishery. The mowed vegetation is usually taken out from the pond onto dams, part of it, however, always remains in the pond and is an attractive environment for micro-fauna development. The aim of this work was to examine the fauna of infusoria developed in concentrated mowed flora remaining in the ponds and placed in the aquarium. Here, I would like to express my thanks to Prof. Starmach for the choice of this subject and for suggestions and help in its elaboration.

Method

The material was collected during the years 1960-1961 from the following ponds of the Experimental Pond Fishery in Gołysz: Baginiec II, Kolejowy, Lipowy, Nowy Mały, and from some ponds named Wyszni (II, III, IV, VI, VII, VIII, and IX). The chief plants appearing on these ponds are given in Table I. Detailed observations concerning the flora overgrowing the ponds in Gołysz were carried out by Krzeczkowska-Wołoszyn (in manuscript).

Samples of concentrated plant shoots floating on the pond were collected 2-3 times during a period of one month, starting immediately after the first mowing which usually took place not earlier than three weeks after the pond was filled. The samples were collected from the bank of the pond by filtering about 5 litres of water with plants through a net made of miller's gauze No 19. Each time the water temperature and pH were taken at a given stand. The material was always collected between 9 and 11 a. m. and was inspected immediately after collection from the pond.

Tab. I

Leading plants in ponds

Species \ Pond	Baginiec II	Kolejowy	Lipowy	Nowy Mały	Rzyszni II	Rzyszni III	Rzyszni IV	Rzyszni VI	Rzyszni VII	Rzyszni VIII	Rzyszni IX
Batrachium aquatile Wimmer						+					
Carex div.sp.	+		+	+		+	+				
Elodea canadensis Richard		+							+	+	+
Glyceria aquatica L.Wahlb.	+	+	+	+	+	+	+	+	+	+	+
Heleocharis acicularis R.Brown			+			+				+	
Phragmites communis Trinius	+			+	+	+		+			
Polygonum amphibium L.		+									
Potamogeton lucens L.		+			+		+		+		+
Potamogeton natans L.		+	+		+				+		
Sagittaria sagittifolia L.											+
Typha angustifolia L.	+							+	+		
Typha latifolia L.	+			+	+	+	+	+	+		

Parallel observations were made on mowed plants placed in three aquaria of 30 l. capacity each. These plants were taken from the pond Baginiec II the day after mowing (April 14, 1960) and placed in two aquaria (A_1 and A_2).

The two aquaria were filled almost to capacity with 1/3 plant shoots and 2/3 of water from the pond.

The composition of the collected vegetation was as follows: *Sparganium ramosum* Hudson, *Iris pseudoacorus* L., *Glyceria aquatica* (L.) Wahlb., *Typha latifolia* L., *T. angustifolia* L., *Potamogeton natans* L., *P. lucens* L., *Lemna minor* L., *Salvinia natans* L. All., *Juncus effesus* L., *Scirpus lacustris* L., *Equisetum limosum* L., *Phragmites communis* Trinius, *Carex* div. sp., and *Eriophorum* sp., and conglomerations of filamentous green algae. Most numerous in the content of the vegetal mass as to volume were: *Glyceria aquatica, Typha latifolia* and *Carex* div. sp.

The second lot of plants was collected after mowing the Nowy Mały pond on the 1st July 1960 and placed in the third aquarium (A_3). The most solid parts of such plants as: *Glyceria aquatica, Typha, Phragmites* and *Carex* were chosen here. The volume of the vegetal mass placed in A_3 was only half that in the previous ones. The aquaria were placed in a cool room.

The experiments in the aquaria were carried out over four months. Simultaneously the temperature of the water, its putrefactive properties, and pH were taken. The chemical observations were carried on in the morning hours (between 9 and 10 a. m.). The determination of the water putrefactive property was carried out by Przyłęcki's method (1954). This value and the pH were very similar in A_1 and A_2, but in A_3 they had a different course. The water temperature in all aquaria was maintained always below 20 °C.

A quantitative and qualitative analysis of the material was made. The number of individuals was estimated by applying the six-grade scale given by Grospietsch (1958):

0 — very rare (1 indiv. under the cover glass)
1 — rare (1-2 indiv. under the cover glass)
2 — sporadic (2-10 indiv. under the cover glass)
3 — mean (10-20 indiv. under the cover glass)
4 — frequent (20-30 indiv. under the cover glass)
5 — mass (above 30 indiv. under the cover glass)

Observations from natural stands

Freshly mowed plants float scattered loosely on the pond. The unremoved parts of plants gathered under the influence of the wind most often in the corners of the pond, forming a thick and compact mass usually covering some square metres. To these places the wind carries everything that floats on the water. In these conglomerations many seeds, snails, and even small dead fish and birds could be found. The compact concentrations of dead plants very soon take on the appearance of skim and a brownish-yellow colour. Many times wadding-like algae concentrations and mass development of *Lemna minor* were observed to appear here.

Mowed plants float some weeks on the water surface. Being gradually subjected to the process of decomposition they lose their stiffness, take on a brown colour and begin slowly to fall to the bottom. The plants are mowed on an average 2-4 times, thus plants cut earlier gather in the extreme corner of the pond, and next to them come the plants mowed later. The dates and frequency of mowing on the individual ponds are usually different.

The decay of the organic matter of plants mowed on the pond takes place when there is a sufficient quantity of oxygen. The gathering of a larger amount of rotting organic matter facilitates the diminishing of the oxygen content dissolved in water. Bombówna (1956) states that according to the process of plant decomposition, which absorbs oxygen, the lowest value of oxygen dissolved in water was found after two weeks. Among the concentrations of plants pH varied from 6,4 to 7,2. During the period from June to September the pH showed constant values below 7. The water temperature was about 20 °C. pH above 7 were noted in September when the water temperature was about 16 °C. The water was usually not very clear. Bick (1958), investigating small reservoirs rich in fallen leaves, observed a reduction in pH from 6,7 to 6,4 during the falling of leaves and even in one reservoir with a large number of fallen leaves and without constant outflow of water he noted a value of 5,9.

In this environment, rich and numerous fauna of the infusoria developed. Bacteria found here suitable conditions for development. The

infusoria developing on such substratum were in the main species of bacteria eaters. The presence was noted of the 47 following species of infusoria: *Aspidisca costata* Clap. et L., *A. lynceus* Ehrbg., *Coleps hirtus* Nitzsch., *Cinetochilum margaritaceum* Perty, *Cyclidium citrullus* Cohn, *C. granulosum* Kahl, *Caenomorpha medusula* Perty, *Chilodonella cucullulus* O. F. Müller, *Ch. uncinata* Ehrbg., Chilodonella sp., *Didinium balbiani* Fabre-Dom., *Dileptus anser* O. F. Müller, *Euplotes patella* Müller, Ehrbg. fo. *latus* Kahl, *E. patella* Müller, Ehrbg. fo. *typicus* Kahl, *Euplotes* sp., *Frontonia acuminata* Ehrbg., *Glaucoma scintillans* Ehrbg., *Halteria grandinella* O. F. Müller, *Lacrymaria olor* O. F. Müller, *Lembadion bullinum* Perty, *L. lucens* Maskell, *Lionotus fasciola* Ehrbg.-Wrześniowski, *L. lamella* Ehrbg., *Lionotus* sp., *Loxodes rostrum* O. F. Müller, *Loxophyllum* sp,. *Metopus* sp., *Mesodinium acarus* Stein, *Mesodinium* sp., *Oxytricha* sp., *Paramaecium caudatum* Ehrbg., *Paruroleptus musculus* Kahl var. *minor* Kahl, *Prorodon teres* Ehrbg., *Prorodon* sp., *Plagiopyla nasuta* Stein, *Spirostomum ambiguum* Müller-Ehrbg., *S. minus Roux*, *Stentor coeruleus* Ehrbg., *S. roeseli* Ehrbg., *Strobilidium gyrans* Stokes, *Stylonychia mytilus* Ehrbg., *Vorticella similis* Stokes, *Vorticella* sp., *Urocentrum turbo* O. F. Müller, *Uroleptus piscis* Müller,-Stein, *Urostyla* sp., *Zoothamnium commune* Kahl.

36 per cent of this number are bacteria eaters, 34 per cent infusoria nourishing with mixed food (algae, bacteria, detritus) and 21,5 per cent rapacious species. Only a few of them were forms eating diatoms and other algae (8,5 per cent). These were: *Chilodonella cucullulus, Chilodonella* sp., *Frontonia acuminata* and *Uroleptus piscis*. All the representatives of the last group were found in small amounts. *Chilodonella* sp. only appeared in larger numbers at the beginning of June 1961, in the pond Baginiec II.

From the total number of the species 12 only appeared almost constantly and were observed periodically fairly numerously (3). They were: *Aspidisca costata* (IX), *Coleps hirtus* (VII, IX), *Chilodonella* sp. (VI), *Cyclidium citrullus* (VI, VII), *Didinium balbiani* (IX), *Glaucoma scintillans* (VII, VIII), *Lionotus lamella* (VI, VIII), *Loxodes rostrum* (VIII), *Oxytricha* sp. (VII), *Paramaecium caudatum* (VI, VIII, IX), *Paruroleptus musculus* (IX), *Stentor roeseli* (VII, VIII). These species were most characteristic for the investigated environment. The months in which they appeared in the largest amounts are given in brackets. Other kinds of species were observed in small numbers or sporadically.

All the species of the infusoria found among mowed vegetation demand oxygen in the environment in order to live. Once only were some specimens found of *Metopus* sp. in the pond Wyszni VIII in June 1961 (species of this kind appear only in an environment with a very low oxygen content and with the presence of hydrogen sulphide). The stand

of these species, which was near the pond bank, showed a very shallow depth and almost all the mass of plants remained at the bottom. In this event conditions almost without oxygen could exist near the bottom under the dense mass of rotten plants.

Among the rapacious infusoria the species *Dileptus anser* (300 μ) willingly ate the predator *Coleps hirtus* (60 μ in length). Several times specimens of *Dileptus anser* were observed filled with many shells of infusoria of the *Coleps* genus.

In the concentrations of the mowed vegetation rich micro-flora periodically develops. Sometimes also *Cryptomonas* sp. appears in large numbers.

Observations in the aquaria with mixed vegetation

The colonisation course in the two aquaria (A_1 and A_2), was similar. Changes in the appearance of plants and noted chemical alterations (Fig. 1)

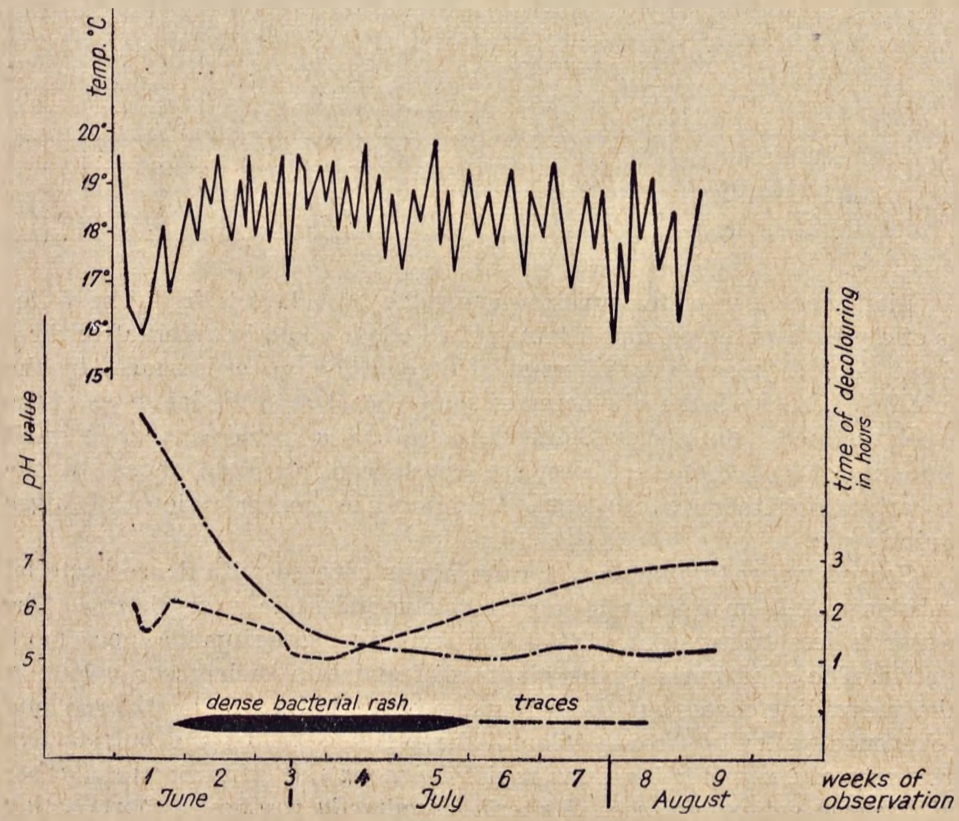

Fig. 1. Temperature, pH and putrefactive property of water in aquaria A_1 and A_2; ——— temperature, - - - - pH, —·—·— putrefactive property

ran in similar and almost parallel way. The development of the infusoria, except for some slight differences, was similar in general outline (Table II).

Tab. II

Infusoria in aquaria with mixed vegetation (A_1 and A_2)

	Species \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nouriahing with mixed food	Aspidisca costata	0	1					1				0						
	Aspidisca lynceus			1										0	0			
	Euplotes patella forma typicus				0				1									
	Euplotes patella forma latus				0					0								
	Euplotes sp.	1	1	0									1					
	Lembadion bullinum	0		0	0													
	Lembadion lucens		0	1				0										
	Stentor roeseli	0												2	1			
Bacteria-eaters	Glaucoma scintillans	0	1	1	0													
	Halteria grandinella	1	4		0													
	Paramecium caudatum	0	3	3	5	5	5	4	3				1	1	1			
	Plagiopyla nasuta	1	2	4	5	4												
	Prorodon teres				2	1		1										
	Prorodon sp	1	1						2					1	3	4		
	Strobilidium gyrans	0																
	Spirostomum ambiguum				0			0		1		3	4	5	5	5	3	
	Urocentrum turbo	1	2	4	4	2	3	2	2	1	1	0		0				
	Vorticella similis	0	1		2		1		1									
	Vorticella sp.		1	1	2					1				0				
Rapacious	Coleps hirtus	0	2	2	0	0		0	0	0	2		4	5	5	5	3	
	Lacrymaria olor		1	2	0			1	0									
	Lionotus fasciola							0		0				0				
	Lionotus sp.		0				0											

First week: the water surface during the first days is free. The water is of a yellow-green colour. A faint putrid odour could be smelt after three days. A stiff green vegetal mass floats on the water surface. In the middle of the week the pH increases somewhat, but in the last days of the week distinctly diminishes. Some of the infusoria species appear in small amounts (0-1). Numerous also are crustacean plankton taken to the aquarium together with plants. Wadding-like concentrations of algae quickly die.

Second week: the whole water surface is covered with dense bacterial substance, 1-2 cm thick ash-grey in colour and of jelly consistence. The water is less transparent. The odour from the aquarium becomes more putrid. The solid parts of the plants still maintain their green colour in the prevailling mass, but the soft parts begin to lose their stiffness and take on a yellowish-brown colour. The pH falls to 5,4 the putrefactive property of the water increases rapidly. Among the infusoria the number of bacteria eaters increases. *Halteria grandinella* reaches a short lasting mass development. *Paramaecium caudatum* is also very numerous. The number of *Plagiopyla nasuta* and *Urocentrum turbo* increases somewhat.

Crustacean plankton do not appear at all. Colourless flagellates can be seen in great numbers.

Third week: the dense bacterial substance is still on the water surface which becomes turbid and acquires a dark yellow colour. The putrid odour is very intensive. The plant shoots lose more of their stiffness, become brownish, and fall to the bottom. The solid parts of the plants, however, remain green. The soft parts of the plants are completely yellow. The pH decreases to the lowest value i. e. 5,2, the putrefactive property of the water still increases. *Halteria grandinella* do not appear at all, but mass development of *Urocentrum turbo* can be observed. *Plagiopyla nasuta* and *Paramaecium caudatum* appear in large quantities (3-4). The number of *Coleps hirtus* increases somewhat. The flagellate of *Cryptomonas* sp. show a mass development.

Fourth week: the water surface remains without change. The water is turbid, with an intensive putrid odour. The appearance of the plants does not show any great change. The pH increases slightly (from 5,2 to 5,6). The putrefactive property of the water still increases somewhat but decidedly more slowly. Among the infusoria the prevailing specimens are *Paramaecium caudatum* and *Plagiopyla nasuta* (5). The mass development of *Urocentrum turbo* continues but to a slightly smaller degree. Great development is also shown by flagellate *Cryptomonas* sp. *Rhizopoda* of *Arcella* genus are also numerous.

Fifth week: the bacterial cover on the water is reduced. The colour and odour of the water is more or less unchanged. Only a small part of the plants are still green. The pH increases up to 6,0.

The mass development of *Paramaecium caudatum* continues. The number of *Plagiopyla nasuta* decreases somewhat. The amount of *Urocentrum turbo* falls significantly. Numerous flagellata can be observed.

Sixth week: the bacterial cover begins to disappear on the water surface. The putrid odour becomes less intensive. The putrefactive property of the water keeps almost on the constant level. The number of the infusoria, bacteria eaters diminishes. Only the mass development of *Paramaecium caudatum* continues. Rather numerous are also *Urocentrum turbo*.

Seventh week: the bacterial cover can be seen only in traces. The putrefaction odour in the aquarium weakens. Numerous are only *Paramaecium caudatum* (4) and *Urocentrum turbo*.

Eighth week: the water surface is completely free, the bacterial cover has disappeared. The water has a dark yellow colour and the odour is distinctly fainter. The vegetal mass has already lost its stiffness: the soft and weak parts of the plants take on altogether a yellowish-brown colour. The quantity of infusoria is distinctly smaller. Rotifers are numerous. An abundant incubation of mosquito larvae takes place.

Ninth week: the state of the aquarium is without major change. The pH values reach nearly 7,0. The rotifers are still numerous. Amounts of *Cyclops* are small. On the walls of the aquarium a mass of rotifers appeared.

During the tenth and eleventh weeks the number of *Rotatoria* decreases. Then comes a slow increase of infusoria: *Spirostomum ambiguum* appears (3).

Twelfth week: *Lemna minor* developed in small amounts on the water surface. The water is clear and bright yellow in colour. The putrid odour is retained only by the fallen mass of rotting plants at the bottom. The number of *Coleps hirtus* (4), and *Spirostomum ambiguum* (4) increases.

In the thirteenth week a mass development of two species, *Spirostomum ambiguum* (5) and *Coleps hirtus* (5), begins. The *Spirostomum ambiguum* can be easily seen as a white suspension in the water. These species still appear profusely during the next week and a half.

During the fifteenth week the *Cyclops* appear again but the quantity of infusoria gradually diminishes.

The two competitive species of infusoria, feeding on the bacteria *Halteria grandinella* and *Plagiopyla nasuta*, did not produce their maximum simultaneously. A short-lasting maximum of *Halteria* appeared in A_1 but in the A_2 a maximum of *Plagiopyla* appeared one week later.

Spirostomum appeared in large amounts in A_2 (5), when in A_1 its development was less intensive and appeared in one and a half weeks later. Also *Urocentrum turbo* could be seen more numerously. With reference to the remainder of the species appearing in smaller amounts the differences were less significant and they appeared only in one of the two aquaria.

Observations in the aquarium containing very solid parts of the plants

The time of plant decomposition was very slow.The lowering of the pH and increased putrefactive property of the water were much slower in comparison with the two previous aquaria (Fig. 2). While in the latter the bacterial cover begins to disappear already at the end of the first week, in A_3 this phenomenon takes place only at the beginning of the fourth week. The course of colonisation was not so clear as in the two previous aquaria. The number of infusoria species was smaller (17). The thick pieces of plants shoots did not lose their stiffness for a long time. Specimens of *Plagiopyla* were found during a longer period of time, but in smaller amounts than in the aquaria with mixed vegetation. *Euplotes patella* forma *latus*, *Lionotus fasciola*, *Lembadion lucens*, *Spirostomum ambiguum*, *Strobilidium gyrans* and *Vorticella* sp. were not observed here.

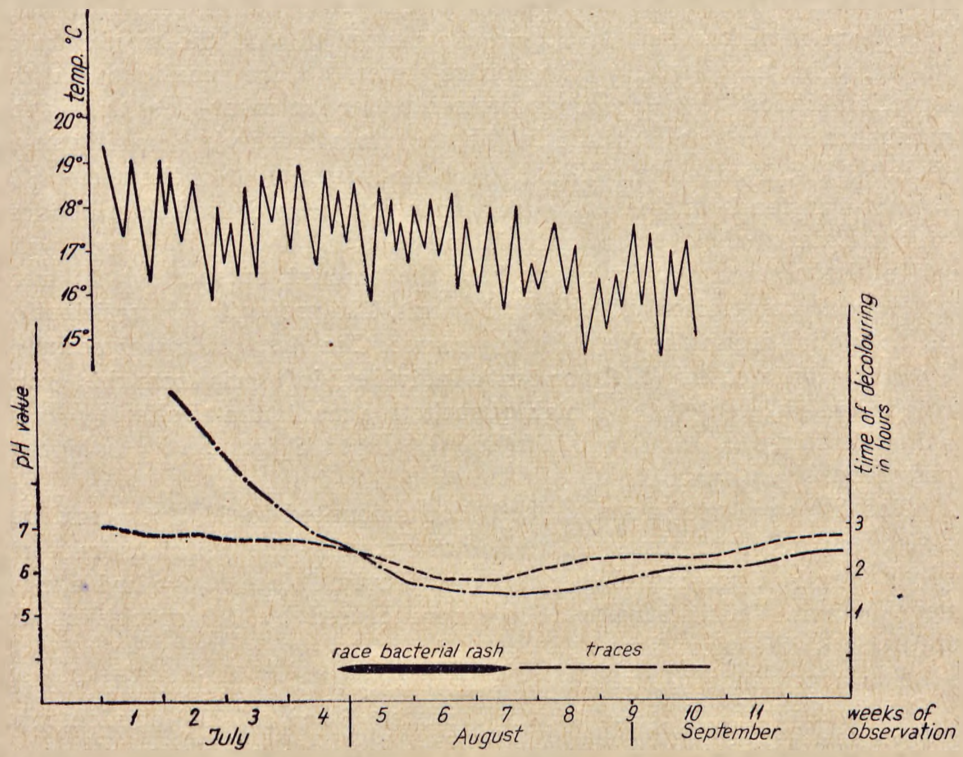

Fig. 2. Temperature, pH and putrefactive property of water in aquarium A_3;
——— temperature, - - - - pH, — • — • — putrefactive property

Discussion of the results

Work on the ecology of infusoria in small water reservoirs with accumulated vegetal matter, in which processes of cellulose decomposition prevail over the decomposition of proteins, was carried out by Bick (1958). He described the fauna of the infusoria in the reservoirs with large amounts of leaves fallen from trees. In his opinion in such reservoirs which are filled with water the whole year round two greater maxima of the infusoria appeared as a rule: in Spring and in Autumn and sometimes additionally in Summer (smaller). The autumn maximum appeared when the leaves were falling. The mass appearance of infusoria was usually the result of mowing the ponds. Larger amounts of infusoria could generally be observed 3-4 weeks after mowing. This relation, however, was not always so distinct; it was obscured by the mixing of freshly cut plants with some left over from the previous mowing.

The infusoria developed in great numbers on the bacterial substrate produced by the decomposition of plants in the aquarium. The mass

appearance of infusoria in the first weeks was a clear result of mass development of bacteria. It should be mentioned that the maximum of infusoria in the ponds was never so great, as the maximum in the aquaria. At most 20 specimens were seen under the cover-glass during the maximum in the ponds, while in the aquarium there were usually more than 30. This is connected with the fact that the number of the bacteria in the natural stands was never so great as to produce a dense bacterial cover on the water surface, as occurred in the aquaria.

In the aquarium only about half the amount of species (23) were observed in comparison with natural stands. The proportional participation of individual groups had a different course. The first place was occupied by the bacteria eaters (47,8 per cent). Individual infusoria from this group reached in different times a high quantitative maximum (*Halteria grandinella, Paramaecium caudatum, Plagiopyla nasuta, Spirostomum ambiguum* and *Urocentrum turbo*).

The infusoria feeding on mixed food amounted to 34,8 per cent, but appeared rarely and always in minimum amounts. The rapacious infusoria group was 17,4 per cent. From this group only *Coleps hirtus* had a mass development. Quantitative maxima were caused by 1-2 species of the infusoria at the same time.

The appearance of *Spirostomum ambiguum* in natural stands and its mass development in the aquarium confirms B i c k's (1958) opinion, who considered this species as specific for reservoirs with cumulation of vegetal organic matter.

STRESZCZENIE

Przeprowadzono obserwacje nad fauną wymoczków rozwijającą się wśród skupień skoszonej roślinności stawowej nagromadzonej przez wiatr w rogach stawu. Materiał zbierano w latach 1960-61 w stawach Gospodarstwa Doświadczalnego v Gołyszu. Równocześnie przeprowadzono obserwacje nad roślinnością umieszczoną w laboratorium w akwariach.

Na stanowiskach naturalnych znaleziono 47 gatunków wymoczków, w akwariach 23 gatunki.

Środowisko skoszonej roślinności sprzyja rozwojowi wymoczków zjadających bakterie (w stawach 36%, w akwariach 47,8%). Pozostałą część tworzyły: wymoczki odżywiające się pokarmem mieszanym (w stawach 34%, w akwariach 34,8%), wymoczki drapieżne (w stawach 21,5%, w akwariach 17,4%) oraz wymoczki zjadające wyłącznie glony i okrzemki znajdywane tylko w stawach (8,5%).

Najliczniej spotykane w stawach były następujące gatunki: *Aspidisca costata, A. lynceus, Coleps hirtus, Chilodonella* sp., *Cyclidium citrullus, Didinium balbiani, Glaucoma scintillans, Lionotus lamella, Loxodes rostrum, Oxytricha* sp., *Paramaecium caudatum, Paruroleptus musculus* var. *minor* oraz *Stentor roeseli.*

W akwariach masowe rozwoje osiągały następujące gatunki: *Coleps hirtus, Halteria grandinella, Paramecium caudatum, Plagiopyla nasuta, Spirostomum ambiguum* oraz *Urocentrum turbo.*

Występowanie *Spirostomum ambiguum* potwierdza obserwacje Bicka (1958), który uznał ten gatunek za specyficzny dla zbiorników wodnych z obfitymi nagromadzeniami materii roślinnej.

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