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Macrophytes and phytophilous macrofauna of the pond w Gołyszu*

Macrophytes and phytophilous macrofauna of the pond Zimowy Wielki at Gołysz

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A b s t r a c t — The paper presents investigations on the process of macrophytes overgrowing a carp pond fed with sugar factory wastes as well as on the development of phytophilous macrofauna in this pond.

In the years 1972—1973 the qualitative composition of higher plants, their share in the process of overgrowing a pond, and the invertebrate fauna settling on the higher plants were investigated within the programme of complex hydrobiological investigations of the pond Zimowy Wielki at the Experimental Farm of the Polish Academy of Sciences at Gołysz.

Since 1967 the pond Zimowy Wielki of the area of 8 ha had been each year filled with sugar factory wastes. In the first years of filling no higher plants occurred and it was not until 1971 that the rapid growth of the first plants was observed. In 1972 the investigation was strated. In this year plants already covered 50% of the pond surface, attaining about 70% in the next year.

In 1972 a marked dalay of about 2 months was noted in the beginning of the vegetation period of the investigated plants, but in the next year this delay was less pronounced and was about 1 month. Under our climatic conditions the beginning of macrophyte development is noted in

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May or June or, in dam reservoris, in June and July (Kuflikowski 1968, 1971). In Zimowy Wielki the first plant species occurred no earlier than the middle of July.

Overgrowing of the pond by macrophytes

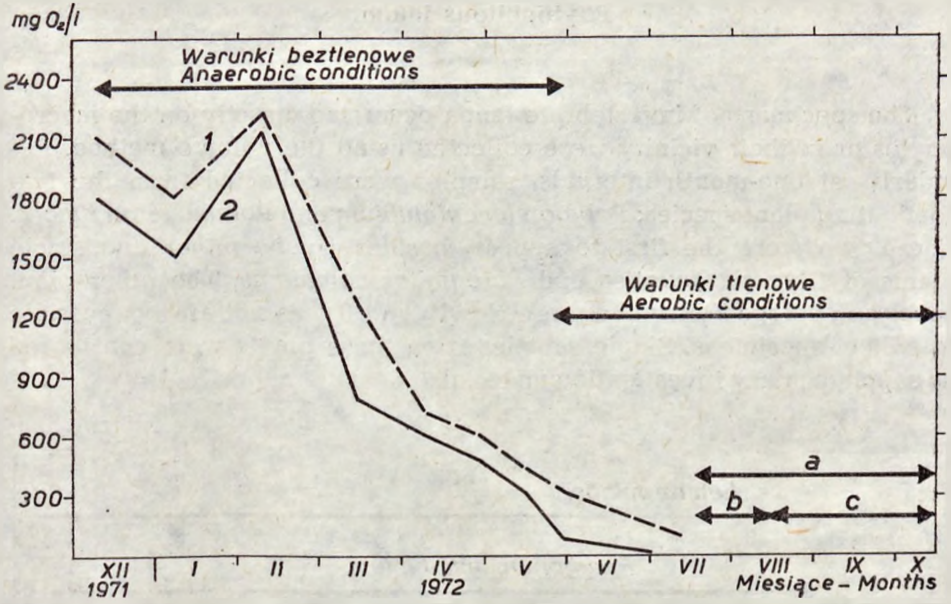
The pond plants were examined once a month throughout the vegetation period. The area was evaluated and the density of individual plants species determined in litres per 1 square metre of the area of the pond bottom, using the volume method.

In Zimowy Wielki the following species of macrophytes were determined in the year 1972: *Polygonum amphibium* L., *Batrachium aquatile* (L.) Dum., *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Sagittaria sagittifolia* L., *Elodea canadensis* Rich., *Potamogeton pectinatus* L., *P. lucens* L., *P. natans* L., *Phragmites communis* Trin., *Glyceria aquatica* Wahl., and *Lemna minor* L. In 1972 the investigated pond was 50% overgrown, this being 4 ha of the pond surface. The greatest area was covered by mixed communities composed of *Polygonum amphibium* and *Potamogeton lucens* — about 2.7 ha. The mean density of growth of this community was 10 litres per 1 square metre of the area of the pond bottom.

Potamogeton lucens and *Polygonum amphibium* also occurred in congeneric communities. The area covered by *Polygonum amphibium* was 0.7 ha, the mean density being 9 l/m², and by *Potamogeton lucens* 0.5 ha with a density of 7 l/m². The remaining species did not paly any great role in the process of pond overgrowing, their area not exceeding 0.1 ha.

Certain difficulties occurred with *Lemna minor*, a floating and unrooted plant which often changed its place and density of settlement. Its volume ranged from 0.5—2.5 l/m² of the water surface. With strong wind and greater undulation of the water surface, it was moved to the leeward of the pond and formed a layer of several centimetres. After the undulation stopped the plant spread amazingly rapidly over the water surface. It seems that this rapid spreading is due to the roots which can contract and expand. When the water surface was covered by a single layer of plants their area amounted to about 0.5 ha.

The plant vegetation always began with *Lemna minor*, followed by *Polygonum amphibium* and *Potamogeton lucens* together. The remaining species gradually appeared from August to September. The succession of individual plant species in Zimowy Wielki in 1972 is shown in fig. 1.



Ryc. 1. Sukcesja makrofitów w stawie Zimowy Wielki w 1972 r.

Fig. 1. Succession of macrophytes in the pond Zimowy Wielki in 1972

In the 1972 vegetation season the following biomass of individual plants was noted:

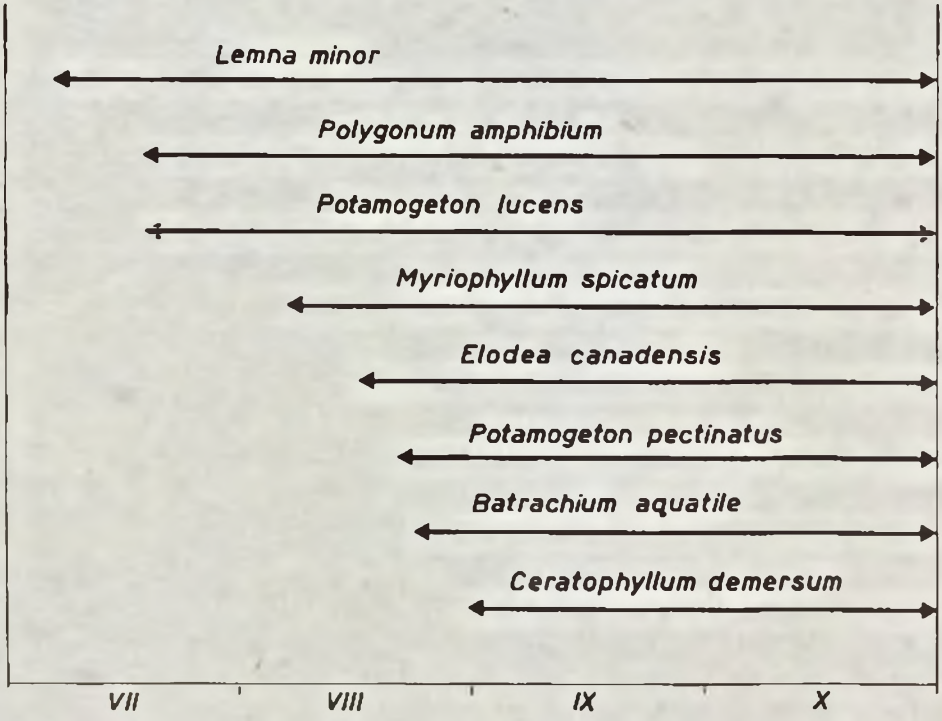
mixed community of *Polygonum amphibium* and *Potamogeton lucens*	2.7 ha	× 10	l/m² =	270 000 l
Polygonum amphibium	0.7 ha	× 9	l/m² =	63 000 l
Potamogeton lucens	0.5 ha	× 7	l/m² =	35 000 l
Lemna minor	0.5 ha	× 0.5	l/m² =	2 500 l
remaining plant species	0.1 ha	× 2	l/m² =	2 000 l
		total:		372 500 l

The above numbers are approximate since the measurements of the area of the investigated plants were not exact; also the density per 1 square metre was an average from several determinations. Thus, in 1972 the biomass of plants in Zimowy Wielki was about 372 500 litres.

In 1973 the number of plant species and their domination was unchanged, while the total area was greater in consequence of the rapid growth of *Polygonum amphibium* and *Potamogeton lucens*. Zimowy Wielki was 70% overgrown, this being about 4.8 ha of its area, while the total biomass was about 450 000 liters. The 2 months delay in the beginning of the vegetation season in the preceding year was reduced to about 1 month.

Phytophilous fauna

The specimens of invertebrate fauna occurring directly on the macrophytes or in their vicinity were collected using the volume method. Regularly, at one-month intervals, samples were collected from the two dominating plant species: *Polygonum amphibium* and *Potamogeton lucens*. These two were the first to appear, besides *Lemna minor* and single plants of *Glyceria aquatica* and *Phragmites communis*. The other plant species developed later and more slowly and it was not always possible to collect specimens. Single samples from these plants were considered as supplementary investigation material.



Ryc. 2. Sezonowa zmienność liczebności i biomasy dominujących gatunków fauny fitofilnej na *Potamogeton lucens* i *Polygonum amphibium* w stawie Zimowy Wielki w 1972 r. (A) i w 1973 (B). 1 — liczebność larw *Chironomus* f. l. *plumosus*; 2 — liczebność larw *Glyptotendipes polytomus*; 3 — biomasa larw *Chironomus* f. l. *plumosus*; 4 — biomasa larw *Glyptotendipes polytomus*

Fig. 2. Seasonal variability of the number and biomass of the dominant species of phytophilous fauna on *Potamogeton lucens* and *Poylgonum amphibium* in the pond Zimowy Wielki in 1972 (A) and 1973 (B). 1 — number of *Chironomus* f. l. *plumosus*; 2 — number of *Glyptotendipes polytomus*; 3 — biomass of *Chironomus* f. l. *plumosus*; 4 — *biomass* of *Glyptotendipes polytomus*

The samples from *Lemna minor* were treated separately because of its continual movement and considerable changes in density per 1 square metre of the water surface. The number of invertebrate fauna settling on this species varied considerably depending on whether the plants covered the water surface in a single layer or with a greater number of layers.

A few samples collected from the remaining plants species were treated as supplementary material. This did not basically affect the results since the area of the pond covered by them was insignificant, amounting to only 2.5%.

The qualitative composition of invertebrate fauna settling the macrophytes of Zimowy Wielki was very poor. Twenty-seven taxonomic units were identified, the most numerous group being *Chironomidae*. Among them two species occurred: *Chironomus* f.l. *plumosus* L. and *Glyptotendipes polytomus*. Their number and biomass in particular months are given in fig. 2. The number of individuals of the two species constituted 80% of all *Chironomidae*. In both years the maximum development of *Chironomidae* on the macrophytes of Zimowy Wielki occurred in September.

Among the remaining *Chironomidae* larvae the following species were identified: *Einfeldia* ex gr. *carbonaria* Meig., *Tanytarsus* ex. gr. *mancus* (Walk.), *T.* ex gr. *gregarius* Kieff., *Cryptochironomus* ex. gr. *pararostratus* Lenz., *C.* ex gr. *defectus* Kieff., *Glyptotendipes* ex gr. *gripekoveni* Kieff., *Limnochironomus* ex gr. *nervosus* Staeg., *Polypedilum* ex gr. *nubeculosum* (Meig.), *Endochironomus* ex gr. *dispar* Mg., *Cricotopus* ex gr. *sylvestris* (Fabr.), *C.* ex gr. *algarum* Kieff., *Ablabesmyia* ex gr. *monilis* (L.), and *Corynoneura celeripes* Winn. The share of *Chironomidae* larvae was over 95% of the whole investebrate fauna.

Other groups of invertebrate fauna were represented by single species, viz.: from *Hirudinea Helobdella stagnalis* (L.) and *Herpobdella octooculata* (L.), from *Aranae Argyroneta aquatica* L., from *Acarina Limnesia maculata* (O. F. Müll.), *Limnesia* sp. and *Piona coccinea* Koch., from *Ephemeroptera Cloëon dipterum* L., from *Odonata Enallagma cyathigerum* (Charp.), from *Coleoptera Haliplus* sp. and *Berosus spinosus* Stev., from *Trichoptera Agraylea multipunctata* (L.), and *Oecetis furva* Ramb., from *Lepidoptera Nymphula nymphaeta* L., and from *Gastropoda Radix limnosa* L. and *Gyraulus albus* Müll.

All the above mentioned species occurred in small numbers and their share in the whole macrofauna was about 5%. The majority of species occurred on all the investigated plants.

The results of the investigation show that there were no significant differences in the settlement of the individual plant species, the only differences being noted in the numbers of animals per 1 litre of a given plant. The following density of settlement was found on the individual

species of plants on *Myriophyllum spicatum* from 1780—8600 specimens/l, on *Ceratophyllum demersum* 1670—8500 specimens/l, on *Batrachium aquatile* from 1920—8350 specimens/l, on *Potamogeton pectinatus* from 1600—8200 specimens/l, on *P. lucens* from 630—6000 specimens/l, on *Polygonum amphibium* from 260—3600 specimens/l, on *Lemna minor* from 450—3000 specimens/l, and on *Elodea canadensis* from 85—1850 specimens/l. The smallest numbers of fauna were noted at the beginning of the vegetation period in the second half of July and the greatest in September.

During the vegetation period (July-October) the mean density of phytophilous fauna, calculated per 1 square metre of the pond area overgrown by the particular plant species, was very great, the respective numbers being:

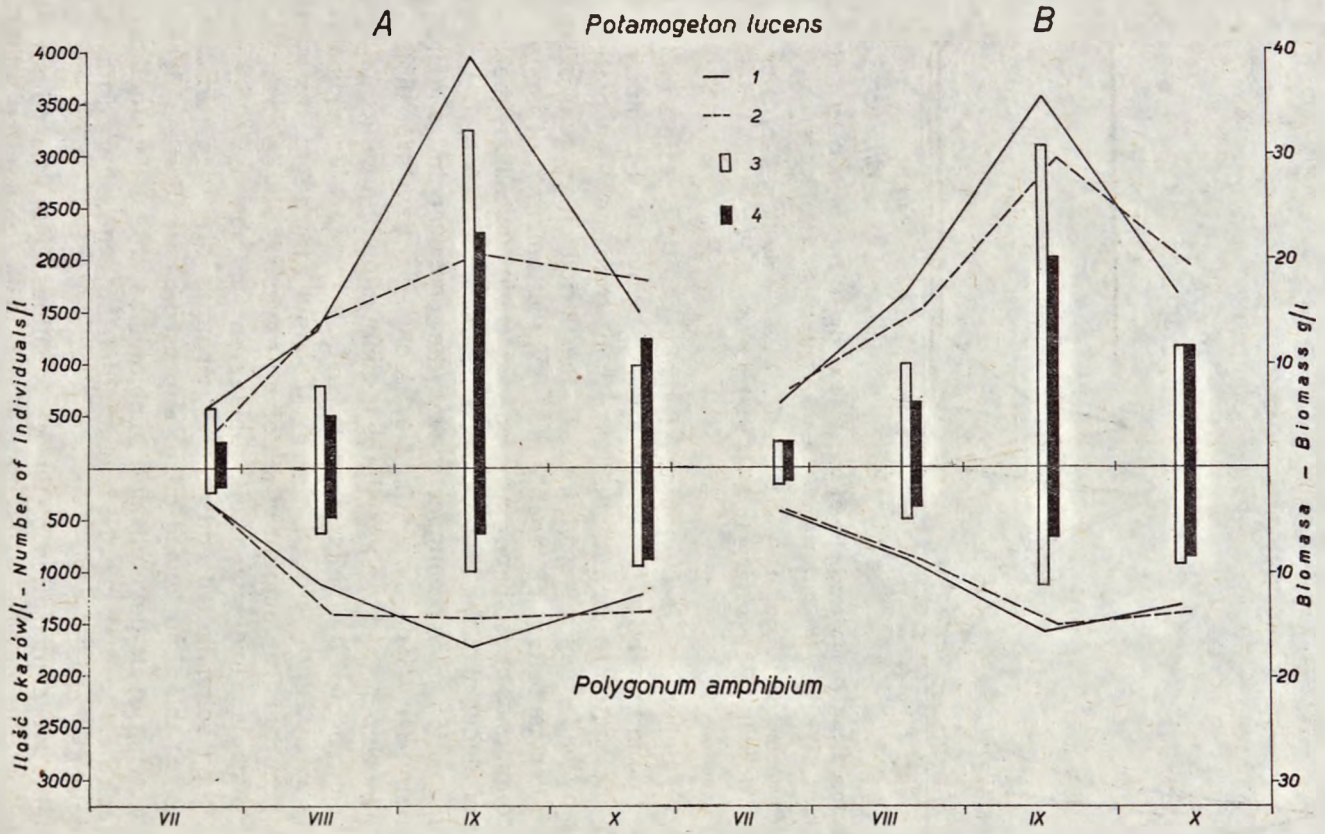
— on the *Polygonum amphibium* and *Potamogeton lucens* community 200 g/m², the mean biomass for the period being 5400 kg.
— on *Potamogeton lucens* 210 g/m² with biomass of 1050 kg.
— on *Polygonum amphibium* 90 g/m² with biomass of 630 kg.
— on the remaining species 190 g/m² with biomass of 220 kg.
— on *Lemna minor* 70 g/m² with biomass of 350 kg.

The mean density and mean biomass of the fauna of *Lemna minor* were calculated at the volume of 0.5 l/m² of the water surface, thus when it formed a single-layer covering. When the number of layers increased, the number of the fauna proportionally decreased.

In 1972 the total mean biomass of the phytophilous fauna of the whole pond, *Lemna minor* being also considered, was about 7 650 kg. In 1973, as the area of overgrowing plants expanded, the biomass of animals increased to about 8 000 kg.

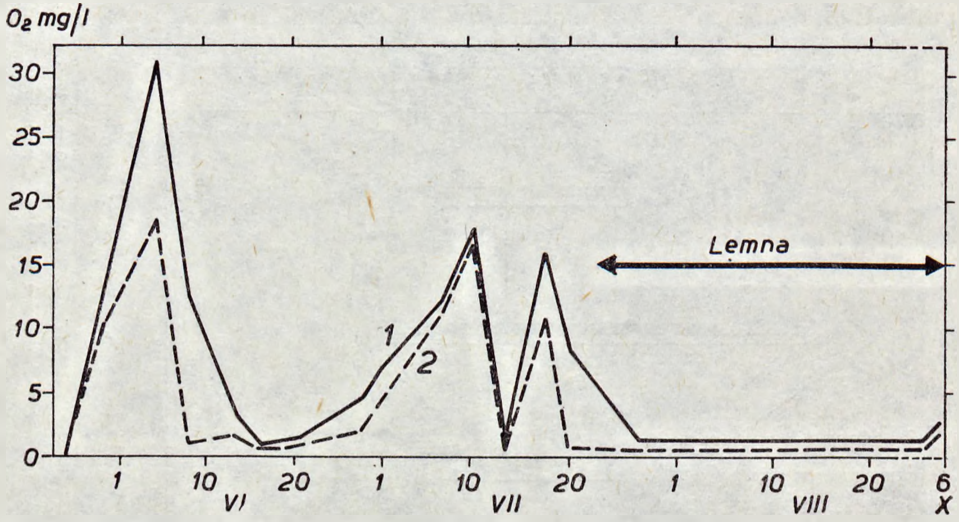
Discussion

The investigation conducted in the pond Zimowy Wielki showed that in the fourth year after filling the pond with sugar factory wastes, a dynamic development of macrophytes occurred. In the seventh year the pond was already 70% overgrown, the dominant species being *Polygonum amphibium* and *Potamogeton lucens*. These two species covered 97% of the area of all macrophytes, besides *Lemna minor*, which occupied a separate area if it occurred outside the zone of rooted vegetation but was most often moved in the direction of rooted plants. At that time it did not cover any additional area of the pond, hence, the result quoted in the text was 4 ha of the overgrown area of the pond in 1972 and not 4.5 ha as might be suggested by summing up.



Ryc. 3. Biologiczne (1) i chemiczne (2) zapotrzebowanie tlenu w wodzie stawu Zimowy Wielki (wg M. Lewkowicz, S. Lewkowicz 1975)

Fig. 3. Biological (1) and chemical (2) oxygen demand in the water of the pond Zimowy Wielki. a — BZT_5 — BOD_5 — 10 mg O_2/l; b — ChZT — COD — 100 mg O_2/l; c — ChZT — COD — 50 mg O_2/l. (According to M. Lewkowicz, S. Lewkowicz 1975)



Ryc. 4. Zawartość tlenu w powierzchniowej warstwie wody (1) i na głębokości 1 m (2) w stawie Zimowy Wielki w 1972 r. (wg M. Lewkowicz, S. Lewkowicz 1975)

Fig. 4. Oxygen content in the surface water layer (1) and at a depth of 1 m (2) in the pond Zimowy Wielki in 1972 (according to M. Lewkowicz, S. Lewkowicz 1975)

A marked delay in the beginning of the vegetation period in the investigated pond may be explained by a very strong initial turbidity of the water, and therefore the elimination of light from the pond bottom, as well as by bad chemical conditions. In the period of oxygen deficit and intense decomposition of organic matter, great amounts of noxious chemical compounds must have gathered and made impossible the development of higher plants.

This supposition may be supported by the chemical investigation carried out by Lewkowicz M., Lewkowicz S. (1975) in this pond in 1972 when, inter alia, a very large accumulation of organic matter was found as indicated by the biochemical and chemical oxygen demand (fig. 3). It was not until the end of May that more favourable oxygen conditions occurred. The amount of dissolved oxygen is shown in fig. 4.

In July a strong development of zooplankton was observed, this development then being halted and greater amounts of organic matter accumulated. At this time *Lemna minor* appeared as the first of higher plants and, owing to its development, inhibited the strong development of phytoplankton. Fig. 1 shows the beginning of the vegetation period of individual plant species in 1972.

The qualitative composition of the phytophilous fauna in Zimowy Wielki was basically different from the fauna of ponds not fed with sugar factory wastes (Arenkova 1965, Kuflikowski 1970, Matlak 1963, Zięba, Srokosz 1974). These differences were noted in both

qualitative composition and quantitative relations. In the investigated pond 27 taxonomic units were noted while in an average carp pond over 100 taxons of invertebrate fauna occur (Zięba, Srokosz 1974, Kuflikowski 1970). The majority of animal taxons occur on all species of plants, the differences being noted only in their numbers.

The enormous biomass of animals was above all influenced by *Chironomidae* larvae and nymphs which constituted on the average about 95% of the weight of the whole macrofauna. Among *Chironomidae* two species, *Chironomus* f.l. *plumosus* and *Glyptotendipes polytomus*, dominated, thus forms unspecific for the phytophilous fauna. Both species are noted almost solely in the bottom of ponds, lakes, and dam reservoirs, and hence are typical representatives of the benthos (Giziński 1974, Kajak 1968, Krzyżanek 1966, Zięba 1963, 1973).

The settlement of plants by *Chironomus* f.l. *plumosus* and *Glyptotendipes polytomus* may be explained by a deficit or even a temporary lack of oxygen at the pond bottom, this compelling them to migrate to the water surface.

The investigations of Kajak (1968) and Giziński (1974) show that, according to their expectations, the qualitative composition of *Chironomidae* larvae is usually connected with the concentration of oxygen dissolved in water. In lakes where the oxygen content was poor no *Chironomidae* larvae were noted or the larvae of *Chironomus plumosus* dominated. Other *Chironomidae* species were scarce, their biomass not exceeding 20%. The species of the remaining animal groups were even rarer and their biomass attained 5%.

STRESZCZENIE

W latach 1972—1973 w ramach kompleksowych badań hydrobiologicznych Stawu Zimowego, użyźnianego ściekami cukrowniczymi, przeprowadzono badania nad rozwojem roślinności wodnej jak również nad makrofauną fitofilną.

Staw Zimowy o powierzchni 8 ha od 1967 roku zalewany był corocznie ściekami cukrowniczymi. W 1972 roku, kiedy podjęto badania, roślinność ta zajmowała już 50% powierzchni stawu, a w 1973 roku 70%.

Wśród roślin dominowały *Polygonum amphibium* i *Potamogeton lucens*. Obydwa gatunki zajmowały 97% powierzchni wszystkich makrofitów w stawie. Stwierdzono również duże opóźnienie początku wegetacji tej roślinności. W 1972 roku dochodziło ono do dwóch miesięcy, a w 1973 roku około jednego miesiąca.

Przyczyną opóźnienia wegetacji mogły być dwa czynniki: początkowe bardzo duże zmętnienie wody i w konsekwencji niedopuszczenie światła do dna stawu oraz brak tlenu wskutek silnego rozkładu materii organicznej, uniemożliwiający wzrost roślinności wyższej.

W związku z opóźnioną wegetacją roślin nastąpiło przesunięcie rozwoju fauny bezkręgowej na nich występującej. Skład gatunkowy fauny był bardzo ubogi. Zidentyfikowano 27 jednostek taksonomicznych. Nie stwierdzono większych różnic jakościowych w zasiedlaniu fauny na poszczególnych gatunkach roślin, dotyczyły one tylko ich ilości.

Najliczniejszą grupą zwierząt były *Chironomidae*, które stanowiły średnio około 95% całej biomasy. Dominowały dwa gatunki: *Chironomus* f. l. *plumosus* i *Glyptotendipes polytomus*. Są to typowi przedstawiciele fauny dennej. Występowanie ich na makrofitach w tak dużej ilości (ok. 80%) można tłumaczyć wyjątkowo niekorzystnymi warunkami tlenowymi w dnie stawu i w przydennej warstwie wody.

Zagęszczenie fauny bezkręgowej występującej na poszczególnych gatunkach roślin było bardzo duże i wynosiło:

W 1972 roku na skupisku *Polygonum amphibium* i *Potamogeton lucens* biomasa na metr kwadr. 200 g, a z całej pow. 5400 kg,
— na *Potamogeton lucens* biomasa na metr kwadr. 210 g, a z całej pow. 1050 kg,
— na *Polygonum amphibium* biomasa na metr kwadr. 90 g, a z całej pow. 630 kg,
— na *Lemna minor* biomasa na metr kwadr. 70 g, a z całej pow. 350 kg,
— na pozostałych roślinach biomasa na metr kwadr. 190 g, a z całej pow. 220 kg.

W sumie biomasa makrofauny fitofilnej całego stawu w 1972 roku wynosiła około 7650 kg, a w roku 1973 około 800 kg.

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