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THE OCCURRENCE AND ROLE OF BIVALVES OF THE FAMILY *UNIONIDAE* IN MIKOŁAJSKIE LAKE*

ABSTRACT: The distribution, numbers, biomass, annual production and age structure of *Unionidae* were investigated. A mathematical relation between the size (age) and weight of a bivalve was determined for two species: *Anodonta piscinalis* Nilsson and *Unio tumidus* Philipsson. The filtration abilities and the role of these invertebrates in Mikołajskie Lake were determined.

Contents

1. INTRODUCTION

The considerable attention given to the family *Unionidae* (Žadin 1938, Agrell 1949, Ökland 1963, Petrov 1964, Negus 1966, Widuto and Kompowski 1968, Piechocki 1969, Tudorancea 1972 and others) is because its members belong to the largest freshwater invertebrates and the contribution of bivalves to benthic biomass is sometimes 99% (Ökland 1963) and thus they are of considerable significance in the biocenosis of a water body. The members of the family *Unionidae* belong to the largest

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freshwater filtrating organisms. These animals purify the water from suspension and excrete faeces which are abundant in organic matter and thus are a suitable life environment for several benthic organisms. The moving *Unionidae* stir the bottom deposits and the accumulation at the bottom of shells of dead individuals which decompose with difficulty cause the increasing shallowness of water bodies.

The aim of this paper was to study the distribution, numbers, annual production and age structure of bivalves of the family *Unionidae* in Mikołajskie Lake. The daily filtration of single *Unionidae* and their numbers allowed to estimate the filtration possibilities for the whole lake.

Detailed study on these animals in Mikołajskie Lake has not been carried out before. There is only a remark about four species of the family *Unionidae* in Mikołajskie Lake given by Berger (1960) who describes the malacofauna of Masurian Lakeland.

2. AREA AND METHODS

Mikołajskie Lake is a typical water body in Great Masurian Lakeland (Fig. 1). This is a tunnel-valley lake, eutrophic, holomictic, of a surface 460 ha, maximum depth 27.8 m, mean depth 11.0 m. The littoral occupies 19% of the total lake surface (Kajak, Hillbricht-Ilkowska and Pieczyńska 1972). The shores of the lake on the southern part are usually high and steep, up to 30 m above the water level. The shallow part of the littoral is narrow and rapidly gains depth (Synowiec 1961). Emergent vegetation covers 39.2 ha, of which 32.3 ha overgrown with reed – *Phragmites communis* Trin. (Kowalczewski and Wasilewski 1966). The reed grows on most of the littoral zone of Mikołajskie Lake, but it does not grow at all in the north-eastern part where is the town Mikołajki. In places not covered with reed, at small depths, the bottom is stony or sandy but is always covered by a thin layer of mud.

The *Unionidae* were collected an 10 sites evenly distributed along Mikołajskie Lake (Fig. 1). The sites were chosen according to the variety of littoral types – distribution of reed and various species of submerged plants, configuration and type of bottom and changes in the environment as a result of man's activities (sewage). On each site, several metres broad and running along the shore, samples were taken starting at the depth of 0.5 m and then at 1.5, 2.5, 3.5 m and etc. down to the depth at which the *Unionidae* practically do not occur. At shallow places (0.5 m) the bivalves were picked by hand on a framed surface (0.5×0.5 m = 0.25 m²) chosen at random at the bottom. This was repeated 10 times on each site. At deeper places the material was collected using the bottom dredge of a side 0.4 m and drawn along the bottom 3 m parallelly to the shore from a boat at anchor. The dredge was drawn 5 times at each depth on particular sites. Thus obtained material was used to estimate the numbers of *Unionidae* in the lake. Of the two commonly applied methods of quantitative catches of bivalves (among others of Widuto and Kompowski 1968, Stańczykowska and Nowicki 1966) the frame method is undoubtedly more precise. The species of bivalves were identified as well as their age and they were measured and weighed fresh and dry (after drying up to constant weight). In order to observe the changes in the distribution of *Unionidae* in the lake during the season the material was collected four times between May and September 1972. The fluctuations of the water level in the lake during the studies did not exceed 10 cm.

In August the studies on the intensity of water filtration by *Unionidae* were also carried out using the method for *Dreissena polymorpha* (Pallas), in Mikołajskie Lake (Mattice, Stańczykowska and Ławacz 1972, Stańczykowska, Ławacz and

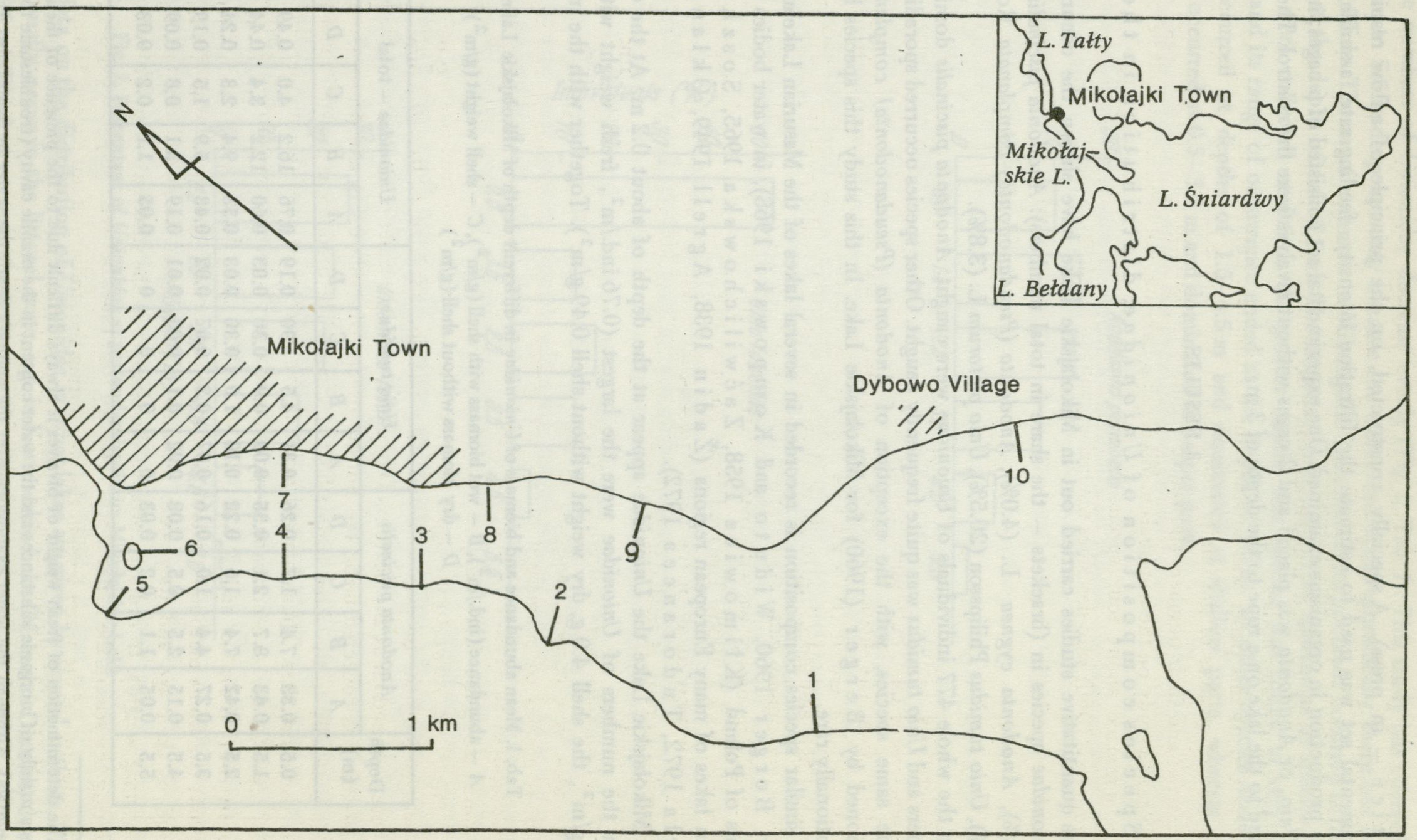

Fig. 1. Mikołajskie Lake – distribution of sites

Mattice – in press). A specially constructed, on the principle of a flow respirometre, experimental set was used to estimate the filtration intensity, feeding rate, assimilation and faeces production in organisms examined. One experimental set consisted of 6 cages; in 4 cages one *Unio*, or *Anodonta* was placed and 2 cages without bivalves were the control. The set was lowered to the lake on a rope to the depth of 3 m.

3. RESULTS

3.1. Species composition of *Unionidae*; distribution in the lake

The quantitative studies carried out in Mikołajskie Lake have shown the occurrence of 5 *Unionidae* species in (brackets – the share in total numbers): *Anodonta piscinalis* Nilsson (71.5%), *Anodonta cygnea* L. (4.0%), *Anodonta* (*Pseudanodonta*) *complanata* Rossmäsler (0.2%), *Unio tumidus* Philipsson (20.5%), *Unio pictorum* L. (3.8%).

On the whole 477 individuals of *Unionidae* were caught. *Anodonta piscinalis* dominated in numbers and *Unio tumidus* was quite frequently caught. Other species occurred sporadically.

The same species, with the exception of *Anodonta (Pseudanodonta) complanata*, are mentioned by Berger (1960) for Mikołajskie Lake. In this study this species has been exceptionally rare.

A similar species composition is recorded in several lakes of the Masurian Lakeland (own study, Berger 1960, Widuto and Kompowski 1968), in water bodies of other regions of Poland (Klimowicz 1958, Zaćwilichowska 1965, Soszka 1968) and in lakes of many European regions (Žadin 1938, Agrell 1949, Ökland 1963, Burla 1972, Tudorancea 1972).

In Mikołajskie Lake the *Unionidae* appear at the depth of about 0.2 m. At the depth of 0.5 m the numbers of *Unionidae* were the largest (0.76 ind./m^2, fresh weight with shell[1] 16.2 g/m^2, the shell 4.0 g, dry weight without shell 0.49 g/m^2). Together with the increasing

Tab. I. Mean abundance and biomass of *Unionidae* in different depth of Mikołajskie Lake
A – abundance (ind./m^2), *B* – wet biomass with shell (g/m^2), *C* – shell weight (g/m^2), *D* – dry biomass without shell (g/m^2)

Depth (m)	*Anodonta piscinalis*				*Unio tumidus*				*Unionidae* – total			
	A	*B*	*C*	*D*	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*
0.5	0.33	7.4	1.7	0.26	0.31	4.5	1.90	0.19	0.76	16.2	4.0	0.49
1.5	0.43	8.7	2.1	0.35	0.09	0.9	0.30	0.03	0.60	12.2	3.4	0.44
2.5	0.42	7.4	1.6	0.22	0.10	1.0	0.30	0.03	0.53	9.4	2.3	0.24
3.5	0.27	4.4	1.0	0.16	0.07	0.2	0.07	0.02	0.43	5.9	1.5	0.19
4.5	0.15	2.5	0.5	0.08	0.02	0.1	0.03	0.01	0.19	3.1	0.8	0.09
5.5	0.05	1.1	0.2	0.03	0	0	0	0	0.05	1.1	0.2	0.03

[1] The determination of fresh weight of bivalves is always difficult due to the presence of the shell which consists mainly of inorganic substances and the water content in the mantle cavity (troublesome to remove in live animals). Although the water evaporates after the animal's death the water in tissues also dries up, and very quickly in the case of young age classes. Thus the results cannot be without an error.

depth the numbers of *Unionidae* decrease evenly (Fig. 2, Tab. I). This study has covered the zone down to 5.5 m deep not only because the *Unionidae* occur sporadically there but at the depth of 4.5 m. The most common in Mikołajskie Lake *Anodonta piscinalis* occurred in largest numbers at the depth of 1.5–2.5 m. The majority, over 50% of all specimens of species *Unio tumidus*, were collected at 0.5 m. At greater depths this species was found in very small numbers and its range of occurrence ended at the depth of 4.5 m. Of other species *Anodonta cygnea* occurred at depths of 1.5–4.5 m and dominated at shallow parts, whereas *Unio pictorum* occurred at 0.5–3.5 m and dominated in deeper parts.

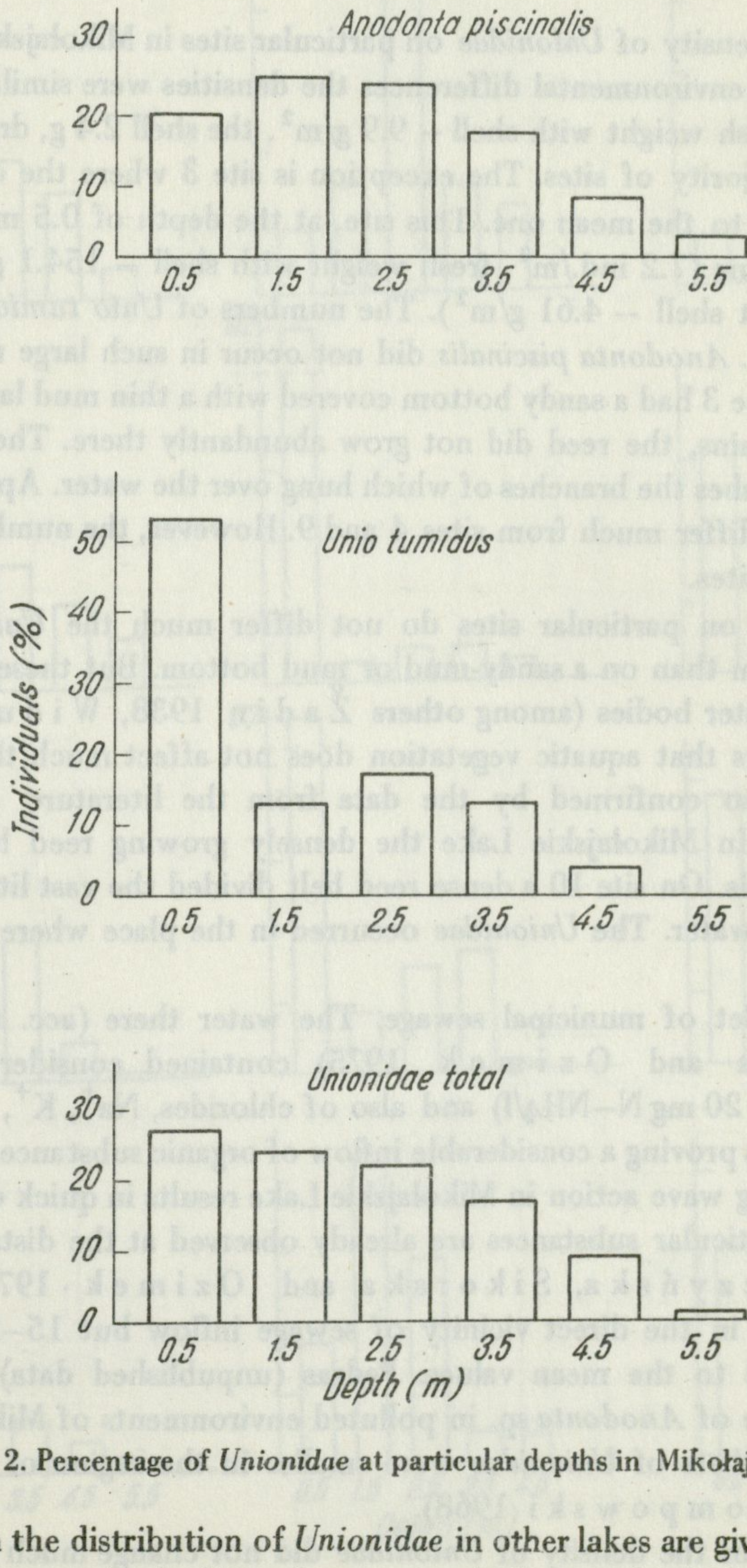

Fig. 2. Percentage of *Unionidae* at particular depths in Mikołajskie Lake

Similar data on the distribution of *Unionidae* in other lakes are given by several authors. The *Unionidae* usually occur in the littoral zone, e.g. in Kortowskie Lake (Masurian District) down to depth of 4 m (W i d u t o and K o m p o w s k i 1968), in lake Borrevann (Norway) down to 6 m deep (Ö k l a n d 1963). They dominate at the depth of 0.5 m, e.g. in Kortowskie Lake (W i d u t o and K o m p o w s k i 1968), in lakes Velikoe and Svjatoe in the USSR (Ž a d i n 1938). In Kortowskie Lake *Unio tumidus* dominates at the depth of 0.5 m (W i d u t o and K o m p o w s k i 1968) and in lake Crapina (the Danube Delta) at the depth of 0.4 m (T u d o r a n c e a 1972) – similarly as in Mikołajskie Lake. But as regards the *Anodonta piscinalis*, it is most abundant at greater depths in other lakes as well – at 2 m in Kortowskie Lake (W i d u t o and K o m p o w s k i 1968), at 1.5 m in lake Drużno (K l i m e k 1960), at 2–3 m in lake Zurich (B u r l a 1972), at 3 m in lake Borrevann (Ö k l a n d 1963). Thus *Unio tumidus* dominates at the depth of about 0.5 m and *Anodonta piscinalis* at about 2 m.

The differences in the density of *Unionidae* on particular sites in Mikołajskie Lake were not great. Despite considerable environmental differences the densities were similar and low (mean numbers – 0.4 ind./m^2, fresh weight with shell – 9.9 g/m^2, the shell 2.4 g, dry weight without shell 0.3 g/m^2) on the majority of sites. The exception is site 3 where the density was three times higher as compared to the mean one. This site, at the depth of 0.5 m, had the largest number of *Unionidae* in June (7.2 ind./m^2, fresh weight with shell – 154.1 g/m^2, the shell – 54.2 g, dry weight without shell – 4.61 g/m^2). The numbers of *Unio tumidus* were also the largest there (6.4 ind./m^2). *Anodonta piscinalis* did not occur in such large numbers and was more evenly distributed. Site 3 had a sandy bottom covered with a thin mud layer and considerable amount of plant remains, the reed did not grow abundantly there. The shore was steep with plenty of trees and bushes the branches of which hung over the water. Apart from the very steep shore site 3 did not differ much from sites 4 and 9. However, the numbers of *Unionidae* were much lower on these sites.

Although the numbers on particular sites do not differ much the *Unionidae* were less numerous on stony bottom than on a sandy-mud or mud bottom. But these differences were not as great as in other water bodies (among others Ž a d i n 1938, W i d u t o and K o m - p o w s k i 1968). It seems that aquatic vegetation does not affect much the distribution of *Unionidae* and this is also confirmed by the data from the literature (W i d u t o and K o m p o w s k i 1968). In Mikołajskie Lake the densely growing reed have affected the movements of these animals. On site 10 a dense reed belt divided the vast littoral bed without *Unionidae* from the open water. The *Unionidae* occurred in the place where the reed belt was narrower and less dense.

Site 7 was at the outlet of municipal sewage. The water there (acc. to data of P i e - c z y ń s k a, S i k o r s k a and O z i m e k 1975) contained considerable amounts of ammonia nitrogen (up to 20 mg N–NH_4/l) and also of chlorides, Na^+, K^+, Ca^{2+}, its oxygen consumption was high thus proving a considerable inflow of organic substances accompanied by oxygen deficits. The strong wave action in Mikołajskie Lake results in quick dilution of sewage and concentrations of particular substances are already observed at the distance of 5 m from the sewage outlet (P i e c z y ń s k a, S i k o r s k a and O z i m e k 1975). On site 7 the *Unionidae* did not occur in the direct vicinity of sewage inflow but 15–20 m farther, the numbers there were close to the mean values. Pędras (unpublished data) observed similar relations in the occurrence of *Anodonta* sp. in polluted environments of Mikołajskie Lake. In Kortowskie Lake the numbers of *Unionidae* were smaller in the region of municipal sewage outlet (W i d u t o and K o m p o w s k i 1968).

Over the summer months the density of *Unionidae* did not change much on particular sites both with large and small numbers.

But there are some regularities in the distribution of *Unionidae* in the summer and at various depths (Fig. 3). The distribution of *Anodonta piscinalis* does not change much although its numbers increase considerably at 0.5 m in August and September. The occurrence of *Anodonta piscinalis* is much more even than of the second species as regards the abundance *Unio tumidus*. *Unio tumidus*, in June and August prefers the depth of 0.5 m, whereas in May and September – greater depths.

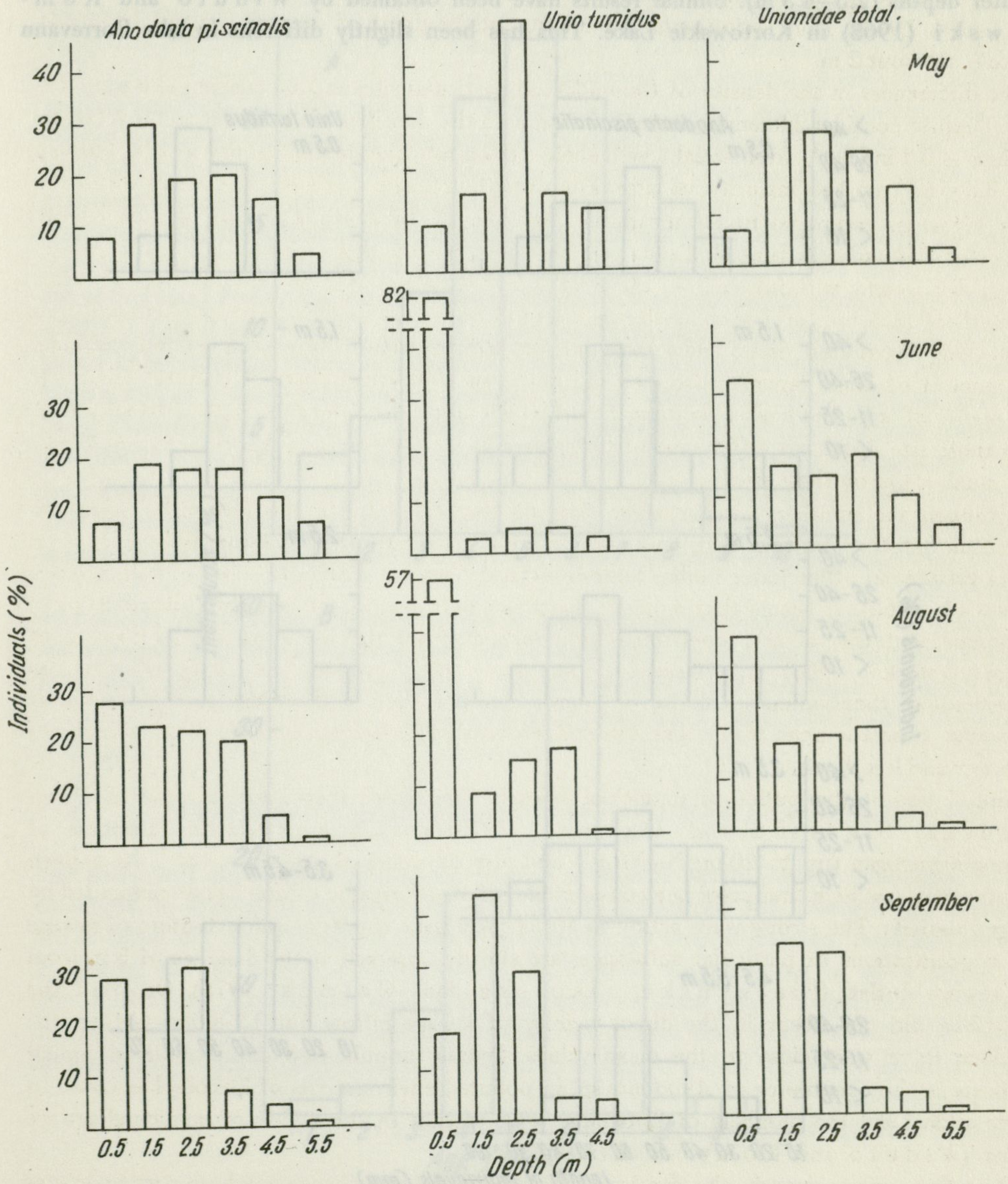

Fig. 3. Percentage of *Unionidae* at particular depths in Mikołajskie Lake in the summer 1972

3.2. Age structure

The members of various age classes (different shell length) of the *Unionidae* are found at different depths (Fig. 4). At the depth of 0.5 m the large individuals of *Anodonta piscinalis* and *Unio tumidus* are usually found. The depth of 1.5 m is colonized by all classes of age of species *Anodonta piscinalis*. Smaller individuals of this species (10–30 mm long) occur abundantly at depths of 2.5–3.5 m. The smallest specimens of *Unio tumidus* are also the most abundant at greater depths (2.5–4.5 m). Similar results have been obtained by Widuto and Kompowski (1968) in Kortowskie Lake. This has been slightly different in lake Borrevann

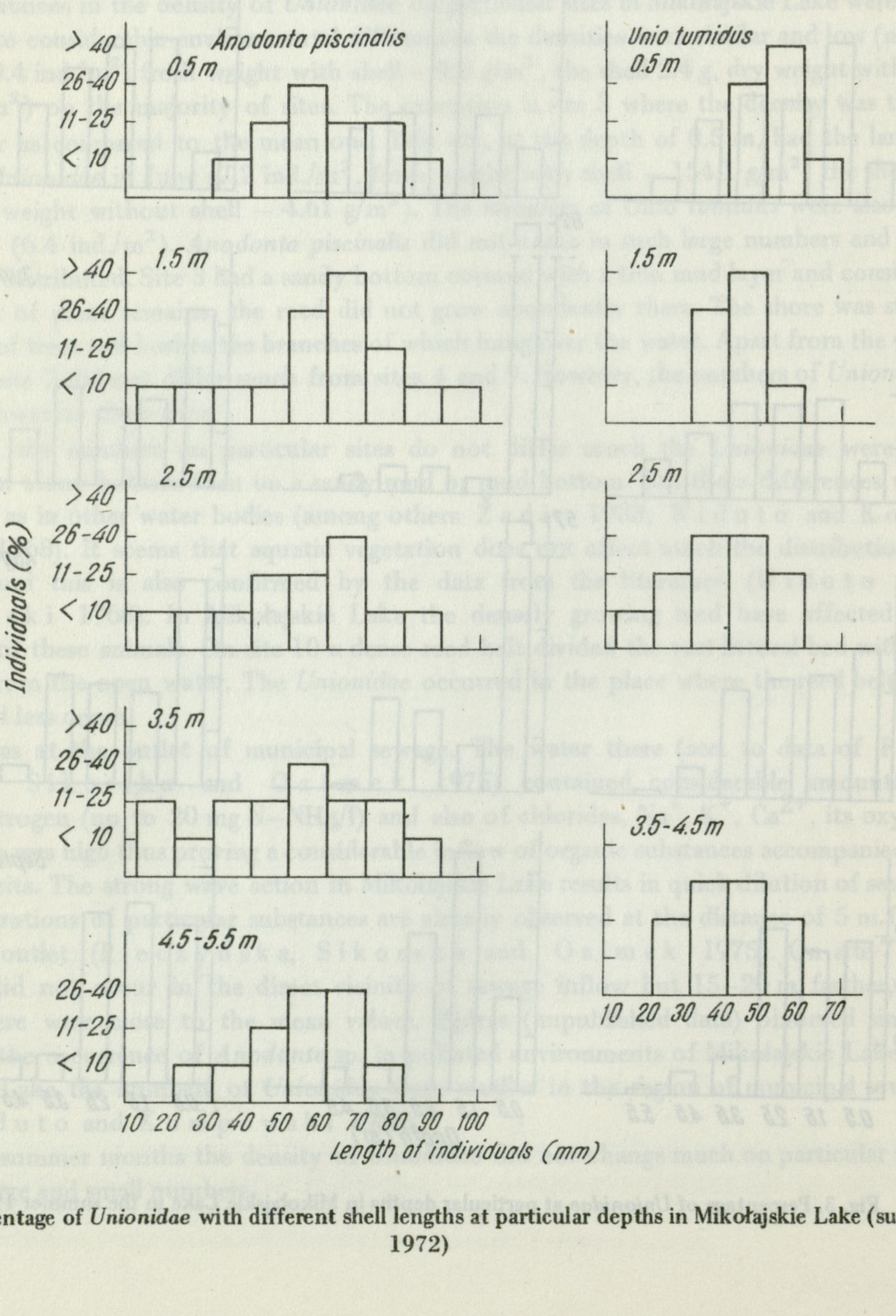

Fig. 4. Percentage of *Unionidae* with different shell lengths at particular depths in Mikołajskie Lake (summer 1972)

(Ö k l a n d 1963). Young *Anodonta piscinalis* dominated both in shallow places (0.4 m) and in deep (6 m), older individuals were caught at 3–5 m.

The age of caught bivalves has been determined using the method of counting growth rings on shells. This method (among others is discussed in detail by C r o w l e y 1957) is commonly applied to specify the age of *Unionidae* (among others Ö k l a n d 1963, N e g u s 1966, P i e c h o c k i 1969, M a g n i n and S t a ń c z y k o w s k a 1971). The oldest specimens of *Anodonta piscinalis* caught in Mikołajskie Lake have been 9–10 years old. The age structure of

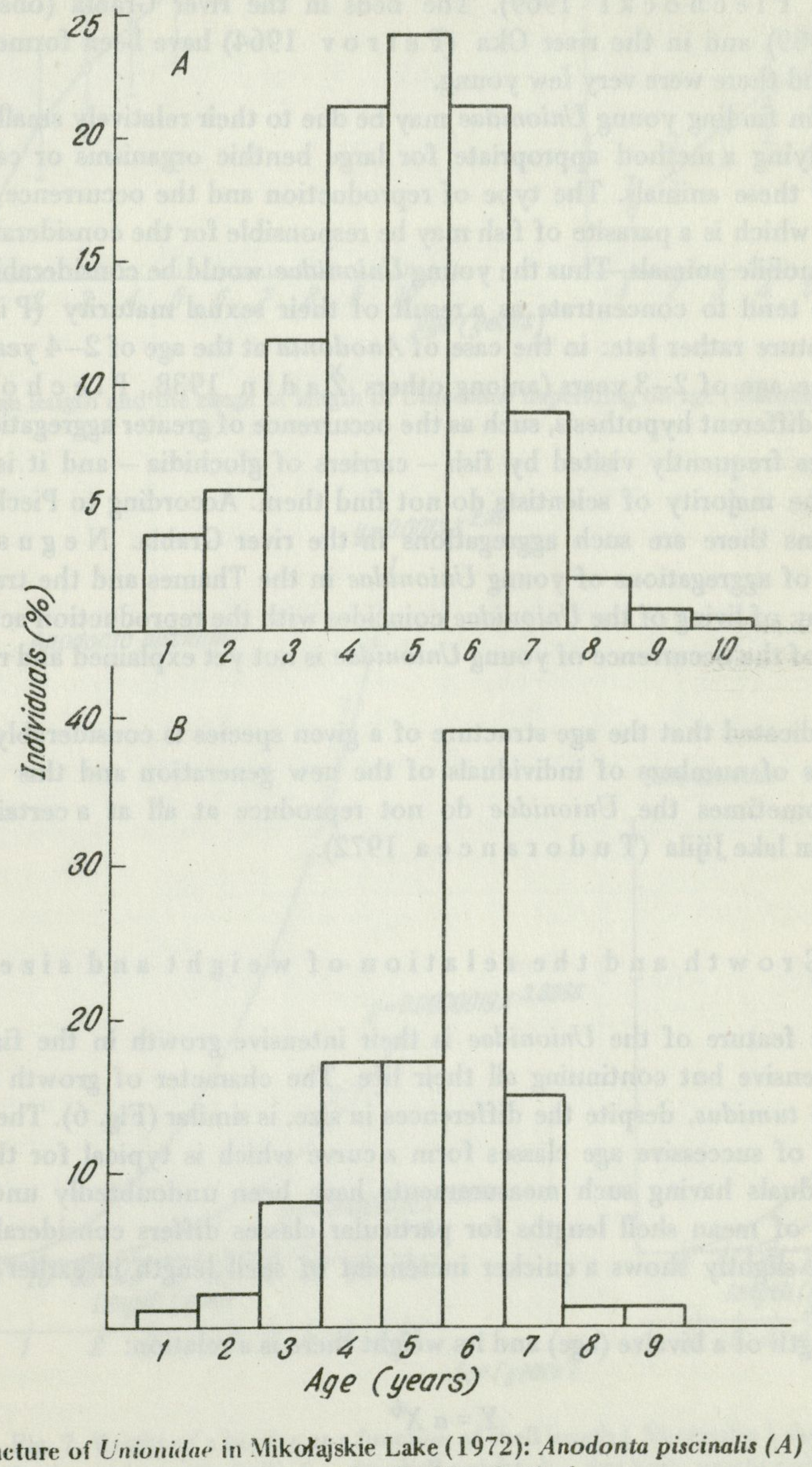

Fig. 5. Age structure of *Unionidae* in Mikołajskie Lake (1972): *Anodonta piscinalis (A)* 303 individuals, *Unio tumidus (B)* 87 individuals

collected *Anodonta piscinalis* and *Unio tumidus* is presented in Figure 5. Individuals 4–6 years old are the majority. It is understandable that the number of older individuals is smaller due to natural mortality. But the small number of the youngest specimens is quite striking. This has been pointed out by several authors studying the *Unionidae* in various water bodies and streams (among others Ökland 1963, Petrov 1964, Negus 1966, Piechocki 1969, Tudorancea 1969, 1972, Magnin and Stańczykowska 1971). The scientists less frequently come across the young specimens in rivers where the *Unionidae* form beds (Petrov 1964, Piechocki 1969). The beds in the river Grabia (observations by Piechocki 1969) and in the river Oka (Petrov 1964) have been formed mainly by adult individuals, and there were very few young.

The difficulties in finding young *Unionidae* may be due to their relatively small size and can be caused by applying a method appropriate for large benthic organisms or caused by the specific biology of these animals. The type of reproduction and the occurrence of the larval stage (glochidium) which is a parasite of fish may be responsible for the considerable spreading of these not very mobile animals. Thus the young *Unionidae* would be considerably scatterred, whereas the adults tend to concentrate as a result of their sexual maturity (Piechocki 1969) and they mature rather late: in the case of *Anodonta* at the age of 2–4 years and in the case of *Unio* at the age of 2–3 years (among others Žadin 1938, Piechocki 1969). But there can be a different hypothesis, such as the occurrence of greater aggregations of young *Unionidae* in places frequently visited by fish – carriers of glochidia – and it is just a sheer coincidence that the majority of scientists do not find them. According to Piechocki's (pers. comm.) observations there are such aggregations in the river Grabia. Negus (1966) has observed this type of aggregations of young *Unionidae* in the Thames and the transition from parasitic to free way of living of the *Unionidae* coincides with the reproduction activity of fish. Thus the problem of the occurrence of young *Unionidae* is not yet explained and requires some further studies.

It should be indicated that the age structure of a given species is considerably affected by annual fluctuations of numbers of individuals of the new generation and this depends on several factors. Sometimes the *Unionidae* do not reproduce at all at a certain year as it happened in 1965 in lake Jijila (Tudorancea 1972).

3.3. Growth and the relation of weight and size

A characteristic feature of the *Unionidae* is their intensive growth in the first years and afterwards less intensive but continuing all their life. The character of growth of *Anodonta piscinalis* and *Unio tumidus*, despite the differences in size, is similar (Fig. 6). The limits of the shell length range of successive age classes form a curve which is typical for the growth of *Unionidae* – individuals having such measurements have been undoubtedly under best conditions. The curve of mean shell lengths for particular classes differs considerably from the former although it slightly shows a quicker increment of shell length in earlier years and its slower rate later on.

Between the length of a bivalve (age) and its weight there is a relation:

$$Y = a X^b$$

where Y – weight, X – length of a bivalve, a and b – parametres. According to empirical data

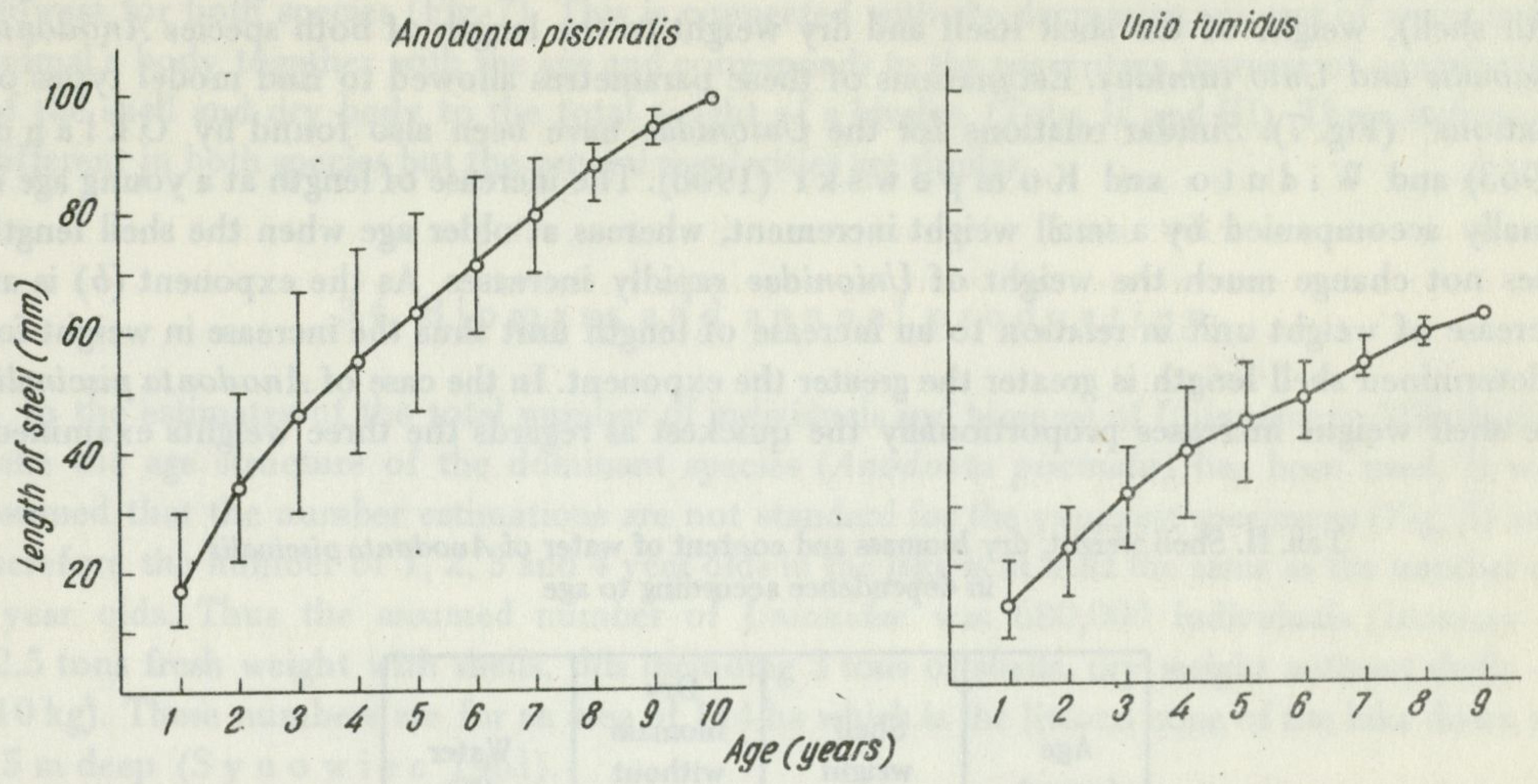

Fig. 6. Mean length and the range of length of *Unionidae* depending on age (Mikołajskie Lake 1972)

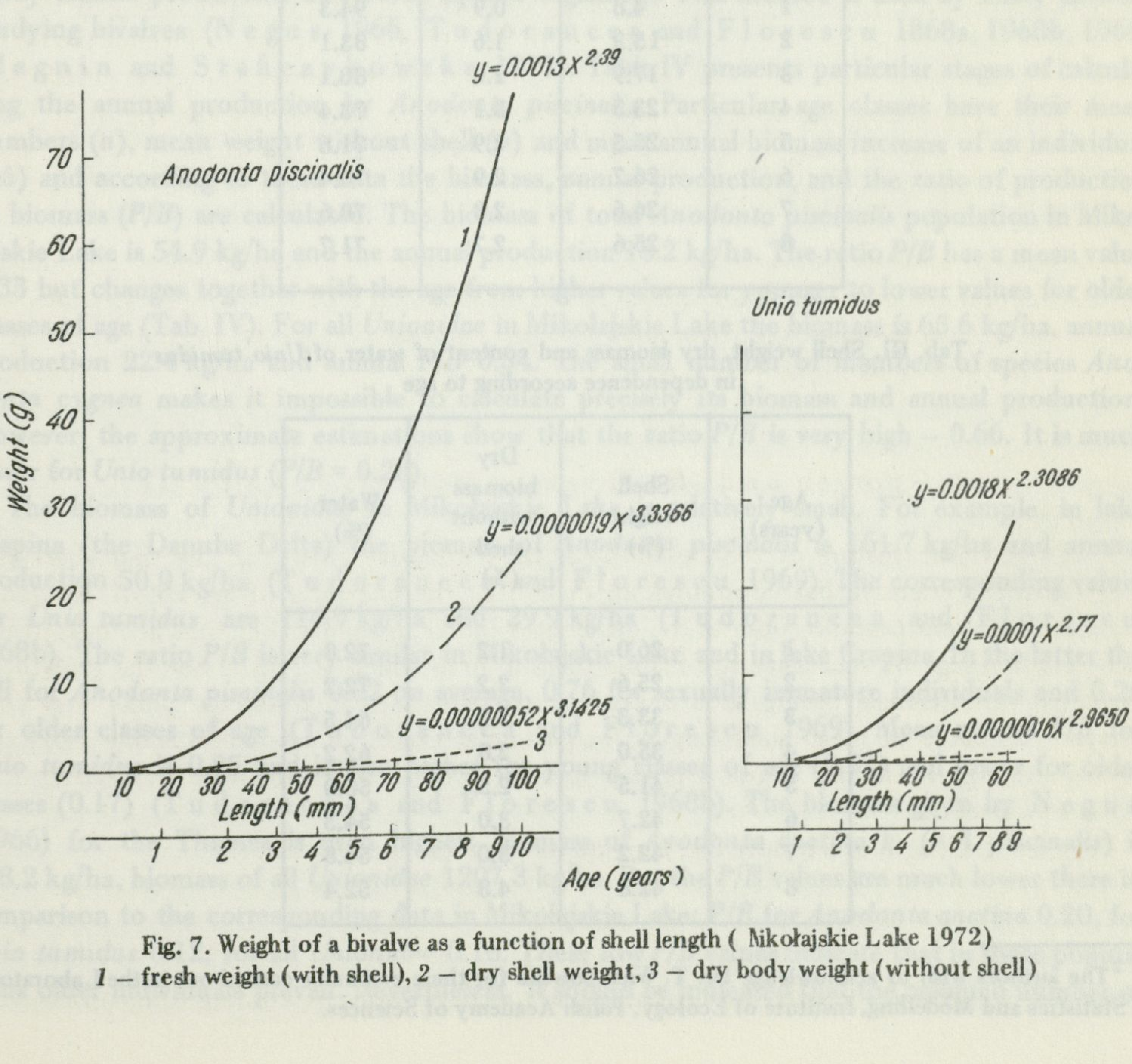

Fig. 7. Weight of a bivalve as a function of shell length (Mikołajskie Lake 1972)
1 — fresh weight (with shell), *2* — dry shell weight, *3* — dry body weight (without shell)

the values of parametres *a* and *b* were estimated for the relation of total weight (fresh weight with shell), weight of the shell itself and dry weight to the length of both species *Anodonta piscinalis and Unio tumidus*. Estimations of these parametres allowed to find model types of relations[2] (Fig. 7). Similar relations for the *Unionidae* have been also found by Ökland (1963) and Widuto and Kompowski (1968). The increase of length at a young age is usually accompanied by a small weight increment, whereas at older age when the shell length does not change much the weight of *Unionidae* rapidly increases. As the exponent (*b*) is an increase of weight unit in relation to an increase of length unit thus the increase in weight for a determined shell length is greater the greater the exponent. In the case of *Anodonta piscinalis* the shell weight increases proportionally the quickest as regards the three weights examined,

Tab. II. Shell weight, dry biomass and content of water of *Anodonta piscinalis* in dependence according to age

Age (years)	Shell weight (%)	Dry biomass without shell (%)	Water (%)
1	4.8	0.9	94.3
2	15.3	1.6	83.1
3	17.9	2.0	80.1
4	23.5	3.1	73.4
5	25.5	2.9	71.6
6	26.7	2.9	70.4
7	26.6	2.8	70.6
8	25.6	2.7	71.7

Tab. III. Shell weight, dry biomass and content of water of *Unio tumidus* in dependence according to age

Age (years)	Shell weight (%)	Dry biomass without shell (%)	Water (%)
1	26.0	1.2	72.8
2	25.6	2.2	72.2
3	33.3	2.2	64.5
4	35.0	2.8	62.2
5	41.5	2.5	56.0
6	42.7	3.0	54.3
7	42.2	3.0	54.8
8	42.8	4.8	52.4

[2] The authors wish to acknowledge Dr. T. Wierzbowska for these estimates carried out in the Laboratory of Statistics and Modelling, Institute of Ecology, Polish Academy of Sciences.

whereas in the case of *Unio tumidus* the dry body weight. The total weight increases the slowest for both species (Fig. 7). This is connected with the decreasing amount of water in the animal's body together with the age and corresponds to the percentage increase of contribution of the shell and dry body to the total weight of a bivalve (Tabs. II and III). These indices are different in both species but the general regularities are similar.

3.4. Biomass and annual production

In the estimates of the total number of individuals and biomass of *Unionidae* in Mikołajskie Lake the age structure of the dominant species (*Anodonta piscinalis*) has been used. It was assumed that the number estimations are not standard for the youngest specimens (Fig. 5) and therefore the number of 1, 2, 3 and 4 year olds in the lake is at least the same as the number of 5 year olds. Thus the assumed number of *Unionidae* was 680,000 individuals (biomass – 12.5 tons fresh weight with shells, this including 3 tons of shells, dry weight without shells – 210 kg). These numbers are for an area of 114 ha which is the littoral zone of the lake down to 5.5 m deep (Synowiec 1961).

The calculations of annual production of *Unionidae* in Mikołajskie Lake were made using the method applied by Greze (1965), Kajak and Rybak (1966) and other methods to study annual production of various aquatic organisms. This method is used by many authors studying bivalves (Negus 1966, Tudorancea and Florescu 1868a, 1968b, 1969, Magnin and Stańczykowska 1971). Table IV presents particular stages of calculating the annual production by *Anodonta piscinalis*. Particular age classes have their mean numbers (*n*), mean weight without shell (*b*) and mean annual biomass increase of an individual (Δb) and according to these data the biomass, annual production, and the ratio of production to biomass (*P*/*B*) are calculated. The biomass of total *Anodonta piscinalis* population in Mikołajskie Lake is 54.9 kg/ha and the annual production 18.2 kg/ha. The ratio *P*/*B* has a mean value 0.33 but changes together with the age from higher values for younger to lower values for older classes of age (Tab. IV). For all *Unionidae* in Mikołajskie Lake the biomass is 65.6 kg/ha, annual production 22.4 kg/ha and annual *P*/*B* 0.34. The small number of members of species *Anodonta cygnea* makes it impossible to calculate precisely its biomass and annual production. However, the approximate estimations show that the ratio *P*/*B* is very high – 0.66. It is much lower for *Unio tumidus* (*P*/*B* = 0.28).

The biomass of *Unionidae* in Mikołajskie Lake is relatively small. For example, in lake Crapina (the Danube Delta) the biomass of *Anodonta piscinalis* is 161.7 kg/ha and annual production 50.9 kg/ha (Tudorancea and Florescu 1969). The corresponding values for *Unio tumidus* are 116.9 kg/ha and 29.9 kg/ha (Tudorancea and Florescu 1968b). The ratio *P*/*B* is very similar in Mikołajskie Lake and in lake Crapina. In the latter the *P*/*B* for *Anodonta piscinalis* 0.32 on average, 0.76 for sexually immature individuals and 0.26 for older classes of age (Tudorancea and Florescu 1969). Mean annual *P*/*B* for *Unio tumidus* is 0.25 and is also higher for young classes of age (0.71) and lower for older classes (0.17) (Tudorancea and Florescu 1968b). The biomass given by Negus (1966) for the Thames is even higher: biomass of *Anodonta anatina* L. (= *A. piscinalis*) is 648.2 kg/ha, biomass of all *Unionidae* 1207.3 kg/ha. But the *P*/*B* values are much lower there in comparison to the corresponding data in Mikołajskie Lake: *P*/*B* for *Anodonta anatina* 0.20, for *Unio tumidus* 0.12, for all *Unionidae* 0.16. These low *P*/*B* values indicate that in these populations older individuals prevail. Nevertheless, it should be indicated that the assumed number of

Tab. IV. Biomass and annual production of *Anodonta piscinalis* in Mikołajskie Lake (1972)

Age (years)	Numbers of indivi-duals per 1 m^2 n	Biomass of one individual (wet weight without shell) (g) b	Increase of the bio-mass of one individual per year (g) Δb	Average biomass (g/m^2) $B = n \cdot b$	Production per year (g/m^2) $P = n \cdot \Delta b$	*P/B*
1	0.06*	1.2	1.2	0.07	0.07	1.00
2	0.06*	3.2	2.0	0.19	0.12	0.62
3	0.06*	8.1	4.9	0.49	0.29	0.58
4	0.06*	14.4	6.3	0.86	0.38	0.43
5	0.06	19.2	4.8	1.15	0.29	0.25
6	0.05	23.3	4.1	1.16	0.21	0.18
7	0.03	33.0	9.7	0.99	0.29	0.29
8	0.005	50.3	17.3	0.25	0.09	0.35
9	0.005	66.0	15.7	0.33	0.08	0.24
Total	0.390	–	–	5.49	1.82	0.33

*Theoretical numbers (= numbers of the 5th class of age).

young in Mikołajskie Lake is higher than it has been found (this has been already mentioned). If calculations are made on the basis of the existing age structure then the *P/B* index will be also lower due to smaller contribution of young (e.g. it would be 0.29 for *Anodonta piscinalis*).

3.5. Filtration possibilities; the role of *Unionidae* in the lake

Partly on the basis of the results of experiments and partly on the basis of the literature data the filtration possibilities of *Unionidae* in Mikołajskie Lake were estimated. In August, two field experiments lasting 24 hours were carried out to study filtration, consumption and assimilation of food in *Unionidae* belonging to the middle class of age (4–5 years). The set of animals was the same in both experiments, i.e. two *Anodonta piscinalis* individuals with shells 60 and 64 mm long, and two *Unio tumidus* individuals with shells 48 and 54 mm long. Every few hours measurements turbidity of water that passed through experimental and control cages was measured. Thus during the experiment the filtration of animals examined could be observed; the periods of decreased filtration intensity were irregular, either shorter or longer. The percentage of used up available seston ranged from 10 to 80% (47% on average). The daily feeding rate was 20.6 mg dry seston weight per individual on average. The *Unionidae* excreted 4.2 mg faeces/ind. per 24 hr on average. Assimilation of food calculated from the equation $A = C - F$ (A – assimilation, C – consumption, F – faeces) was on average 16.4 mg/ind. per 24 hr (= 79.6% in proportion to the filtrated seston). Both species had similar filtration rates – they filtrated on average 300 ml water per hour (= 14.3 ml/hr per g fresh weight with shell) but at high individual variability ranging from 60 to 490 ml/hr. Similar values were obtained by Voskresenskij and Kondratev, cited by Alimov (1965), and according to them *Anodonta* *piscinalis* and *Unio tumidus*, 46 mm long, filtrate 400 ml water per hour. The filtration rate for *Anodonta cygnea*, 80–100 mm long is 250–300 ml/hr according to De Bruin and Davids (1970).

For the calculations of filtration possibilities of *Unionidae* populations in Mikołajskie Lake including all classes of age the equation given by Alimov (1969) was used:

$$V = 84.14\,P^{-0.51}$$

for the relation between filtration rate – V (ml/hr per g) and weight of *Anodonta piscinalis* – P (g). The filtration rates obtained for the field experiments in Mikołajskie Lake are similar to analogous values calculated according to the equation above. Although in these calculations only *Anodonta piscinalis* (most abundant in the lake) is taken into account the results are related to the total number of *Unionidae* in the lake as the filtration possibilities of species belonging to this family are similar. Table V presents the results of this equation for particular

Tab. V. Filtration of *Anodonta piscinalis* in various age classes

Age (years)	Average biomass of individual (g) P	Filtration* (ml/1 hr per 1 g of animal body) V	Filtration (ml/1 hr per animal) $V \cdot P$
1	1.25	76.5	96
2	3.80	44.3	168
3	9.90	27.1	268
4	18.80	19.5	366
5	25.80	16.5	425
6	31.80	15.0	477
7	44.90	12.6	566
8	65.00	10.4	676
9	88.00	8.9	783

*According to Alimov (1969).

classes of age of *Anodonta piscinalis*. According to these data the *Unionidae* in Mikołajskie Lake can filtrate during 24 hours about 5000 m^3 of water and during the whole vegetation season (i.e. about 6 months) the thirtieth part of all epilimnion down to 7 m deep and can filtrate from water about 2.5 tons dry seston weight.

3.6. Final remarks

Generally it can be said that in Mikołajskie Lake there are the same *Unionidae* species as in other water bodies. The domination relations are also similar – usually the most abundant are *Anodonta piscinalis* and *Unio tumidus*. Still the numbers of *Unionidae* are much smaller in other water bodies and the same can be said of biomass and annual production. These numbers are much higher in Kortowskie Lake where the mean value in the zone of occurrence is 10.6 ind./m^2 and at the inflow of ground waters rich in humic substances the maximum number of 256 ind./m^2 is found (W i d u t o and K o m p o w s k i 1968). The numbers of the order 200–400 individuals/m^2 are given by Ž a d i n (1938) for rivers with dams and dikes. A similar number has been recorded (300 ind./m^2) in the dam reservoir Goczałkowice (Krzyżanek, pers. comm.). According to A g r e l l (1949) the abundance of *Unionidae* depends on the extent of lake trophy. And thus he gives the number of 1.8 individuals of *Anodonta piscinalis* per 1 m^2 of oligotrophic and mesotrophic lakes in southern Sweden, 8.2 ind./m^2 of eutrophic lakes and 20–30 ind./m^2 of highly eutrophic lakes. Together with the increasing trophy the numbers of *Unio pictorum* increase and of *Unio tumidus* decrease. In similar lakes of the same geographical regions some authors observe estremely different numbers of *Unionidae*, e.g. in lakes Jijila and Crapina (the Danube Delta) 3.8 and 11.5 ind./m^2 (T u d o r a n c e a 1972), in lakes Saint-Louis and Deux Montagnes (south-eastern Canada) 1 and 25 ind./m^2 (M a g n i n and S t a ń c z y k o w s k a 1971) and in lakes Parovoe and Velikoe (central European part of the USSR) 4 and 65 ind./m^2 at the depth of 0.5 m (Ž a d i n 1938). In water bodies where *Unionidae* are very abundant their percentage in total benthic biomass is very high. In lake Borrevann in which *Anodonta piscinalis* is the only species of the family *Unionidae* its mean number is 10 ind./m^2 and as regards its weight 95.7% of total benthic fauna in this lake (Ö k l a n d 1963). In Mikołajskie Lake the number of *Unionidae* is small as well as their percentage in the biomass of entire bottom fauna although molluscs dominate in this lake and the contribution of *Dreissena polymorpha* to benthic biomass is the largest in its zone of occurrence (0.2–8.0 m) and has the mean number of 300 ind./m^2 (S t a ń c z y k o w s k a et al. – in press). The effect of bivalves on the lake biocenosis is primarily connected with their filtration. All populations of bivalves in Mikołajskie Lake (bivalves of the family *Unionidae*, *Dreissena polymorpha*, bivalves of the family *Sphaeriidae*) can filtrate during the vegetation season a double amount of water contained by the epilimnion in this lake. The dominant role is that of *Dreissena polymorpha* (S t a ń c z y k o w s k a et al. – in press).

The majority of material used here is from the master's thesis of Mr. K. Lewandowski "Selected problems of the ecology of bivalves of the family *Unionidae* in Mikołajskie Lake" which has been carried out in the Department of Hydrobiology, Zoological Institute, University of Warsaw, under the guidance of Asst. Prof. Dr. Ewa Pieczyńska. The work was given the award of Polish Hydrobiological Society in 1974.

4. SUMMARY

The study on bivalves of the family *Unionidae* was carried out in eutrophic Mikołajskie Lake (Masurian Lakeland) (surface area 460 ha, mean depth 11.0 m) on 10 sites (Fig. 1) and the material was collected four times between May and September 1972. Five *Unionidae* species were found. *Anodonta piscinalis* Nilsson (71.5%) and *Unio tumidus* Philipsson (20.5%) were the most abundant species. Other species: *Anodonta cygnea* L., *Unio pictorum* L. and *Anodonta (Pseudanodonta) complanata* Rossmässler were found sporadically. The numbers of *Unionidae* in the littoral zone down to 5.5 m deep compared to the data of other authors were relatively low (mean value 0.4 ind./m^2, maximum value 7.2 ind./m^2). The largest numbers were observed at small depths: at 1.5–2.5 m *A. piscinalis*, at 0.5 m *U. tumidus* (Fig. 2) and during the summer season there were some changes in the distribution of various species at particular depths which were very clear in the case of *U. tumidus* (Fig. 3). The most frequently caught *Unionidae* were those 4–6 years old. Young individuals were rarely found (Fig. 5). And thus in further estimates (biomass, production and filtration of *Unionidae* in this lake) higher numbers of younger classes of age were used than those found in reality. For two *Unionidae* species the relation between the length of a bivalve (age) and its total weight, weight of the shell only and the dry body weight was determined (Fig. 7). Annual production of *Unionidae* in Mikołajskie Lake was 22.4 kg/ha at a biomass 65.6 kg/ha (annual means of $P/B = 0.34$). The mean annual P/B for *A. piscinalis* was 0.33 (Tab. IV), 0.28 for *U. tumidus* and 0.66 for *A. cygnea*. Data on the filtration of *Unionidae* were obtained in field experiments. Four and five year old *A. piscinalis* and *U. tumidus*

(48–60 mm long) filtrated about 300 ml per hour. Their daily feeding rate was on average 20.6 mg dry seston weight per individual, and faeces production – 4.2 mg. Food assimilation in the summer season was 79.6% in relation to filtrated seston. According to the data presented and the literature data on the filtration of *Unionidae* it was estimated that over the period of one vegetation season all *Unionidae* in Mikołajskie Lake (680,000 individuals) can filtrate the thirtieth part of the total volume of epilimnion in this lake and can filtrate from water about 2.5 tons dry seston weight.

5. POLISH SUMMARY (STRESZCZENIE)

Badania nad małżami z rodziny *Unionidae* prowadzono w eutroficznym Jeziorze Mikołajskim (pow. 460 ha, gł. śr. 11,0 m), wyznaczając na nim 10 stanowisk (fig. 1) i zbierając materiał czterokrotnie w okresie maj – wrzesień 1972 r. Stwierdzono występowanie pięciu gatunków *Unionidae*. Najpospolitsza jest *Anodonta piscinalis* Nilsson (71,5%) i *Unio tumidus* Philipsson (20,5%). Pozostałe sporadycznie spotykane gatunki to *Anodonta cygnea* L., *Unio pictorum* L. i *Anodonta (Pseudanodonta) complanata* Rossmässler. Liczebność *Unionidae* w strefie litoralu do głębokości 5,5 m była, w porównaniu z danymi innych autorów, stosunkowo niska (średnio – 0,4 osobnika/m^2, maksymalnie – 7,2 osobnika/m^2). Największe liczebności stwierdzane były na małych głębokościach: na głębokości 1,5–2,5 m – *A. piscinalis*, na głębokości 0,5 m – *U. tumidus* (fig. 2), przy czym w ciągu sezonu letniego notowane były pewne zmiany w rozmieszczeniu różnych gatunków na poszczególnych głębokościach, szczególnie wyraźne u *U. tumidus* (fig. 3). Najliczniej poławiano *Unionidae* w średnim wieku, mające 4–6 lat. Stosunkowo rzadko były znajdowane osobniki młode (fig. 5). Toteż do dalszych szacunkowych obliczeń (biomasy, produkcji i filtracji *Unionidae* w tym jeziorze) przyjęto wyższą liczebność młodych klas wiekowych niż stwierdzono w rzeczywistości. Dla dwóch gatunków *Unionidae* ustalono zależność między długością małża (wiekiem) a jego ciężarem całkowitym, ciężarem samej muszli i ciężarem suchego ciała (fig. 7). Produkcja roczna *Unionidae* Jeziora Mikołajskiego wynosi 22,4 kg/ha przy biomasie – 65,6 kg/ha (średnie roczne $P/B = 0,34$). U *A. piscinalis* średnie roczne P/B wynosi 0,33 (tab. IV), u *U. tumidus* – 0,28 a u *A. cygnea* – 0,66. W eksperymentach terenowych uzyskano dane o filtracji *Unionidae*. *A. piscinalis* i *U. tumidus* w wieku 4–5 lat (przy długości 48–60 mm) filtrują około 300 ml wody na godzinę. Ich dobowa racja pokarmowa wynosi średnio 20,6 mg suchej masy sestonu na osobnika, fekalia – 4,2 mg. Asymilacja pokarmu w okresie letnim wynosi 79,6% w stosunku do odfiltrowanego sestonu. Opierając się na własnych i literaturowych danych o filtracji *Unionidae* oszacowano, że w ciągu jednego sezonu wegetacyjnego wszystkie *Unionidae* występujące w Jeziorze Mikołajskim (680 000 osobników) mogą przefiltrować trzydziestą część całej objętości epilimnionu tego jeziora, odfiltrować zaś mogą z wody około 2,5 tony suchej masy sestonu.

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