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Role of bivalves in the phosphorus and nitrogen budget in lakes

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With 5 tables in the text

Dreissena polymorpha (PALL.) is one of the most numerous mussels in littoral of lakes, and certainly the most important one regarding the biomass. Their role in water ecosystems is, since a long time, considered to be important. In the last years a special role is attributed to their filtration activity (WIKTOR 1969; STAŃCZYKOWSKA 1977; WALZ 1978). Mass appearance of mussels and their intensive filtration activity may also remove from the ecosystem, for the considerable period of time, an amount of P and N, the elements highly responsible for the process of lakes eutrophication.

The question arises, whether mussels occurring in lakes in such great numbers as *D. polymorpha* may be of importance in counteracting the process of lakes eutrophication. In what type of lakes its role is the most important?

The studies related to this problem were carried out in meso- and eutrophic lakes of Masurian Lakeland: 5 lakes of Jorka R. watershed (STAŃCZYKOWSKA & PLANTER in prep.), Mikołajskie Lake and Tałtowisko Lake (STAŃCZYKOWSKA unpubl.), in which the parameters of *D. polymorpha* population (density, biomass, age structure) were estimated. The content of N and P in mussel body, shell, as well as in the food (seston) and the faeces was measured. A comparison of mussel occurrence in dimictic and polymictic lakes with various P concentration in epilimnion was made for 42 lakes (STAŃCZYKOWSKA et al. 1983).

Results

Phosphorus and nitrogen content in mussels

The results indicated that P and N contents (dry weight) ranged from 0.85 % to 0.93 % and from 11 % to 12.8 %, respectively, in *Dreissena* body. However, in the shells P started with 0.015 % and N with 0.33 %. The nutrients in the body liquids were not taken into consideration; according to KUENZLER (1961) it is about 3 % of total P in mussel.

The amounts of P and N in mussels were analysed three times yearly. The highest percentage of P was noticed in the pre-reproductive period. It was also indicated that the percentage of P and N in the body was changing in accordance with the age of mussels, reaching the highest values in the youngest individuals.

The differences among the *Dreissena* population in each of the lakes caused that the values of P and N accumulated in mussels and, expressed per 1 m^2 of bottom surface in the zone of their occurrence, were considerable (Table 1).

Still greater differences were found when the values of P and N accumulated in the *Dreissena* population and expressed per 1 ha were compared (Table 2). In lakes where

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Table 1. Standing crop of *D. polymorpha* and its contents of P and N (values for 1 m^{-2} in the zone of occurrence).

Lakes	Majcz	Tałtowisko	Jorzec	Mikołajskie
trophic type	mesotrophic		eutrophic	
Density (indiv. · m^{-2})	510	2600	130	2000
Biomass (D.W. + shell)	152	550	130	742
P (g · m^{-2})	0.13	0.52	0.08	0.47
N (g · m^{-2})	1.88	7.67	1.12	7.27

Table 2. Standing crop of P and N in *D. polymorpha* whole populations in different lakes (values for 1 ha of the whole lake).

Lakes	Majcz	Tałtowisko	Jorzec	Mikołajskie
Surface of lakes (ha)	163	323	42	460
occurrence zone of *D. p.* (%)	63	35	24	19
Population *D. p.* (indiv. · 10^6)	523	2938	12	1840
P (kg)	0.8	1.8	0.2	0.9
N (kg)	11.9	26.8	2.7	14.5

Table 3. Comparison of P and N content in *Dreissena* populations (D) and submerged macrophytes (M) in lakes of R. Jorka watershed.

Lakes		Majcz	Zełwążek	Głębokie	Inulec	Jorzec
Zone of occurrence (ha)	D	103	4	10	85	9
	M	49	6	6	22	2
Dry biomass (t)	D	155	3.2	6.5	77.7	11.6
	M	109	3.4	2.6	1.1	<0.1
P (kg per lake)	D	129	2	5	60	7
	M*	327	3	8	10	1
N (kg per lake)	D	1920	32	81	910	103
	M*	3270	33	78	100	11

Macrophytes acc. to OZIMEK (1983).
* Average content in macrophytes (N = 3 %, P = 0.3 %, KAJAK 1978).

the density of mussels (occupying fairly large bottom areas) was great, these values may be comparatively very high and be of great importance for the whole lake. E. g. in Mikołajskie Lake, with the whole P stock in lake about 50 t, the stock in the *Dreissena* population (0.47 t) was not much lower than the stock of P in macrophytes (0.7 t) and in fishes (0.8 t) (KAJAK 1978). Comparison of P and N content in submerged macrophytes (OZIMEK 1983) and the *Dreissena* population carried out in some Masurian lakes indicated similar results (Table 3).

The quantities of P accumulated in mussel populations in mesotrophic Lake Majcz are similar to loading of P measured in this lake, but in the highly eutrophic Lake Jorzec about 50 times smaller than the annual loading (Table 2) (HILLBRICHT-ILKOWSKA & ŁAWACZ 1983).

Table 4. Consumption of seston and its content of P and N by *D. polymorpha* populations (values per 1 m^{-2}, May—October).

Lakes	Majcz	Tałtowisko	Jorzec	Mikołajskie
Density of *D. p.*	510	2600	130	2000
Consumption (g D.W.)				
Seston	245	1227	66	868
P	0.61	3.07	0.16	3.47
N	7.84	39.26	0.19	52.34

Table 5. The mean rate of elimination of P and N in *Dreissena* faeces (values in g D.W. · m^{-2}, May—October).

Lakes	Majcz	Tałtowisko	Jorzec	Mikołajskie
Faeces	60	312	18	207
P	0.06	0.312	0.018	0.207
N	2.12	11.01	0.6	7.31

It should be noticed that the amount of P and N accumulated in mussels is removed from the cycling in the lake for a period of a few years (the life time of mussels is estimated 4—6 years) or partly even for a longer time about 20 years-period of shell decomposition.

P and N in process of filtration

Besides of the P and N accumulation in the body and shell the importance of mussels in lake metabolism lies in the filtration activity. The values of P and N intake and output in the filtration process were assessed. Taking into account the data of the *Dreissena* population, their food as well as the environmental conditions, I have calculated the average filtration, consumption rate and production of faeces. Seston (mussels' food) in investigated lakes was different in concentration as well as in nutrient contents. The values of consumption of mussels and their content of P and N differed greatly (Table 4).

From the seston taken in, about ⅔ reached the alimentary tract and about ⅓ were expelled into the environment in the form of pseudofaeces, being comparatively not much changed. The output of P and N from mussel populations is given by the removal of faeces, individual death and reproduction. As indicated by analysis the excretion of faeces is most significant in these processes. According to the experiments carried out previously (Stańczykowska 1977), one should accept that the average food assimilation ratio by *D. polymorpha* in Masurian lakes is about 40%. The estimation of faeces production indicated the content of P = 0.1% and N = 3.53% of faeces mass. I calculated values of P and N, which after passing through the *D. polymorpha* population on the surface of 1 m^2 were supplied to the water during the period of filtration activity (Table 5). Nutrients output by dead mussels and sex products formed only about 10% of all values of P and N of the populations.

Conclusions

The values of P and N flowing through the populations of *D. polymorpha* are much greater than those contained in the organisms, nearly reaching the values accumulated in macrophytes or

fishes in the same lakes. In lakes, where *D. polymorpha* occurs in great density and occupies considerable surface of the lake bottom, its role in P and N cycling within lakes should not be neglected. The data of comparison of *D. polymorpha* occurrence in dimictic and polymictic lakes of different trophy led to the statement that this mussel was significantly more dominant in dimictic and less eutrophic polymictic lakes than in the rest of investigated lakes, i. e. in the polymictic more fertile ones (STAŃCZYKOWSKA et al. 1983). The data presented here suggest that the role of *D. polymorpha* in P and N cycling is important in meso- and moderate eutrophic lakes, but it is not significant in high eutrophic or hypertrophic lakes.

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