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THE OCCURRENCE OF *DREISSENA POLYMORPHA* (PALL.) IN SOME MESOTROPHIC LAKES OF THE MASURIAN LAKELAND (POLAND)*

ABSTRACT: The occurrence of the bivalve *Dreissena polymorpha* in seven mesotrophic lakes of the Masurian Lakeland was evaluated. There were great differences between lakes in the *D. polymorpha* populations; they involved the numbers, biomass, occurrence zone and age structure of the settled individuals. The numbers of planktonic larvae, measured in three lakes, greatly differed. One lake (Majcz Wielki) was characterized by the greatest differences in the planktonic larvae numbers between years of studies.

KEY WORDS: mesotrophic lakes, bivalve *Dreissena polymorpha*, numbers, biomass, planktonic larvae.

1. INTRODUCTION

Dreissena polymorpha (Pall.) is a bivalve occurring commonly and often in masses in lakes of different trophy. In the end of the seventies, several tens of lakes in North-East Poland have been investigated, among others — from the standpoint of *D. polymorpha* occurrence. Some of these lakes were of a mesotrophic nature.

On account of advancing eutrophication of Polish lakes, the number of mesotrophic lakes steadily decreases. As it is indispensable to protect these scarce lakes, attention is directed to the problems of their functioning.

In the present paper some data concerning *D. polymorpha* occurrence in mesotrophic lakes are compiled. A part of them have earlier been published, but they are scattered in several reports and are often incomplete (Lewandowski 1982a,

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1982b, Lewandowski 1983, Stańczykowska et al. 1983a, Stańczykowska et al. 1983b). Moreover, some data not so far reported are presented.

2. AREA AND METHODS

The occurrence of *D. polymorpha* was investigated in seven mesotrophic lakes of the Masurian Lakeland. These lakes display considerable water transparency and low phytoplankton biomass (Table 1). Their near-bottom water layer is rich in

Table 1. Characterization of the investigated mesotrophic lakes

Lake	Surface area (ha)	Depth (m)		SD visibility summer (m)*	Phytoplankton biomass in summer ($\text{mg}\cdot\text{l}^{-1}$)*
		maximal	mean		
Piłakno	259	56.6	13.0	6.4	1.0
Probarskie	201	31.0	9.2	5.1	3.0
Majcz Wielki	163	16.4	6.0	3.0–4.5	2.6
Kuc	99	28.0	8.0	5.4	0.4
Kierzlińskie	93	44.5	11.7	6.9	0.5
Kołowin	78	7.2	4.0	2.4	1.3
Ołów	61	40.1	12.9	3.8	0.4

* All data (except for the Majcz Wielki Lake) according to Kajak and Zdanowski (1983); data for the Majcz Wielki Lake according to Spodniewska (1983).

oxygen; only in the Ołów Lake a deficit of oxygen at the bottom has been noted (Kajak and Zdanowski 1983). The highest phosphorus concentrations in the epilimnion, somewhat exceeding $50 \mu\text{g}\cdot\text{l}^{-1}$, have been found in summer in the Kołowin Lake; in the remaining lakes they amounted to $20\text{--}40 \mu\text{g}\cdot\text{l}^{-1}$ (Kajak and Zdanowski 1983). It is stressed that the studies of *D. polymorpha* occurrence in the Kołowin Lake have been performed prior to the ecological catastrophe which took place in the middle of the seventies and led to poisoning of all fish.

In the present studies *D. polymorpha* samples were collected from 2–10 sampling stations per lake, using a bottom dredge dragged behind a boat along a definite fragment of the bottom. A similar procedure for quantitative collection of great bivalves has been applied fairly often (Stańczykowska 1964, Widuto and Kompowski 1968, and others). The content of the dredge was placed on a benthos sieve from which living *D. polymorpha* (mainly in the form of colonies) as well as objects and plants with settled postveligers were picked out. They were preserved with a 4% formalin solution. For the determination of biomass (dry weight), bivalves were dried for 2 days at 60°C .

The age of the adult bivalves was determined by counting annuli on shells. Although this is a subjective and not always reliable method, particularly in the case of old individuals, it remains in general use (e.g. Crowley 1957, Ökland 1963, Negus 1966, Lewandowski and Stańczykowska 1975, Spiridonov 1975).

The occurrence of planktonic larvae was evaluated in three lakes: Kołowin, Ołów and Majcz Wielki (in the last of them – in three consecutive years). Samples were collected with a 5-l Bernatowicz sampler; they were concentrated using a plankton net whereupon they were preserved with a 4% formalin solution. In a part of the sample corresponding to 1 l of lake water, all *D. polymorpha* larvae were counted under a microscope.

3. RESULTS

3.1. NUMBERS OF *D. POLYMORPHA* AND THE CHARACTER OF ITS OCCURRENCE

The bivalve *D. polymorpha* was present in all the mesotrophic lakes studied. There were great differences between lakes in its mean numbers. It occurred most abundantly in the Kołowin and Ołów Lakes (ca. 2000 indiv.·m⁻²), and was least frequent in the Piłakno Lake (ca. 20 indiv.·m⁻²) (Table 2).

Table 2. Mean numbers and biomass of *Dreissena polymorpha* in mesotrophic lakes

Lake	Period of studies	Numbers (indiv.·m ⁻²)	Biomass (dry wt, without shells) (g·m ⁻²)
Piłakno	May 1977	20	0.8
Probarskie	May 1977	120	8.8
Kuc	June 1978	260	1.1
Majcz Wielki	June 1977	510	12.0
Kierzlińskie	May 1977	600	2.5
Ołów	June 1978	1830	43.2
Kołowin	May 1978	2340	15.1

The maximal numbers recorded at various sites in the lakes often exceeded several thousands of individuals per 1 m²; in the Kołowin Lake they attained 12000 indiv.·m⁻². In the Piłakno Lake, the maximal numbers were less than 100 indiv.·m⁻².

An analysis of the presence of *D. polymorpha* at various depths pointed to fairly great differences between lakes in its occurrence zones. This bivalve was present most deeply (down to a 7-m depth) in the Majcz Wielki Lake. It occurred deeply (to a 6-m depth) in the Piłakno, Kierzlińskie and Ołów lakes. In the remaining lakes (Kuc,

Kołowin and Probarskie) it was recorded only down to a 4-m depth. In the Probarskie Lake no samples could be collected from greater depths, on account of very strong wind blowing at this time; nevertheless, *D. polymorpha* numbers were minimal even at a 4-m depth. The same objections can be raised in the case of the Kierzlińskie and Piłakno lakes where — likewise — no consideration was given to depths greater than 6 m. Namely, in the Kierzlińskie Lake more than 600 indiv.·m⁻² still occurred at a 6-m depth, whereas in the Piłakno Lake in fact at this depth only ca. 50 indiv.·m⁻² were present, but this was the greatest value, as compared with more shallow sites.

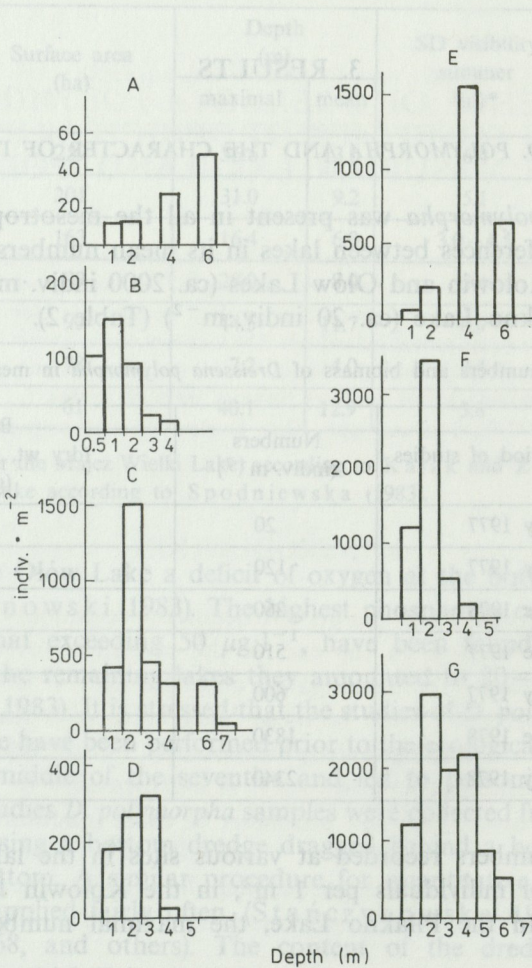


Fig. 1. The occurrence of *Dreissena polymorpha* at various depths in mesotrophic lakes
 A — Piłakno L., B — Probarskie L., C — Majcz Wielki L., D — Kuc L., E — Kierzlińskie L.,
 F — Kołowin L., G — Ołów L.

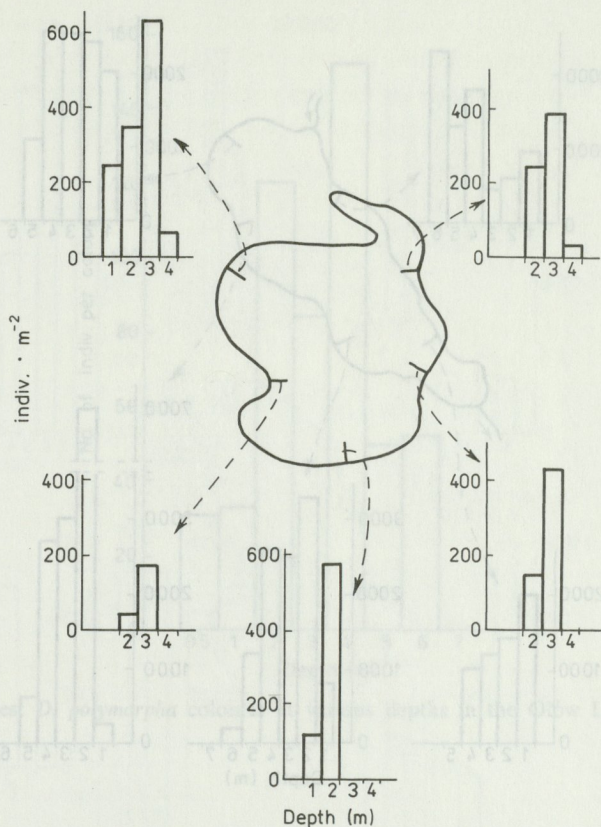


Fig. 2. The occurrence of *D. polymorpha* in the Kuc Lake

Usually *D. polymorpha* numbers were greatest at 2–4 m depths; nevertheless, there were some exceptions, e.g. the Probarskie and Piłakno lakes where the numbers were maximum at a depth of 1 and 6 m, respectively (Fig. 1).

Horizontal distribution of *D. polymorpha* was evaluated in detail in three lakes: Kuc, Ołów and Kołowin. In the Kuc Lake this bivalve occurred within a relatively narrow zone limited on one side by a reed belt which often reached down to a depth exceeding 1.5 m, and on the other side by a muddy zone which in some sites began already at a depth below 2–3 m (Fig. 2). In the *D. polymorpha* occurrence zone there were stands of *Characeae*, *Elodea canadensis* and *Fontinalis*. Bivalves were frequently settled on emerged macrophytes.

In the Ołów Lake, the zone of *D. polymorpha* occurrence was wider than in the Kuc Lake, and reached down to a 6-m depth. Also the numbers of this bivalve at various sampling stations and depths were much greater (Fig. 3). Likewise, the character of its occurrence differed from that described for the Kuc Lake. In the Ołów Lake the emerged vegetation was poor and distributed insularly. *D. polymorpha* mostly appeared at the bottom in the form of usually great colonies

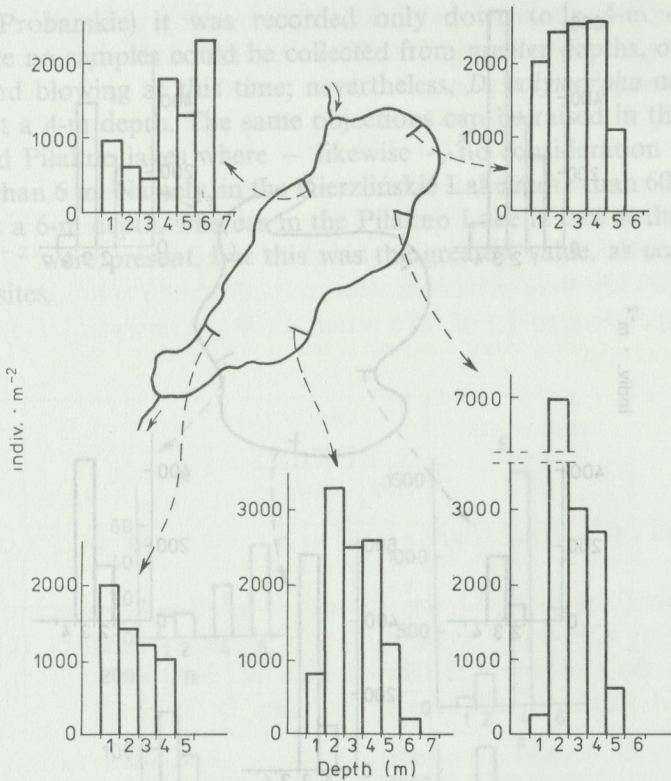


Fig. 3. The occurrence of *D. polymorpha* in the Ołów Lake

comprising from several tens to more than 100 individuals. The most numerous colonies were present at 2–4 m depths, i.e. in the zone within which also the numbers of *D. polymorpha* were maximal (Fig. 4). This confirms the directly proportional relationship between *D. polymorpha* numbers and number of individuals in colonies, as observed by Stańczykowska (1964). In the Ołów Lake the colonies occurred also in the muddy part at a 5–6 m depth.

In the Kołowin Lake *D. polymorpha* appeared similarly as in the Kuc Lake. The occurrence zone did not exceed a 4-m depth, and often it only reached down to a depth of 2 m, because below abundant mud was present. Despite the narrow occurrence zone, the numbers of this bivalve were very great (Fig. 5). This zone was almost completely overgrown with *Characeae* on which *D. polymorpha* individuals were settled. This bivalve occurred in colonies at the bottom only in the North-East part of the lake (sampling station 2). In the Kołowin Lake *D. polymorpha* was also settled on reed shoots, sometimes forming great colonies of more than a hundred individuals, but only on the edge of the reed belt from the side of open water. A similar situation was found also in the Majcz Wielki Lake.

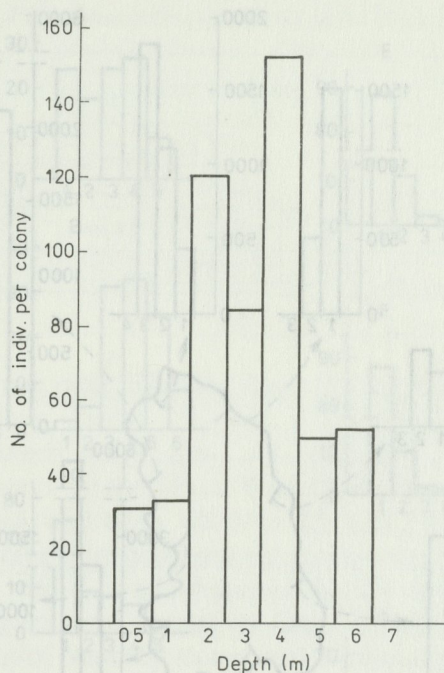


Fig. 4. The greatest *D. polymorpha* colonies at various depths in the Olów Lake (June 1978)

3.2. BIOMASS AND AGE STRUCTURE OF *D. POLYMORPHA*

The mean biomass of *D. polymorpha* did not always correspond to its numbers in the different lakes. For example, in the Olów Lake — as compared with the Kołowin Lake — its numbers were lower, whereas the biomass was almost three times greater. In the Kuc and Kierzlińskie lakes the biomass was exceptionally low (Table 2). Namely, apart from the numbers of animals, the biomass is in the first place related to the age and size structure of the *D. polymorpha* population.

In the Kuc, Kierzlińskie and Kołowin lakes the youngest (1-year old) individuals were dominant, accounting for 80–90% of the populations. In these lakes the oldest individuals (3–5 years of age) represented a minimal proportion of the populations.

In contrast, in the Probarskie Lake the numbers were low and the biomass was relatively great; namely, in this lake the oldest *D. polymorpha* individuals were dominant and the proportion of 1–2 years old ones was low (Fig. 6).

The lengths of *D. polymorpha* individuals of different age, found in the various lakes, are presented in Table 3. As these animals were not collected at the same time, the individuals caught in June in the Majecz Wielki, Kuc and Olów lakes were usually longer than those collected in the remaining lakes in May. These age-dependent differences in length were more evident in the greatest animals of a given age class,

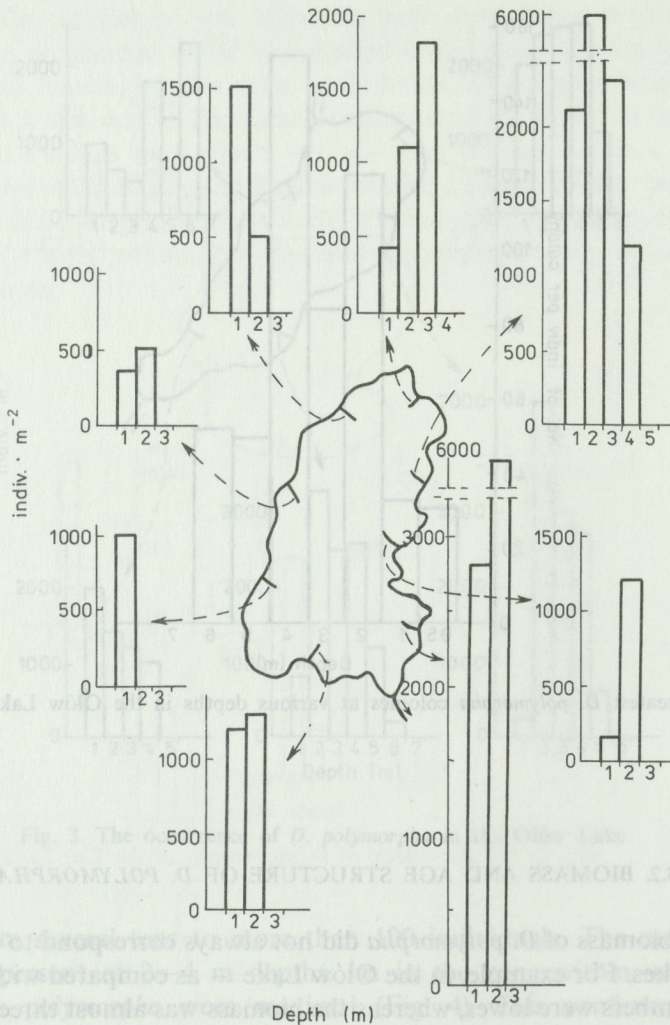


Fig. 5. The occurrence of *D. polymorpha* in the Kolowin Lake

while the smallest individuals in the different age classes were in fact similar. The size structure of a *D. polymorpha* colony in the Ołów Lake is exemplified in Figure 7.

In the Ołów Lake the age structure of *D. polymorpha* was evaluated in May of two consecutive years: 1977 and 1978. In 1977, it greatly resembled that found in 1978 (presented in Figure 6). In contrast, very great differences between years in *D. polymorpha* age structure were observed in the Majcz Wielki Lake during three consecutive years (1977–1979), as described in detail in an earlier paper (Lewandowski 1982b). In June 1978, i.e. one year after the situation recorded in Figure 6, in this lake 2 years old individuals (which as 1-year old ones have been most abundant in 1977) occurred in the greatest numbers. In 1978 the youngest (1-year old) individuals accounted for an only minimal proportion of the population.

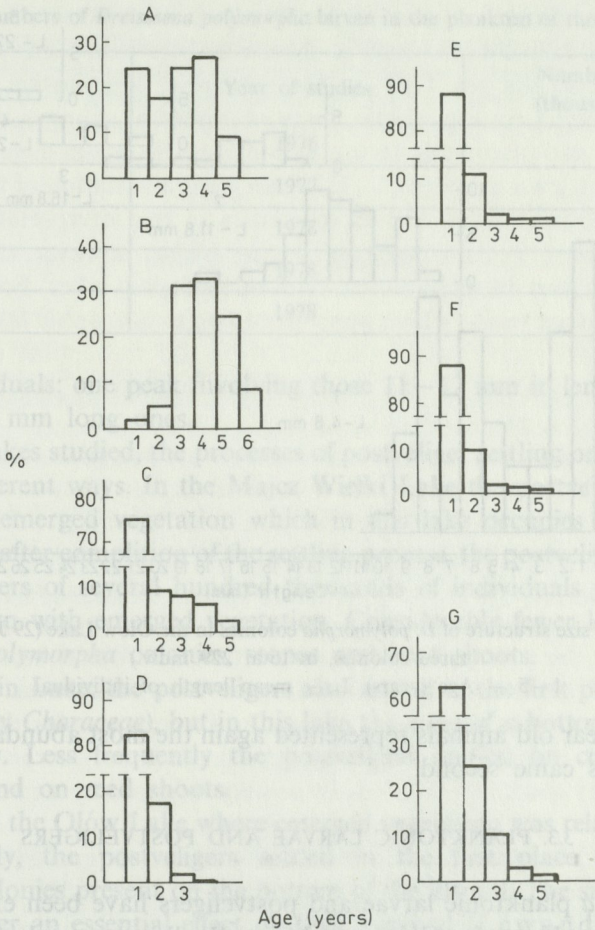


Fig. 6. Age structure of *D. polymorpha* in mesotrophic lakes

A – Piłakno L. (May 1977), B – Probarskie L. (May 1977), C – Majcz Wielki L. (June 1977), D – Kuc L. (June 1978), E – Kierzlińskie L. (May 1977), F – Kołowin L. (May 1978), G – Ołów L. (June 1978)

Table 3. Length ranges (mm) of *Dreissena polymorpha* individuals of different age in mesotrophic lakes

Lake	Date of sample collection	<i>D. polymorpha</i> age (years)					
		1	2	3	4	5	6
Kołowin	17 May 1978	1–7	7–15	15–18	18–21	24	–
Piłakno	20 May 1977	2–7	9–13	13–20	20–24	23–25	–
Probarskie	25 May 1977	2	8–13	12–20	19–24	23–28	26–31
Kierzlińskie	27 May 1977	1–8	6–15	13–19	21	26–27	–
Majcz Wielki	14 June 1977	1–11	9–19	14–23	20–27	24–28	–
Kuc	18 June 1978	1–10	10–16	14–21	–	–	–
Ołów	29 June 1978	1–12	8–18	14–22	19–25	25–29	–

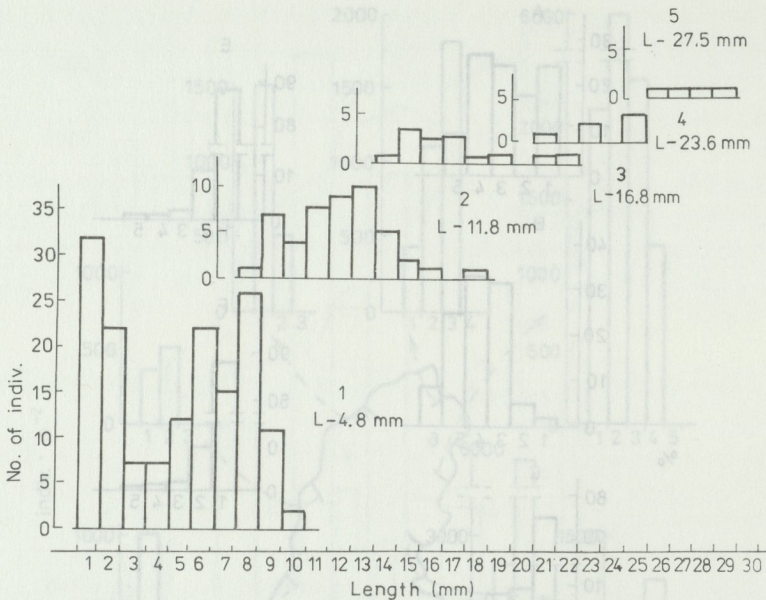


Fig. 7. An example of size structure of *D. polymorpha* colonies in the Ołów Lake (29 June 1978, 4-m depth, three colonies, in total 229 indiv.)

1–5 — Age (years), L — mean length of individual

In June 1979 1-year old animals represented again the most abundant class, and the 3 years old ones came second.

3.3. PLANKTONIC LARVAE AND POSTVELIGERS

D. polymorpha planktonic larvae and postveligers have been examined in three mesotrophic lakes: Kołowin, Ołów and Majcz Wielki; the results were reported in detail in an earlier paper (Lewandowski 1982a).

In all three lakes, these larvae usually occurred in the plankton between mid-June and the beginning of September. The appearance of larvae in the plankton, particularly their first emergence, depends on the thermal conditions. In these studies the first emergences of larvae took place at water temperature of 17–19°C.

Lakes greatly differed in the numbers of larvae in the plankton; moreover, there were very great differences between the consecutive years of studies performed in one lake (Majcz Wielki) (Table 4). These big fluctuations of the numbers of *D. polymorpha* larvae in the Majcz Wielki Lake were responsible for the earlier discussed age structure of the population of the settled *D. polymorpha*, leading to a minimal proportion of 1-year old individuals in 1978.

The Majcz Wielki Lake was in 1978 characterized by two peaks of the numbers of settling postveligers: in the second half of June and in mid-July. This two-peak nature of postveliger settling was also testified to by the size structure of 1-year old individuals in the Ołów Lake (Fig. 7). Likewise, in the Kołowin Lake, by the end of July 1978 (1 year after the settling process) there were two peaks of the numbers of

Table 4. Maximal numbers of *Dreissena polymorpha* larvae in the plankton of three mesotrophic lakes

Lake	Year of studies	Numbers of larvae (thous. indiv.·m ⁻³)
Majcz Wielki	1976	213
Majcz Wielki	1977	4
Majcz Wielki	1978	42
Kołowin	1978	56
Ołów	1978	16

1-year old individuals: one peak involving those 11–12 mm in length and another one of the 3–5 mm long ones.

In the three lakes studied, the processes of postveliger settling on solid substrates proceeded in different ways. In the Majcz Wielki Lake the postveligers in the first place settled on emerged vegetation which in this lake occupies a large area. In autumn 1978, i.e. after completion of the settling process, the postveligers displayed at some sites numbers of several hundred thousands of individuals per 1 m² of the bottom overgrown with emerged vegetation. Considerably fewer larvae settled on the formed *D. polymorpha* colonies, stones and reed shoots.

In the Kołowin Lake, the postveligers also settled in the first place on emerged vegetation (mainly *Characeae*), but in this lake the zone of a bottom of this kind is relatively narrow. Less frequently the postveligers settled on colonies of adult *D. polymorpha* and on reed shoots.

In contrast, in the Ołów Lake where emerged vegetation was relatively poor and occurred insularly, the postveligers settled in the first place on the formed *D. polymorpha* colonies present on the bottom of the littoral. The site of postveliger settling exerts later an essential effect on their survival (Lewandowski 1982b).

4. DISCUSSION

In the examined lakes the *D. polymorpha* populations greatly differed. The numbers and biomass fluctuated from very small ones (Piłakno Lake) to exceptionally high ones (Ołów and Kołowin lakes) (Table 2). The occurrence zone was widest in the Majcz Wielki Lake, reaching down to a 7-m depth; in some other lakes it only attained a 4-m depth. In the Kołowin Lake, at many sites *D. polymorpha* occurred only at a 1–2 m depth (Fig. 5).

The differences involved also the age structure. Some lakes were characterized by dominance of young individuals, and some – of older ones (Fig. 6). Even a single lake (Majcz Wielki) in which studies were performed for 3 years, the *D. polymorpha* population displayed high variation with respect to e.g. the numbers of planktonic larvae or age structure of the settled individuals.

The literature affords many examples of variation of *D. polymorpha* numbers in different water bodies. Fluctuations of these numbers from nearly 0 to more than 2000 settled individuals per 1 m² in the eutrophic Mikołajskie Lake have been reported (Stańczykowska 1961). Such examples of changes in the numbers of adult individuals and planktonic larvae, as well as their causes have been reviewed in an earlier paper (Lewandowski 1982c). So great a variation of the *D. polymorpha* population in different lakes creates difficulties in the interpretation of the living conditions prevailing in their habitats. On the whole, however, the numbers of *D. polymorpha* are higher in mesotrophic than in eutrophic lakes. For example, in the Jorka River drainage basin, where apart from one mesotrophic lake (Majcz Wielki) four eutrophic lakes have been examined from the standpoint of *D. polymorpha* populations, the numbers of this bivalve were highest in the mesotrophic lake (Stańczykowska et al. 1983b).

According to the present results, in as many as three lakes (Kołowin, Ołów and Kierzlińskie) *D. polymorpha* numbers were even higher than in the Majcz Wielki Lake (Table 2). In both greatest lakes (Piłakno and Probarskie) these numbers were relatively low; however, since there the samples were collected only once at two sampling stations, the results fail to be fully reliable. Whereas some eutrophic lakes may display great numbers of *D. polymorpha*, such lakes are usually scarce. For example, among the several hundreds of North-East Poland lakes studied (Stańczykowska et al. 1983a) only two eutrophic lakes (Lidzbarskie and Czos) have exhibited *D. polymorpha* numbers approaching those found for the Ołów Lake. As above-mentioned, in the eutrophic Mikołajskie Lake *D. polymorpha* numbers were in some periods very great, but this was invariably followed by an abrupt reduction of these numbers.

In mesotrophic lakes *D. polymorpha* usually occurs at greater depths than in the eutrophic ones, most likely because of the better oxygen conditions in the former. In both types of lakes, the abundance of *D. polymorpha* greatly depends on the presence of appropriate substrates for settling veligers. The most suitable substrate consists in emerged macrophytes, particularly *Characeae* forming vast submerged meadows in many mesotrophic lakes. The formed *D. polymorpha* colonies are very good substrates allowing for a higher survival of the settled postveligers, as compared with plants. This type of substrates occurred in the first place in the Ołów Lake characterized by very great *D. polymorpha* numbers.

5. SUMMARY

Analysis was made of the occurrence of the bivalve *Dreissena polymorpha* in seven mesotrophic lakes of the Masurian Lakeland (Kierzlińskie, Kołowin, Kuc, Majcz Wielki, Ołów, Piłakno, Probarskie lakes). There were great differences between lakes in the *D. polymorpha* numbers which fluctuated from 20 indiv. · m⁻² (Piłakno Lake) to more than 2000 indiv. · m⁻² (Kołowin Lake) (Table 2). Likewise, the lakes considerable differed in the biomass and age structure of *D. polymorpha* (Fig. 6). The depth of the zone of occurrence of this bivalve remained between 4 m (Kołowin Lake) and 7 m (Majcz Wielki Lake) (Fig. 1).

In three lakes (Kołowin, Majcz Wielki, Ołów) the occurrence of the planktonic larvae of *D. polymorpha* was evaluated. There were substantial differences in their numbers between lakes. The differences between years in these numbers were maximal in the case of the Majcz Wielki Lake (Table 4). So high a variation of the *D. polymorpha* populations, confirmed by literature data, creates difficulties in the interpretation of the living conditions of this species in different lakes. On the whole, the numbers of *D. polymorpha* are greater in mesotrophic than in eutrophic lakes.

6. POLISH SUMMARY

Analizowano występowanie małży *Dreissena polymorpha* w siedmiu jeziorach mezotroficznym Pojezierza Mazurskiego (Kierzlińskie, Kołowin, Kuc, Majcz Wielki, Ołów, Piłakno, Probarskie). Liczebności *D. polymorpha* bardzo różniły się między jeziorami i wynosiły od 20 osobn. \cdot m⁻² (Piłakno) do ponad 2000 osobn. \cdot m⁻² (Kołowin) (tab. 2). Znacznie różniła się także biomasa i struktura wiekowa tych małży (rys. 6), a zasięg ich występowania wahał się od 4 m głębokości (Kołowin) do 7 m (Majcz Wielki) (rys. 1).

W trzech jeziorach (Kołowin, Majcz Wielki, Ołów) analizowano występowanie larw planktonowych tego gatunku i tu różnice były również znaczne, lecz największe różnice zarejestrowano w jeziorze Majcz Wielki w różnych latach badań (tab. 4). Tak duża, znajdująca potwierdzenie i w literaturze, zmienność populacji *D. polymorpha* utrudnia interpretację warunków życiowych tego gatunku, panujących w różnych jeziorach. Na ogół jednak w jeziorach mezotroficznym, w porównaniu z jeziorami eutroficznymi, notuje się wyższe liczebności tych małży.

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