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USE OF FIELD MEASUREMENTS OF CONSUMPTION AND ASSIMILATION IN EVALUATION OF THE ROLE OF *DREISSENA POLYMORPHA* PALL. IN A LAKE ECOSYSTEM

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ABSTRACT

Consumption, assimilation and feces production were measured using a set of containers submerged in Mikołajskie Lake. Experiments run from May till mid October 1971 and from June till September 1972. Values for filtration, consumption, assimilation and feces production were found per individual per day, for the mean size animal in the population in different temperature and trophic conditions. These data calculated for the whole population attest the ecological importance of *Dreissena*.

1. INTRODUCTION

Dreissena polymorpha invaded Europe in 19 century, coming from the Black and Caspian Seas. The economic importance of clogging water supply structures has resulted in considerable interest in and research on *Dreissena polymorpha*. This bivalve mollusk has been found to make up a significant (up to 90%) part of the living biomass in freshwater or estuarine environments — in Danmark (Berg 1938), Poland (Wiktor 1963, 1969, Stańczykowska (1964), Russia (Mikheyev 1966, Lvova-Katchanova 1971), and England (Morton 1969). *Dreissena* populations have been said to be important in energy flow from the first trophic level to fish level and in sedimentation of seston material as well as in the fouling of water intake structures and pipes.

The role of *Dreissena* populations in the environments was deducted by inference of the large biomass as the starting point or from extrapolation of laboratory derived filtration rates to field conditions. The methods employed whether direct (Wallengren 1905, Galtsoff 1928, Drinnan 1964, Caughlan, Ansell 1964, de Bruin, Davids 1970, or references in either) or indirect — (Allen 1962, Alimov 1965, Ali 1970, Haven, Morales-Alamo 1970, Morton 1971, or references in them), are of unknown applicability to field situations either because they used non-food substances (graphite, silt, carmine, etc.) or unialgal cultures. The extrapolation is especially questionable when applied to *Dreissena polymorpha* since Morton (1971) found that filtration rate of this species varied with type of food supplied (see also Mattice et al. 1972).

Attempts to measure bivalve filtration in the field by use of the natural seston complement are very rare. One of these methods was elaborated and put to use by Mikheyev (1966, 1967). Later on this method was employed for examination of bivalve filtration in some Mazurian Lakes (Stańczykowska 1968). Mikheyev used an open water system which allowed only short-term experiments. Filtration was computed from the difference between feces and pseudofeces production by *Dreissena* in the experimental funnels and sedimentation in the control funnels. Assimilation was thus ignored. In the present experiments, we have utilized closed containers submerged in the lake and peristaltic pumping of the natural lake water. In this way consumption, feces pro-

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duction and assimilation could be measured under conditions approaching those in the natural environment. Comparison of the values obtained with yearly estimates of primary production and sedimentation allowed thus an evaluation of the role of *Dreissena* in the dynamics of a lake.

2. MATERIALS AND METHODS

The experimental device consisted of a peristaltic pump which produced a flow of water through specially shaped containers (Fig. 1) into which bivalves could be placed, and of baloons for volumetric water collection. The containers which were made of organic glass were divided into two sections by nylon net of mesh size about 0.5 cm upon which the animals were placed. The cylindrical chamber above this net had a volume of about 350 cm^3. The tightly fitting screw cap could be removed for animal placement. Inlet and outlet tubes passed through rubber stoppers were placed in holes in this top. Both tube openings faced the same direction, tangent to the axis of the chamber. Preliminary tests with the use of dyes indicated that circulation within this upper chamber was relatively rapid and complete. However, both the netting and the experimental animals acted as a barrier between the upper and lower chambers. Water in the lower chamber was quite still, especially at the lower end. This lower section functioned for fecal collection. It was funnel-shaped to help to concentrate the fecal material and sediment in a small glass tube. Feces and pseudofeces sank to the bottom of the container fast and did not float in the water. The glass tube contained several drops of chloroform to prevent bacterial growth.

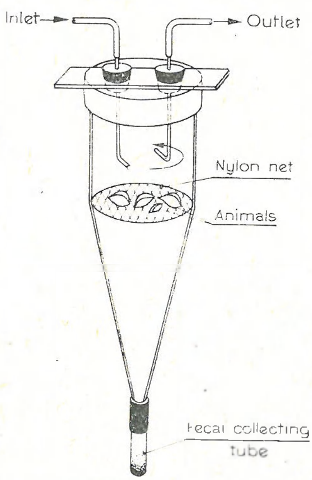

Fig. 1. Experimental container

Six or ten of these containers fixed together in a frame were submerged near a boat at the depth of 2–3 meters (Fig. 2). This approximated the mean depth at which the animals were collected. Polyethylene tubing (2 mm) was positioned in such a way that the inlet openings for all containers were together and at about the same level as the bivalves. Each experimental run included five or eight containers with bivalves and one or two controls (without bivalves). The experimental animals were acclimatised in containers for 24 hours. To all appearance *Dreissena* did not find the environment of containers inhospitable, i.e. in almost all cases, all individuals in each container had attached themselves either to the mesh or to the container's wall by the end of the 24-hr period. Using the same attached animals in second run did not result in any significant changes in filtration, consumption, fecal production or assimilation values.

It is known that the rate of filtration is the function of molluscan weight (Alimov 1969, Morton 1971). To obtain comparable data, individues of one size class — 22 mm length — were taken for this experiment. In all presented here experiments 10 adult individuals were put into each container.

The peristaltic pump, located on the board of the boat, caused the flow of water through the containers (Fig. 3). The speed of rotation of the pump, and thus the volume water flowing through the system, was easily controlled. The water containing seston was thus drawn through the containers. In the containers, part of the suspension was filtered out by the bivalves. Then, the partially cleared water flowed from the containers through the pump and into storage bottles. The water flow through every container was approximately 0.5 liter per hour.

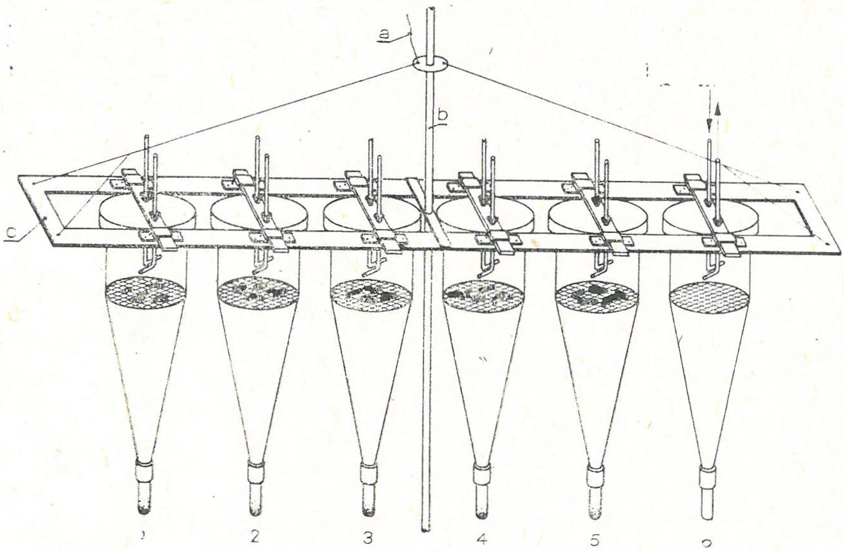

Fig. 2. Frame with containers a — rope, b — stick, c — frame 1 — 5 experimental containers, 6 — control container

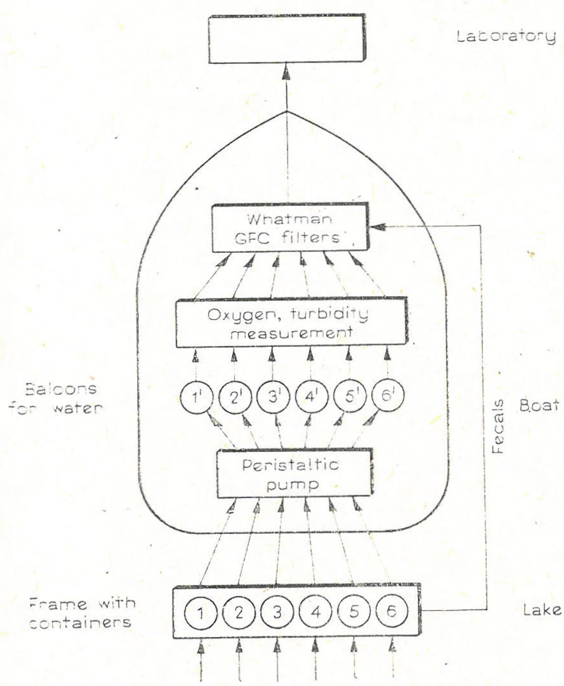

Fig. 3. Schema of experiment. 1 — 5 experimental containers, 6 — control container

Each experiment lasted 24 hours. Two-liter subsamples of outflowing water were collected 3–4 times during the experiment and were filtrated through dried preweighted Whatman GF/C glass filtres. After, the filter was dried in an oven at 105°C, it was reweighted to determine the concentration (mg/l) of seston. The difference between control experimental and seston weights was an estimate of the seston filtrated out by the bivalves. (The amount of filtered suspension was also estimated by a nephelometer; turbidity was measured by this method every two hours). At the end of the 24-hr period, the fecal collecting tubes were removed and their content was filtered, dried, and weighed as above. To find the sedimentation of seston during the passage of water through the containers, the weight of material which had accumulated in the fecal collecting tubes of the control container was measured.

All results were calculated for one individual for a 24-hr period and expressed in terms of dry weight. In 1971 the number of experiments was 35, they were conducted from the end of May till mid October, and in 1972 — 15 experiments from June through August.

The actual measurements were: a — volume of water passed through each container, b — concentration of seston in water after the passage through the control and experimental containers c — weight of material in the fecal collecting tubes of control and experimental containers, d — water temperature, and e — phytoplankton composition in the lake.

The amount of material consumed by *Dreissena* was calculated as the difference between the concentration of seston after leaving the control container and the concentration of seston after leaving the containers with bivalves.

The weight of material in each experimental fecal collecting tube, less that in the control fecal collecting tube (sedimentation) gave the total feces produced by the bivalves during the experiment. Consumption less feces production gave the value of assimilation for each container (A=C—F).

The values of consumption were presented in absolute values (mg/indiv.·24 hrs) and in per cent of the mass of seston accessible to the bivalves. Similarly assimilation was characterized in unit of dry mass per individual per 24 hours and relatively in per cent as compared with consumption. Both of these measurements when expressed as per cents are used here only to eliminate the variation due to differences in the volume of water pumped through each container and in the day to day variation in seston concentration so that an indication of the error involved in replicate measurements, using this method, may be obtained.

Knowing the bivalves consumption and concentration of seston in the water, one could calculate the rate of filtration i.e. the amount of water passing through the animal in a unit of time.

The results of experiments run on June the 5th and June the 10th are presented in Table I and give an indication of the variation within one experiment as well as that from day to day. This

Table I. Raw data of the two consecutive 24-hr experiments during 1971

	Experimental Containers with 10 animals				
	1	2	3	4	5
	June 5 — seston concentration in lake 3.27 mg/l				
Volume (l)[a]	12.6	12.2	12.4	11.9	11.9
Seston IN (mg)[b]	41.20	39.89	40.55	38.91	38.91
Seston OUT (mg)[c]	12.35	10.86	8.68	10.83	9.52
Feces (mg)[d]	8.2	9.9	11.1	14.1	8.8
Consumption (mg)	28.85	29.03	31.87	28.08	29.39
Assimilation (mg)	20.65	19.13	20.77	14.08	20.59
% Consumption	70.0	72.8	78.6	72.2	75.5
% Assimilation	70.1	65.9	65.2	49.9	70.1
	June 10 — seston concentration in lake 2.58 mg/l				
Volume (l)[a]	12.6	12.3	12.7	14.1	11.9
Seston IN (mg)[b]	32.51	31.73	32.77	36.38	30.70
Seston OUT (mg)[c]	12.47	9.96	10.92	11.84	9.16
Feces (mg)[d]	10.65	9.36	10.94	12.88	10.01
Consumption (mg)	20.04	21.77	21.85	24.54	21.54
Assimilation (mg)	9.39	12.41	10.91	11.66	12.38
% Consumption	61.8	68.6	66.6	67.5	70.2
% Assimilation	46.9	57.3	49.9	47.5	57.5

Total

a — Volume of water passed throught each container, b — Mean control seston concentration times the volume, c — Mean experimental seston concentration times the volume, d — Experimental fecal collection weight minus control weight (sedimentation).

difference is reflected in most of the measurements, but largely disappears when per cents are considered. Variation on one date is generally much less, of the order of 10% or less, of the mean consumption value. Variation in assimilation values is somewhat higher. Higher variability was expected in the latter because of the problems derived from the production of pseudofeces. Some material which is filtrated by mollusks may not actually be consumed, but be rejected before reaching the mouth. This material is collected by cilliary currents and finally expelled by clapping of the two value.

The material which is filtered and later on rejected is called pseudofeces. Pseudofecal production is affected by various factors including size, weight and concentration of food particles (Atkins 1936, Loosanoff 1949, Mikheyev 1967) and age of animals (Mikheyev 1967). Production of pseudofeces results in a decrease of assimilation values since some of the filtered food would not be exposed to the digestive process; but in our experiment increasses the total mass of feces.

Simultaneously with the above experiments the content of oxygen was measured in the water after the passage through the experimental and control containers. In addition in 1971 and 1972 some experiments were carried out with series of different densities of adult individuals (5, 10, 20 and 40 animals per 1 container), and some experiments with *Dreissena* of different age classes, and also experiments which run at various depths in the lake. All these results will be published elsewhere.

Beside the present use, the method presented offers considerable versability — in natural conditions and in the laboratory.

3. RESULTS AND DISCUSSION

Long, regular intervals in the bivalve filtration activity which were observed in *D. polymorpha* (Morton 1971) and *Unionidae* (many authors) under the laboratory conditions, did not occur in the experiments conducted in Mikołajskie Lake. The bivalves filtered with similar activity over the 24-hr period. The periods when the shells of particular individuals were closed did not last for a long time, and were not regular.

In Mikołajskie Lake in 1971 from May till mid October the rate of consumption of *Dreissena polymorpha* ranged from 0.56 to 4.69 mg/indiv.·24hrs in different periods of time. The assimilation — from 0.3 to 3.7 mg/indiv.·24hrs and fecal production from 0.3 to 4.0 mg/indiv.·24hrs. Similarly a great range of oscillation was noticed in the values of filtration as deducted from the values of consumption; this range amounted from 8 to 44 ml per hour during the season (Tables II, III). The values of filtration found in laboratory conditions, presented by others authors for individuals of the same size as in our experiments are as follows:

45.5	ml/indiv.·hr	— Mikheyev, Sorokin 1966
2–50	,,	— Mikheyev 1967
35	,,	— Stańczykowska 1968
43.0–56.3	,,	— Lvova-Katchanova 1971
5–180	,,	— Morton 1971
13.0–70.7	,,	— Hinz, Scheil 1972

It was found in Mikołajskie Lake that in the spring and early summer (1971) the consumption was rather high (Fig. 4) and assimilation reached 55–65% of the consumption values (Fig. 5). In spring these values are connected with the variations of temperature and seston concentration in water. Each decrease or increase in temperature was followed by change in the feeding rate of animals. Only at the end of July the filtration rate and consumption were lower than earlier, although the water temperature (about 25°C) and food concentration were optimal for this

Table II. Average experimental data — *D. polymorpha* — Mikołajskie Lake 1971

Period (months)	V–VI	VI–VII	VII (end)	VIII (1–10)	VIII (10–30)	IX–X
Consumption (mg/indiv.·24 hrs)	2.5	4.0	3.3	4.1	2.0	0.9
Feces (mg/indiv.·24 hrs)	1.1	1.4	2.8	2.6	0.8	0.4
Assimilation (mg/indiv.·24 hrs)	1.4	2.6	0.5	1.5	1.2	0.5
Filtration (ml/indiv.·hrs)	32	40	28	34	20	15

Table III. Average experimental data — *D. polymorpha* — Mikołajskie Lake 1972

Period		VII	VII–VIII	VIII (middle)	VIII (end)
Water temperature (0°C)		23.0	25.3	22.2	22.0
Seston concentration (mg/l·dry weight)		2.6	6.3	4.5	3.3
Consumption	mg/indiv.·24 hrs	2.4	1.4	1.8	3.2
	% of seston concentration	67	73	40	85
Feces mg/indiv.·24 hrs		1.5	1.3	0.3	0.2
Assimilation	mg/indiv.·24 hrs	0.9	0.08	1.5	3.0
	% of consumption	40	6	84	95

animal (Mikheyev 1966, Morton 1971). The assimilation of food was also low (about 15% on the average) and during several days the bivalves did not assimilate almost at all. The more detailed analysis indicates that these variations in feeding most probably was the result of the changes in the food quality. In the spring and early summer mainly diatoms and blue-green algae predominated in the phytoplankton of Mikołajskie Lake, while in the second half of July a heavy *Din. flagellata* bloom ocurred and 99% of the phytoplankton biomass consisted of *Ceratium hirundinella* (Fig. 6). It probably did not provide a favorable food for *D. polymorpha* because of its large size (about 215 μ). Many outcomes of laboratory experiments, indicate a relationship between intensity of the consumption processes and the size of food particles (Morton 1971, Vahl 1972). Morton (1971) comparing filtration rate of *Dreissena* while feeding consecutively with 6 species of algae (the size of cell being 1–200 μ), write that *Dreissena* "prefers to feed on smaller organisms". During the period of the bloom decline, i.e. early in August, the values

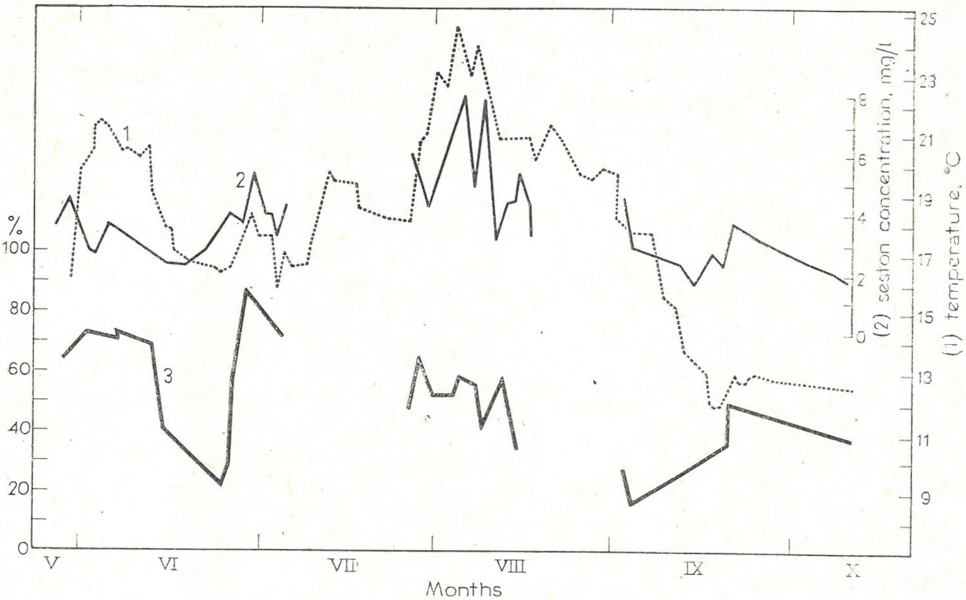

Fig. 4. Consumption of seston by *D. polymorpha* in different conditions of water temperature and seston concentration in 1971. 1 — water temperature, 2 — seston concentration, 3 — consumption in % of seston concentration

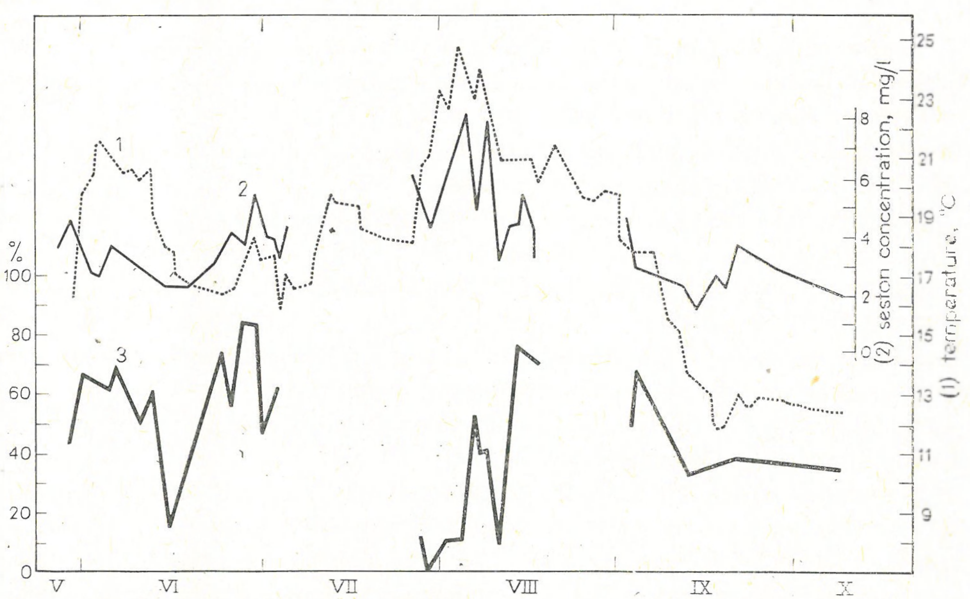

Fig. 5. Food assimilation by *D. polymorpha* in different conditions of water temperature and seston concentration in 1971. 1 — water temperature, 2 — seston concentration, 3 — assimilation in % of consumption

of consumption and assimilation increased. In the late summer and autumn period, when blue-green algae predominated in the phytoplankton, the feeding of the bivalves was parallel to the variation in water temperature and seston concentration, as it was the case in the spring. However the consumption was much lower than in June and early July, the assimilation was high and approximated 60% of the consumption.

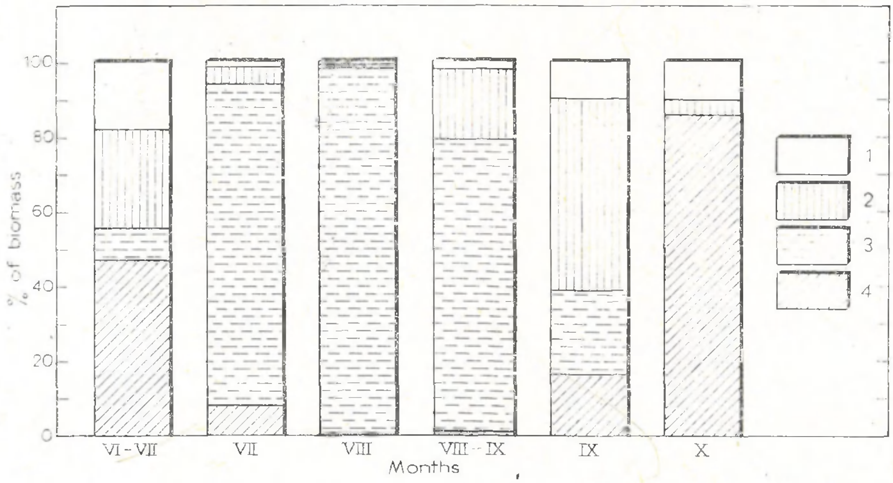

Fig. 6. Biomass of different groups of phytoplankton in Mikołajskie Lake (1971). 1 — other algae, 2 — *Cyanophycae*, 3 — *Ceratium hirundinella*, 4 — *Diatomae*

Similar seasonal changes in the feeding of *D. polymorpha* were observed in 1972 (Table II). In June the consumption and assimilation were high. During the period of *Ceratium hirundinella* bloom (end of July and begining of August) the assimilation of food decreased rapidly. In the mid — August the bloom of *Ceratium* declined and food assimilation of *Dreissena* was higher.

The experimental data for all dates from 1971 were averaged to give values of consumption, feces and assimilation of 2.62, 1.05 and 1.56 respectively, all in milligrams dry weight per individual per 24 hrs. The data of 1972 were: consumption — 2.2, feces production — 0.8 and assimilation — 1.4. Judging from the filtration at the extremes of the experimental period it appears reasonable to assume that *Dreissena* will filter normally in Mazurian region for at least 6 months of the year: second half of April, May, June, July, August, September and a part of October. This is a period of about 180 days.

The surface area of Mikołajskie Lake which was inhabited by *Dreissena* was the zone between 0.2 to 8.0 meters, the value for density of this animal in this zone — in 1971 — 300 indiv./m^2, and in 1972 — 700 indiv./m^2. The population of *Dreissena* for the whole lake was in 1971 — 350 millions of individuals, and in 1972 about 816 millions. Therefore the total values for the lake in terms of metric tons of dry weight are: 1971 — consumption 165.0, feces 98.2, assimilation 66.8 and in 1972 — consumption 385.0, feces 229.0, assimilation 156.0 (Table IV).

Konsumpcja sestonu przez populację *D. polymorpha* stanowiła w 1971 roku — 4.17%, a w 1972 roku 9.73% produkcji pierwotnej fitoplanktonu jeziora. Odchody małży w porównaniu z roczną sedymentacją tryptonu w jeziorze Mikołajskim stanowiły 5.6% (1971) i 13,1% (1972).

Dane te wskazują jak dużą rolę odgrywa *Dreissena polymorpha* w badanym jeziorze.

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