EKOLOGIA POLSKA (Ekol. pol.)	43	3–4	267–276	1995

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INDIVIDUAL GROWTH OF THE FRESHWATER MUSSEL *DREISSENA POLYMORPHA* (PALL.) IN MIKOŁAJSKIE LAKE; ESTIMATES IN SITU

ABSTRACT: Measurements were made of the variations in shell length and weight of the bivalve *Dreissena polymorpha* during the period from April until July of the next year. The bivalves being divided into four size classes were placed in cages submerged at several sampling stations of the lake. At the same time, materials were collected for the assessment of both, the shell and body weight increments. Determinations were made during the season, of the increase in shell length and weight within the distinguished size classes. The most intensive growth was recorded for the young individuals, while the slowest for the oldest animals. An increase of dry body weight was noted young individuals: several-fold decrease was found for the older bivalves. This observation has been related to a summer reproductive period and the deterioration of feeding conditions.

KEY WORDS: *Dreissena polymorpha*, growth, lake.

1. INTRODUCTION

Individual growth of *Dreissena polymorpha* (Pall.) has been the study subject in the living populations of different environments. Literature data show, that growth rate may undergo changes both in time (seasonal and multi-annual changes) and space i.e. in different habitat (Lvova-Kačanova 1972, Stańczykowska 1977). Variations in the growth rate of bivalves are usually related to such environmental factors, as temperature (Kačanova 1963, Lvova-Kačanova 1972, Morton 1969, Waltz 1978c), water flow (Micheev 1964, Smit et al. 1992), trophic conditions, e.g. concentration and

species composition of phytoplankton, and the size of food particles (Stańczykowska 1977, Waltz 1978b, 1978c, Smit et al. 1992).

Most studies pertain to the so called "condition" of *D. polymorpha*, that is to its size and weight compared in different years. Relatively few works deal with growth rate changes during the vegetative season from early spring to late autumn. Still fewer publications include the changes of shell size, or the shell and body weights (Walz 1978a, 1978b, 1978c).

Studies of the growth rates of bivalves in time are usually conducted in laboratory conditions in aquaria and basins (Walz 1978a, 1978c), or in various types of cages being placed in the reservoirs during field experiments (Lvova-Kačanova 1972, Walz 1978b, 1978c, Jantz and Neumann 1992, Smit et al. 1992). Some investigators use the labelling of the individuals. An intermediate method of the growth increase is also used through the population size structure analysis (Morton 1969, Dorgelo and Gorter 1984).

Growth studies of the individuals of *D. polymorpha* were carried out in Mikołajskie Lake, in the Masurian Lakeland. In the years preceding the present experiment, studies were made on the type of the bivalve's occurrence, its density, population numbers dynamics, size structure, the so called "condition", and feeding (Lewandowski 1982, Stańczykowska 1964, 1975, 1977). Investigations of individual growth of *D. polymorpha* were carried out in the period of a relative population numbers stability, in the seventies, when average density in the area of occurrence amount to several hundred individuals per 1 m^2.

The purpose of the studies has been to determine the growth rate of individuals, thus the length and weight of shells and dry body weight of *D. polymorpha* within distinguished age classed, during the vegetative season from spring to autumn. Variations in the body and shell weights are shown against the linear increase of shells.

Most investigators compare the changes in body weight with time to the weight of a standard individual having stable length. In the present studies, the weight changes have been related to growing individuals displaying an increase in the length of shells.

2. STUDY AREA AND METHODS

Growth studies of the mollusc *D. polymorpha* were carried out in Mikołajskie Lake. This channel-shaped eutrophic lake is located in the centre of the Great Masurian Lakes. It is connected with the lakes Tałty, Śniardwy and Bełdany. Its surface area covers 460 ha, maximum depth is 27.8 m; average depth 11.3 m. Surface area of the littoral takes 19% of the total reservoir area (Kajak 1978).

The studied individuals of *D. polymorpha* were placed in cages made of plastic net with the mesh size of 5 x 5 mm. To counteract the surfacing of cages they were weighted with stones and fastened to bricks in the littoral beyond the belt of reeds, at 1.5 m depth in places devoid of submerged vegetation. Sets of four cages were lo-

cated several hundred meters from one another, at four stations of a similar type of habitat. In total 16 cages have been installed.

One hundred individuals of *D. polymorpha* of the following four size classes were placed in every cage: class I, 8 mm (± 1 mm); class II, 12 mm (± 1 mm); class III, 18 mm (± 1 mm); class IV, 22 mm (± 1 mm).

The segregated bivalves in cages had rather quickly developed bysseal threads attaching them to stones, or, they formed small colonies of several individuals. With time the cages became overgrown with periphyton, which was removed with each sampling to keep the net meshes open during the experiment. Very young individuals of *D. polymorpha*, ca. 1–2 mm in length would enter the cages, but were removed during the measurements. Other invertebrates, mainly leeches and the larvae of Chironomidae also invaded the cages.

Cages containing the smallest bivalves of the 1 size class were encircled in the enterior with a fringe of a plastic net with the mesh size of 2 x 2 mm.

During the experiment lasting about one year, there was noted an insignificant mortality of *D. polymorpha* in cages. No dead individuals were recorded in 83% of the observations made. In the remaining cases mortality accounted for 1–5%, i.e. 1 to 5 individuals: only once in July, 15 dead individuals of *D. polymorpha* were found in one cage.

Cages were placed in the lake at the end of April. Measurements of the bivalve's shells were made once or twice a month. After removing the cages from water on boat, 10 individuals from each cage were measured with a slide – ruler. Care was taken not to destroy the colony structure, or the byssal threads between the individuals. Colonies with measured bivalves were replaced in their cage which was subsequently submerged in the same place in the lake.

Observations of the variation in shell weight and dry body weight, were based on *D. polymorpha* samples collected in the vicinity of the experimental stations with cages in Mikołajskie Lake, at 2 m depth, from spring to autumn. For this purpose, 30 individuals representative of each size class were used from the obtained sample of *D. polymorpha* population. The collected mussels were dried at 60 °C during 24 h. The body and shell were weight with the precision of 0.1 mg. Some experimental sets located in the lake were destroyed by the summer tourists.

3. RESULTS

3.1. AN INCREASE OF SHELL LENGTH

The entire set of cages containing all the size classes had stayed until autumn at only one sampling station (1). One cage at station 2 was lost in August, but the others lasted until June next year. Only four observations were made at station 3, and two at station 4. Results obtained from station 1 are shown in Figure 1.

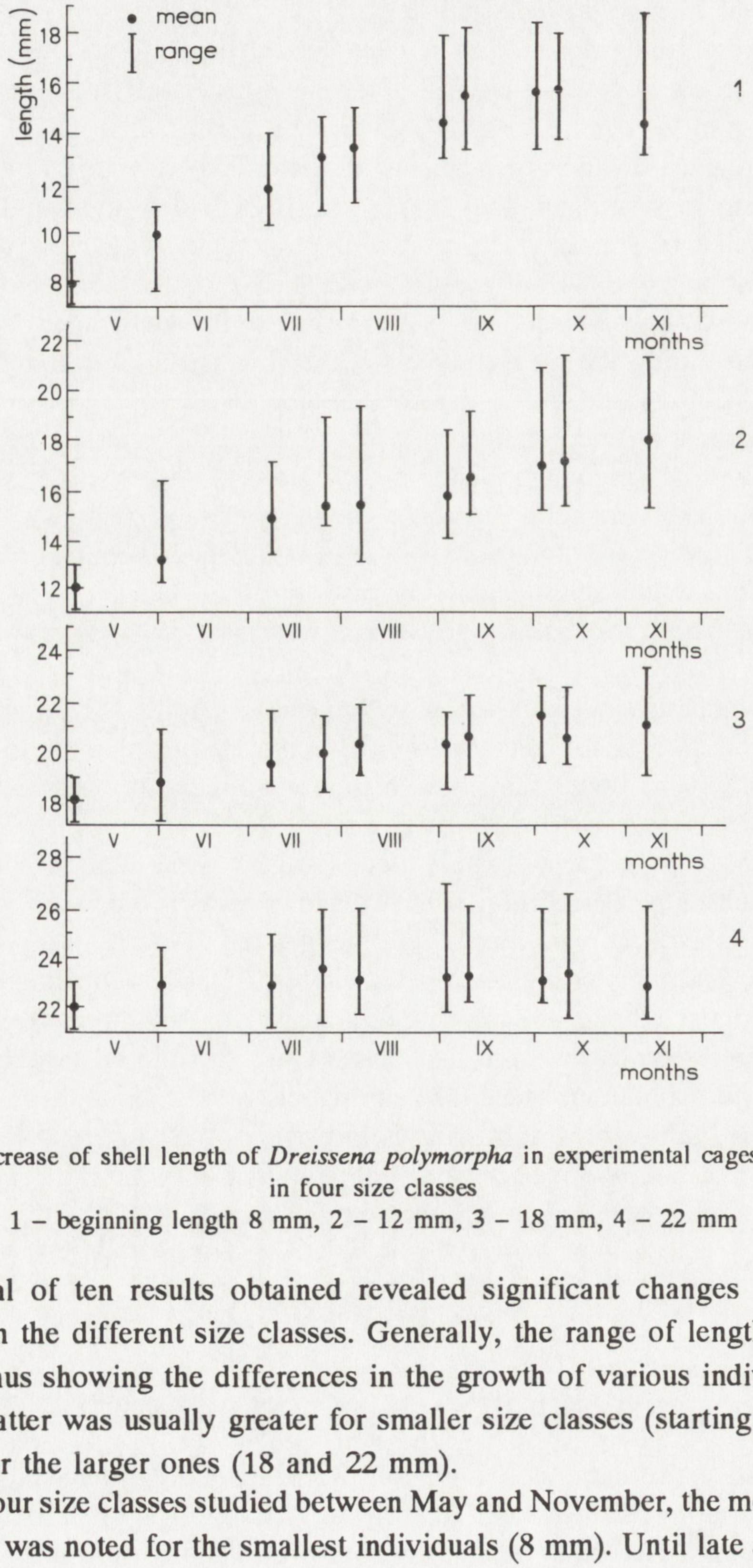

Fig. 1. An increase of shell length of *Dreissena polymorpha* in experimental cages at station 1, in four size classes
1 – beginning length 8 mm, 2 – 12 mm, 3 – 18 mm, 4 – 22 mm

The total of ten results obtained revealed significant changes in the shell length within the different size classes. Generally, the range of lengths increased with time, thus showing the differences in the growth of various individuals. The shell size scatter was usually greater for smaller size classes (starting at 8 and 12 mm) than for the larger ones (18 and 22 mm).

Of the four size classes studied between May and November, the most intensive shell growth was noted for the smallest individuals (8 mm). Until late autumn they had twice increased their length with the average of 8.2 mm. Bivalves with the be-

ginning shell length of 12 mm attained on the average 6.0 mm; those of 18 mm had added 3.0 mm. The slowest shell growth, with an average of 2.2 mm was noted, during the same period, for the largest individuals (22 mm).

Changes in shell length were similar at different sampling stations. They were the highest in the spring and summer (Figs. 1, 2) and somewhat slower in autumn. Inhibition of shell growth was observed during winter. In April of the next year shall lengths of *D. polymorpha* in individual cages resembled those noted in November. The growth was resumed from the middle of April next year (Fig. 2).

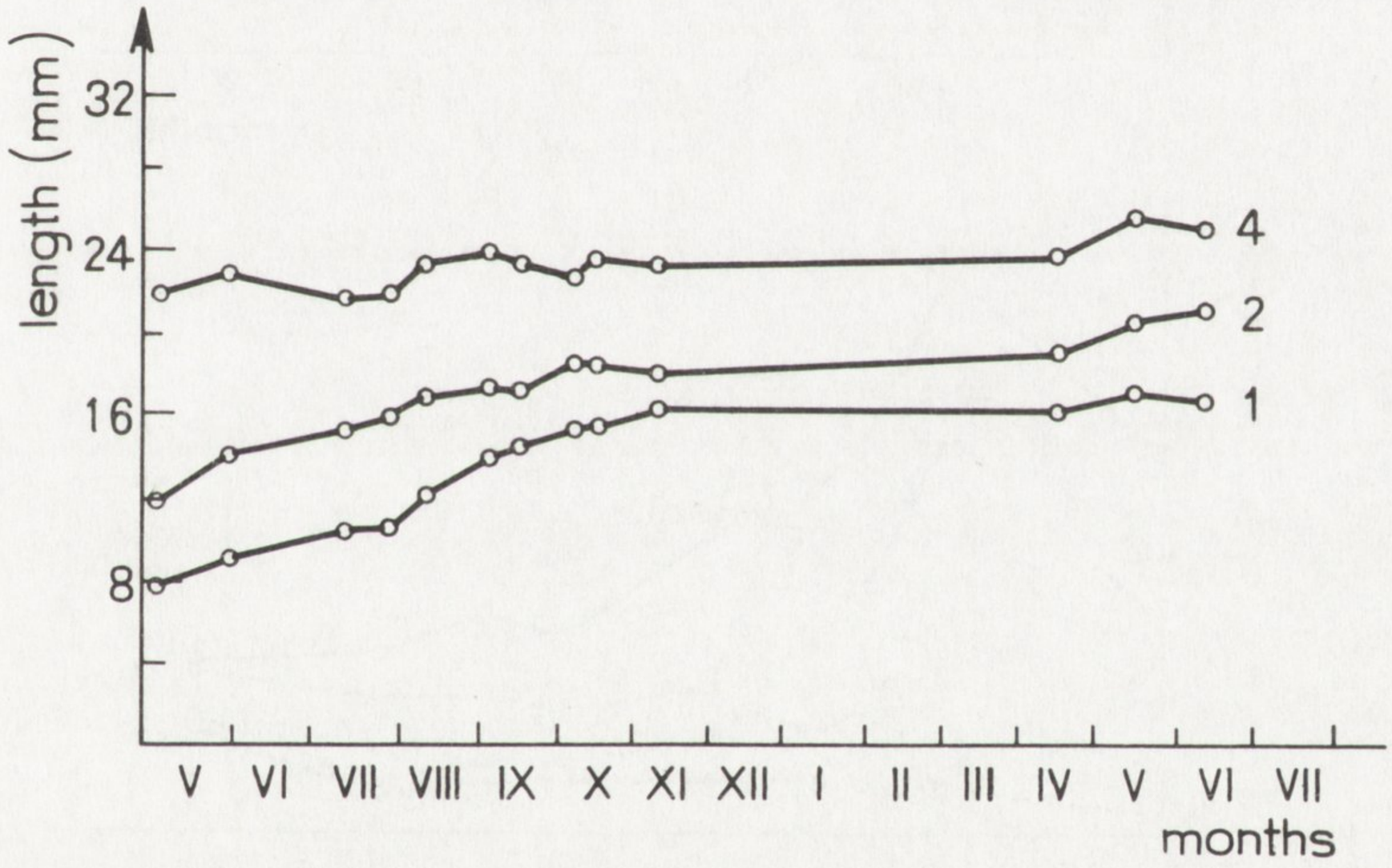

Fig. 2. An increase of shell length of *D. polymorpha* in experimental cages at station 2, within three size classes
1 – beginning length 8 mm, 2 – 12 mm, 4 – 22 mm

3.2. INCREASE OF BODY WEIGHT AND SHELL WEIGHT

As mentioned in the chapter on methods, dry body weight and shell weight were determined by comparing bivalves in cages with those collected in the lake outside the experimental sets. This procedure resulted from the fact, that we could not obtain both measurements, of dry body weight and shell weight of the individuals participating in the experiment, since those in not destroyed colonies were replaced in the cages.

Of the samples collected in the vicinity of cages, care was taken to choose the individuals of similar shell size to those of the molluscs inside the cages. With only one exception, the differences of the average animal length within the various size classes were smaller than 0.15 mm. Once the difference was higher (0.45 mm).

Analysis of the results on body and shell weights indicates, that weight changes vary from the changes of *D. polymorpha* shell length. Steady (uniform) and small increase of dry body weight was only observed in the youngest class having the starting shell length of 8 mm (Fig. 3). A distinct growth inhibition was

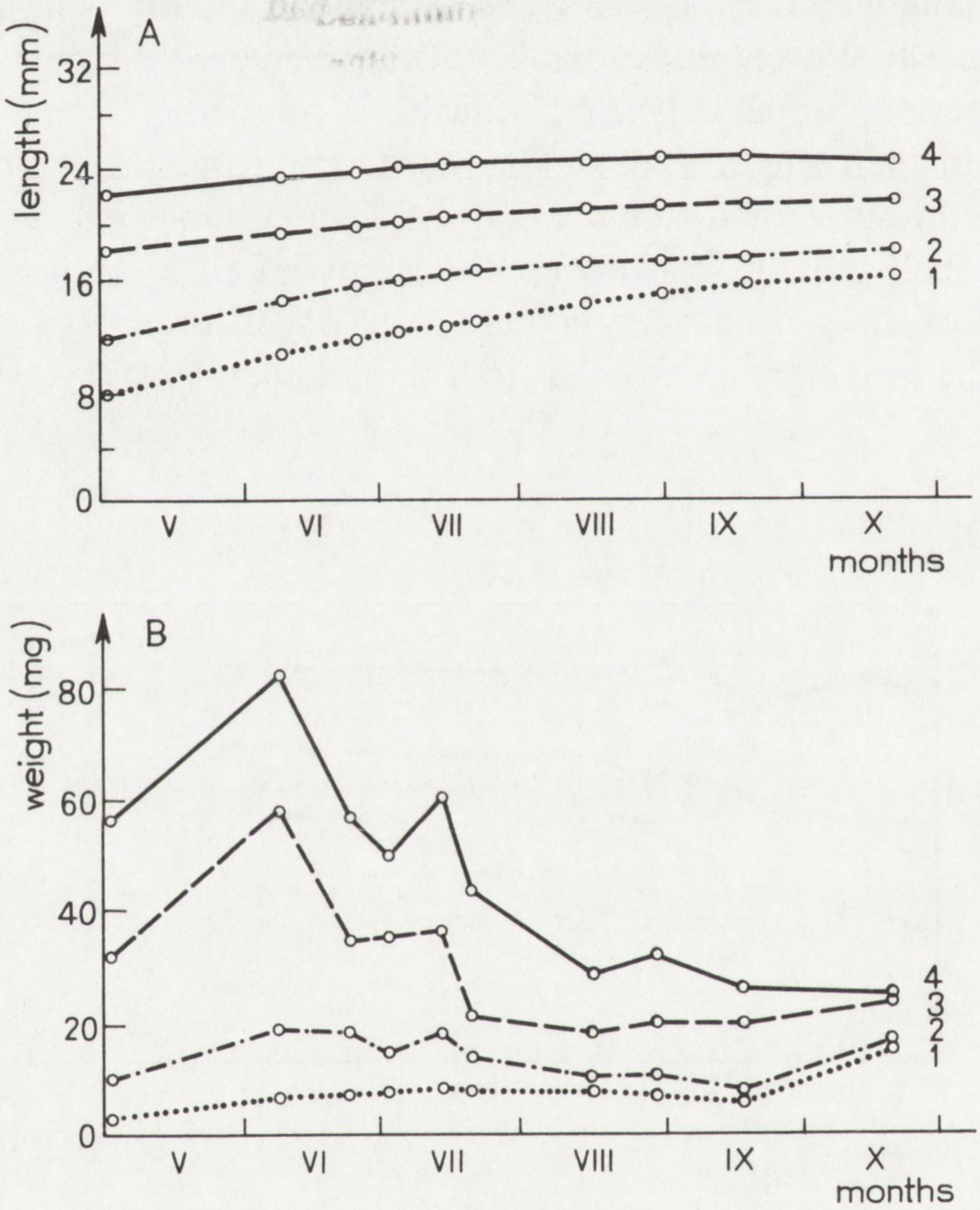

Fig. 3. Changes of shell length (A) and dry body weight (B) of *D. polymorpha* individuals within four size classes (1–4), Mikołajskie Lake

evident during summer in July and August, and a renewal of growth followed in September and October. Within the remaining size classes, changes of body weight were very much pronounced and quite synchronized in the various classes of the starting shell sizes. An intensive growth of body weight was observed in spring, its studded decline was noted from the middle of June, and a renewed growth occurred in autumn (Fig. 3).

A decline of dry body weight in summer was particularly notable for the largest individuals of the starting length 22 mm. From the middle of June to the middle of September it amounted to 65,2% in spite of the simultaneous increase of shell length.

The results also show, that increments in the shell lengths are accompanied by relatively small increases of the shell weight. The most evident increase in the shell weight from May until November was ascertained for the smallest size classes; it was less distinct for the larger classes (Fig. 4). An increase in shell weight was especially observed in spring. It was relatively insignificant in summer, particularly for the larger size classes.

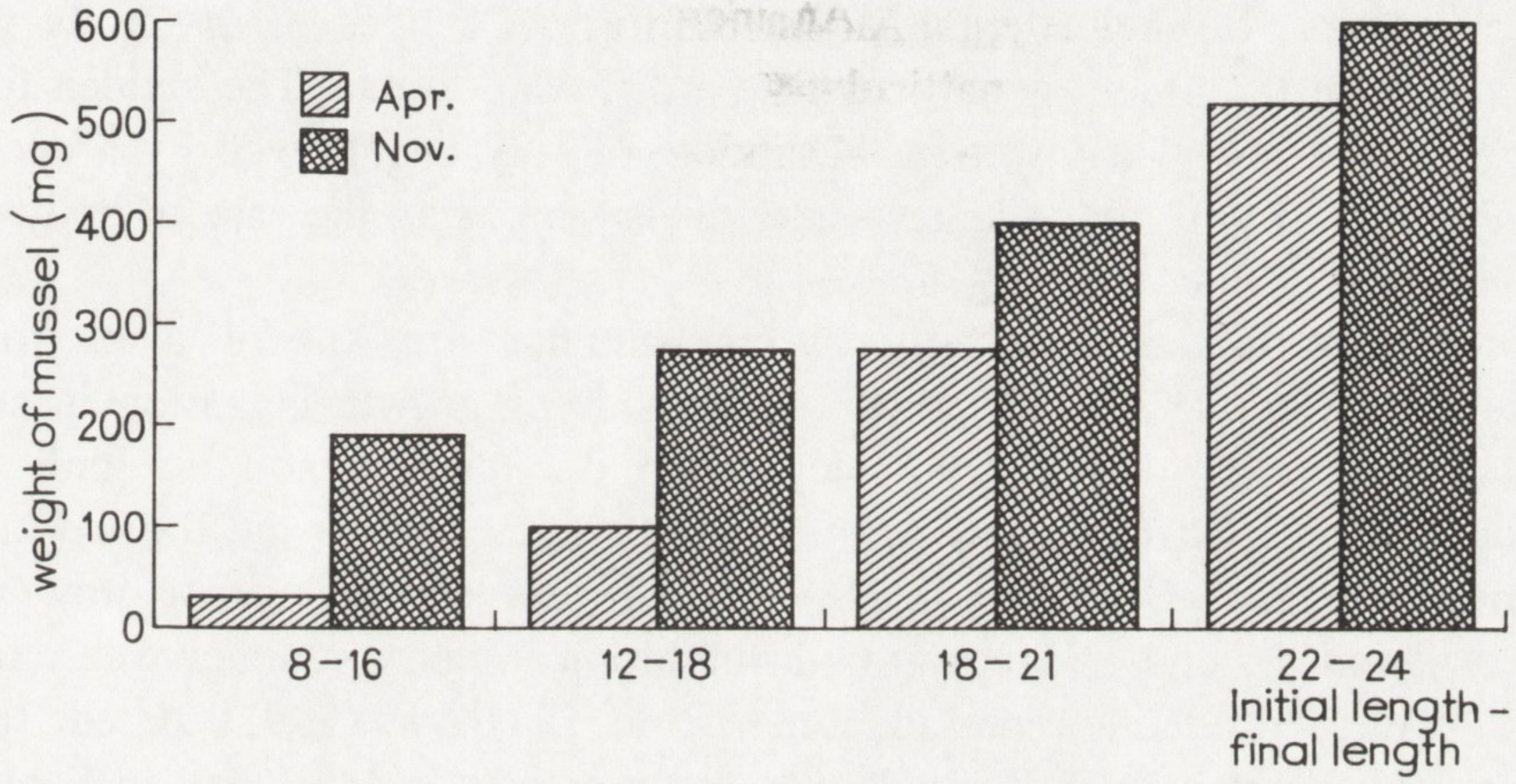

Fig. 4. An increase of *D. polymorpha* shell weight in four size classes during the vegetative season in Mikołajskie Lake

4. DISCUSSION

Changes in the shell length and weight of *Dreissena polymorpha* observed in the present field experiment indicate, that the linear shell increment, an increase of shell weight and body weight are not parallel and are variable within the season. The growth of shell length is the most uniform.

Changes in the increase of shell length found for Mikołajskie Lake are similar to those cited in the literature. Somewhat slower rate of increase was observed in the river Rhine (Jantz and Neumann 1992), while much higher increase was noted in the Učinski retention reservoir (Lvova-Kačanova 1972) (Fig. 5). As known, the best developed and most dense populations of *D. polymorpha* are found in retention reservoirs (literature review; Lewandowski 1982). On the other hand, growth rates in rivers are being limited by strong currents and high contents of mineral substances.

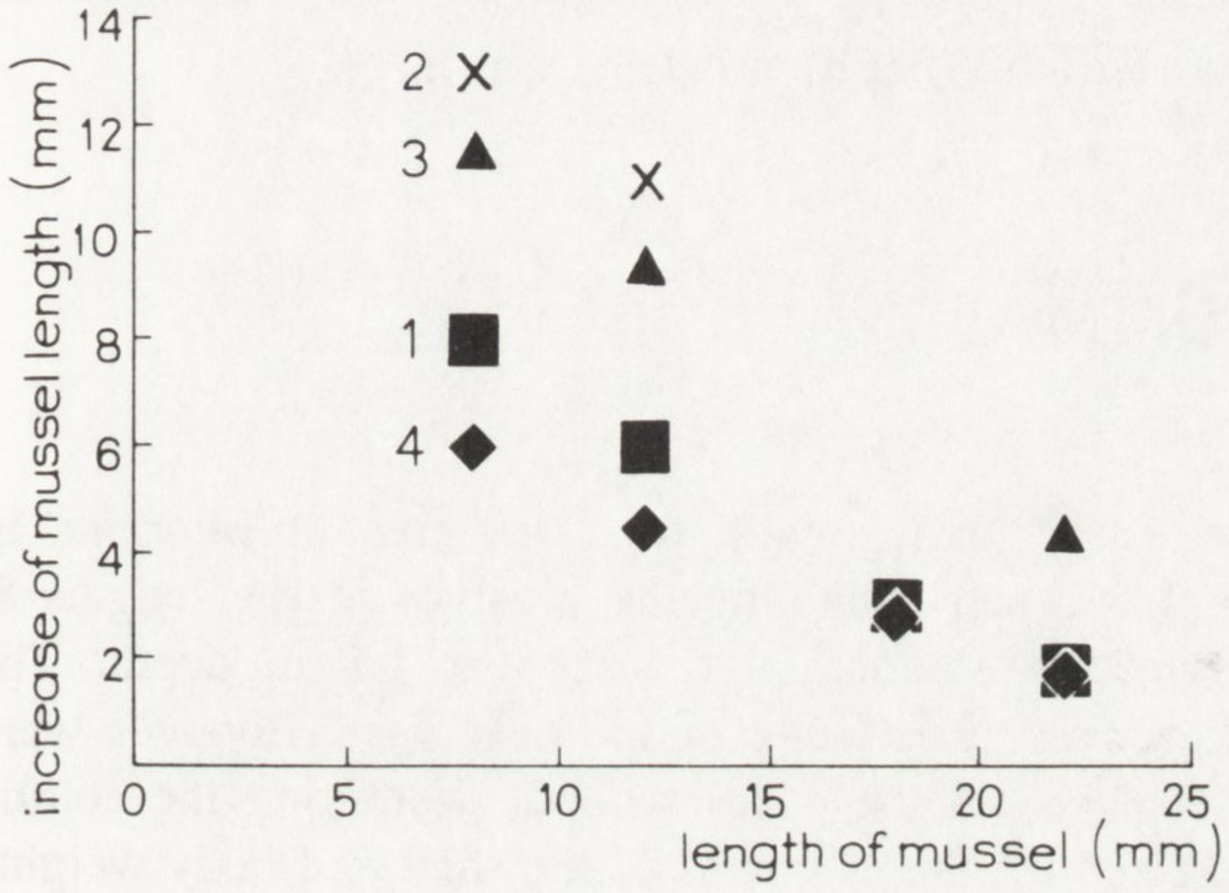

Fig. 5. Average increase of *D. polymorpha* shell length within four size classes from May to November, in experimental sets in different environments
1 – Mikołajskie Lake, 2 – Učinski Reservoir, 1967, 3 – Učinski Reservoir, 1968 (Lvova-Kačanova 1972), 4 – river Rhine (Jantz and Neumann 1992)

An increase of shell weight is also uniform. Changes of dry body weight, particularly for the older age classes take a different course. The sudden increase in spring and somewhat lower in the middle of July is followed by a decline of body weight. Only for the youngest individuals there is an increase of body weight similar to that of the shell.

Growth variations especially during summer are known also from the literature. Walz (1978b) observed two periods of growth cessation in summer for two years old mussels (2+). He related the phenomenon not only to the reproductive period (mass shedding of gametes), but also to the limited amounts of appropriate food. Smit et al. (1992) also observed the highest growth of *D. polymorpha* at the end of May; growth inhibition in early summer was related to the intensive reproduction period. Smit and Dudok (1992) stated, that the biomass of 10 mm long individuals was twice greater in May than in September. Morton (1969) also distinguished two periods of *D. polymorpha* shell increase; short one in early summer, and second in late summer. These kind of changes were followed by a deposition of a summer ring over the shell surface.

Similar variations in body weight and shell length during summer were observed in American populations in lake Erie by Garton and Haag (1993), and in lake St. Clair by Nalepa et al. (1993). The latter authors related the many literature data on the subject to both, expulsion of gamets and the lack of suitable food. If the relationship between dry body weight with reproduction has been suggested by many authors, the lack of food has only been hypothesised by others.

Our studies conducted in Mikołajskie Lake in a period directly preceding the investigation of *D. polymorpha* growth (Stańczykowska et al. 1975, Stańczykowska et al. 1976) provide most direct evidence of the relationship between body weight changes and the changes of natural food. Analyses of food consumption and assimilation by *D. polymorpha* compared with the quantitative and qualitative changes of phytoplankton were carried out in a field experiment, in conditions similar to natural environment. These studies showed a complete cessation of food assimilation, and a significant decline in consumption in the period of the peak bloom of the dinoflagellate species *Ceratium hirundinella* (O.F.M.) Bergh. In other periods, such as spring and autumn, the changes in consumption and assimilation followed those of temperature changes.

5. SUMMARY

Field experiments were conducted to study the growth of *Dreissena polymorpha* in Mikołajskie Lake. Sets of cages made of a plastic net containing the bivalves of the lengths 8, 12, 18 and 22 mm were placed at four sampling stations in the lake at 1.5 m depth. The experiment lasted from the end of April of one year until June of the next year. Bivalves were measured once or twice a month and were replaced in the cages without destroying the colony structure. At the same time bivalves were collected for the estimates of the shell and body weights

increases. Natural populations in the lake were sampled for individuals of the sizes corresponding to those for *D. polymorpha* in the experiment.

It has ascertained, that the young individuals desployed the most intensive growth increase (average of 8.2 mm) during the vegetative season. The slowest growth (2.2 mm increase) was observed for the oldest bivalves (Figs 1, 2). Most intensive growth occurred in spring and summer, and slower in autumn (Figs 1, 2). An increase of dry body weight corresponding to the length changes was recorded for only the youngest class with the beginning shell length of 8 mm. In the remaining size classes, dry body weight increases were noted during spring; they were followed by a sudden decline from the middle of June, and a return of the growth tendency in autumn (Fig. 3). In the largest size class, a summer decline of dry body weight (average 65.2%) occurred in spite of a simultaneous increase in length. The summer decreases of body weigher in Mikołajskie Lake are caused, on the one hand, by the shedding of reproduction gametes, and on the other, by the feeding inhibition of *D. polymorpha* which is related to the bloom of the dinoflagellate, *Ceratium hirundinella*.

6. POLISH SUMMARY

W Jeziorze Mikołajskim przeprowadzono badania wzrostu *Dreissena polymorpha* metodą eksperymentu terenowego. Na czterech stanowiskach w jeziorze na głębokości 1,5 m umieszczono zestawy klatek z siatki plastikowej, w których znajdowały się osobniki *Dreissena polymorpha* o długościach: 8, 12, 18 i 22 mm. Eksperyment trwał od końca kwietnia jednego roku do czerwca roku następnego. Jeden lub dwa razy w miesiącu małże mierzono i ponownie wkładano do klatek, nie niszcząc kolonii. Równocześnie zbierano małże w celu oceny przyrostu ciężaru muszli i masy ciała. Z naturalnej populacji w jeziorze wybierano osobniki o rozmiarach odpowiadających długościom *D. polymorpha* uzyskanych w eksperymencie.

Stwierdzono, że najistotniejszy wzrost był u osobników młodych, które w ciągu sezonu wegetacyjnego zwiększyły długość średnio o 8,2 mm, a najwolniejszy – u najstarszych (przyrost o 2,2 mm) (rys. 1, 2). Wzrost był intensywniejszy wiosną i latem, słabszy – jesienią (rys. 1, 2). Zwiększanie się suchej masy ciała równolegle do zmian długości stwierdzono tylko w klasie najmłodszej, o wyjściowej długości muszli 8 mm. U pozostałych klas wielkościowych sucha masa ciała rosła na wiosnę, po czym od połowy czerwca gwałtownie spadała, a ponowną tendencję wzrostową zaczęła wykazywać jesienią (rys. 3). Letni spadek suchej masy ciała, mimo jednoczesnego przyrostu długości, w klasie osobników największych wynosił średnio 65,2%. Obserwowane latem spadki ciężaru ciała są spowodowane z jednej strony wydalaniem produktów płciowych, z drugiej – zahamowaniem odżywiania się *D. polymorpha* w związku z silnym zakwitem *Ceratium hirundinella* w Jez. Mikołajskim.

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(*Received after revising 31 January 1995*)