*Polish Journal of Environmental Studies Vol. 11, No. 4 (2002), 355-359*

# Differentiation of Phosphorus Concentration in Selected Mollusc Species from the Zegrzynski Reservoir (Central Poland): Implications for P Accumulation in Mollusc Communities

E. Jurkiewicz-Karnkowska

University of Podlasie, ul. B. Prusa 12, 08-110 Siedlce, Poland

*Received: 10 December, 2001*
*Accepted: 21 February, 2002*

## Abstract

Comparisons of P concentration in soft tissues and shells of molluscs being main components of malacocenoses of the Zegrzynski Reservoir as well as analyses of spatial, temporal and size dependent diversity of P concentration in particular mollusc species were performed. Percent content of P in the soft tissues of the investigated species varied significantly when comparing taxonomically distant species, whereas P level in shells was relatively similar. Owing to the interspecies diversity and size dependence of P concentration, the species composition and dominance patterns of malacocenoses as well as size-frequency relations in populations of dominant species are expected to influence the accumulation of P by molluscs in a given habitat.

**Keywords:** molluscs, P concentration, dam reservoir

## Introduction

Phosphorus content in freshwater ecosystems is an essential factor in determining trophic status. Molluscs can play a significant role both in accumulation and circulation of this biogenic element, especially in habitats where they are numerous and their biomass is high [1-7]. In the Zegrzynski Reservoir they are abundant and they dominate in the biomass of bottom macrofauna [8-14].

The present work aimed at comparison of P concentrations in soft tissues and shells of molluscs being main components of malacocenoses of the Zegrzynski Reservoir as well as an assessment of P level in specimens of different sizes within 2 dominant species. Analyses of spatial diversity of percentage content of P in particular mollusc species and changes of these values in the period from May to September were also performed.

Correspondence to: Dr. E. Jurkiewicz-Karnkowska

## Material and Methods

Concentration of phosphorus was analysed in the soft tissues and shells of 3 snail species: *Viviparus viviparus* (L.), *Lymnaea stagnalis* (L.) and *L. peregra* (O. F. Mull.) as well as 3 bivalves: *Dreissena polymorpha* (Pall.), *Anodonta anatina* (L.) and *A. cygnea* (L.). *V. viviparus* and *D. polymorpha* are the main dominants in the mollusc communities of the Zegrzynski Reservoir [9, 10, 13, 14]. The other species being significant elements of malacocenoses were: *L. stagnalis* and *L. peregra* within the littoral zone, and *A. anatina* and *A. cygnea* in habitats where they occur (due to heavy weight). The molluscs studied were collected in the years 1997 - 1999 (May, July, September) at sites located in different parts of the reservoir, using Ekman-Birge's grab with catching area 250 $cm^2$ and rectangular dredge with working side length of 33 cm. The samples were rinsed on a sieve, some of them were frozen and the others were preserved in 4% formaldehyde solution. *V. viviparus* and *D. polymorpha*

individuals were divided into 4 size classes (up to 15 mm, 15.1 - 20 mm, 20.1 - 25 mm and over 25 mm) analysed separately. In the case of *Lymnaea* spp and *Anodonta* spp big individuals of similar size were taken for investigations *(L. stagnalis* 35 - 50 mm, *L. peregra* 10 - 20 mm, *A. anatina* 50 - 75 mm, *A. cygnea* 85 - 110 mm). The molluscs were washed in redistilled water, the soft tissues were separated from shells and both were dried at 105°C to a constant weight and homogenized in an agate mortar. The samples contained 10 to 30 specimens, only in the case of *Anodonta* spp 1 to 3 specimens. The subsamples of the soft tissues (0.5 g) and shells (1 g) were mineralised with concentrated nitric acid and 30% perhydrol. The concentration of P was determined by the molybdate blue method using a spectrophotometer Novaspec 2 (Pharmacia LKB). The results were statistically processed using Statistica software. Mean values and standard deviations of P concentrations in mollusc bodies and shells were calculated. Differentiation of P concentrations was evaluated using the Scheffe test [15].

## Results

The mean percent content of P in the soft tissues of the species investigated ranged from 0.63% *(V. viviparus)* to 2.68% *(A. cygnea).* A comparison of the obtained values revealed statistically significant differences in some cases (Scheffe test, $p < 0.05$). Such differences were found for taxonomically distant species, whereas within the genus *(Lymnaea* and *Anodonta)* the P concentrations were similar (Fig. 1 a).

The level of phosphorus in the tissues of the snails investigated was relatively even and distinctly lower than the corresponding values for bivalves. Differences in the P concentrations in bodies between bivalves and snails were statistically significant except for *D. pofymorpha* and *Lymnaea* spp (Scheffe test, $p < 0.05$). A particularly high P concentration was found in *A. anatina* and *A. cygnea*. The shells of all the species investigated were characterized by similar levels of phosphorus, which was at least one order of magnitude lower than in the soft tissues (Fig. 1 b).

A comparison of P concentration in the soft tissues of the specimens belonging to the same species collected in different parts of the reservoir has shown statistically significant differences neither among mean values for the sampling period nor among mean values from samples collected at the same time. Relatively small (not statistically significant) were also the fluctuations of P level in tissues during the period from May to September. P concentration in the bodies of *L. stagnalis* and *V. viviparus* was about 20% higher in September than in May (Fig. 2a). In bivalves a decrease of P concentration in the soft tissues (by about 20% in *A. anatina* and over 10% in *D. pofymorpha)* was found in September when compared to the values from May (Fig. 2b).

Analysis of the P concentration in the soft tissues of individuals of *V. viviparus* and *D. pofymorpha* from different size classes (Fig. 3) revealed significantly lower values in small specimens (up to 15 mm) when compared to large individuals (Scheffe test, $p < 0.05$). Similar regularity was observed in the shells of these species; however, in *V. viviparus* the difference between small and large individuals was not statistically significant.

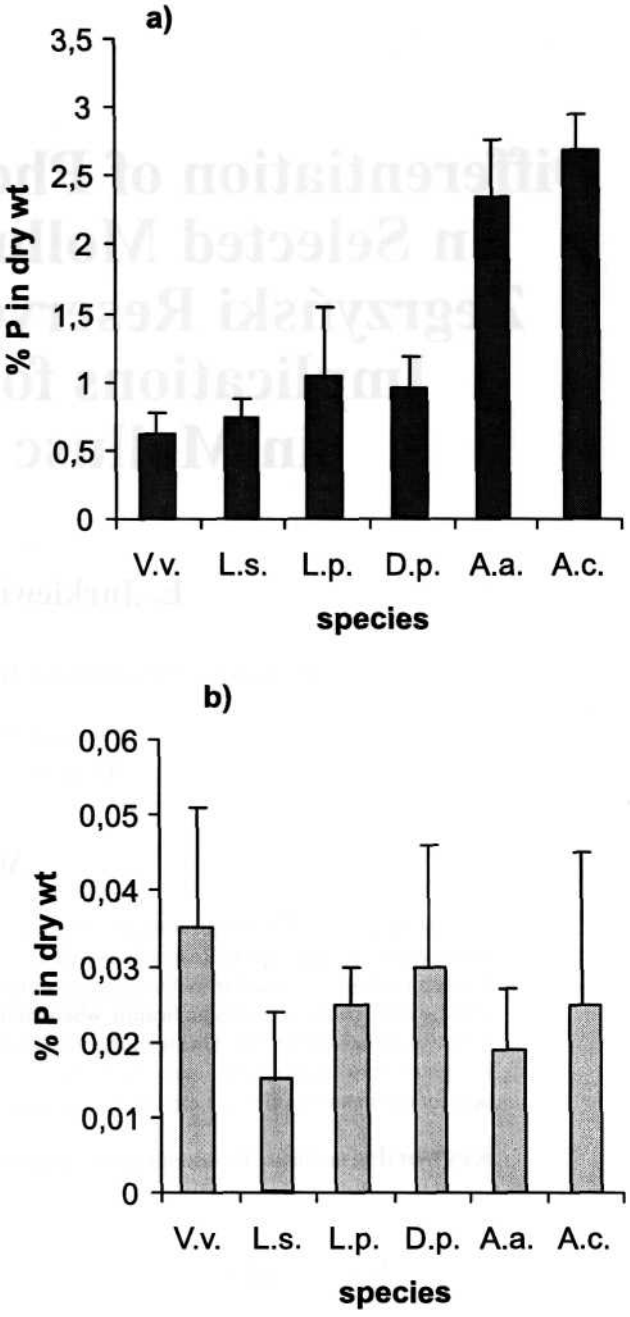


Fig. 1. Mean P concentrations (and SD) in the soft tissues (a) and shells (b) of the investigated mollusc species; V. v. - *Viviparus viviparus,* L. s. - *Lymnaea stagnalis,* L. p. - *L. peregra,* D. p. -*Dreissena pofymorpha,* A. a. -*Anodonta anatina,* A. c. -*A. cygnea.*

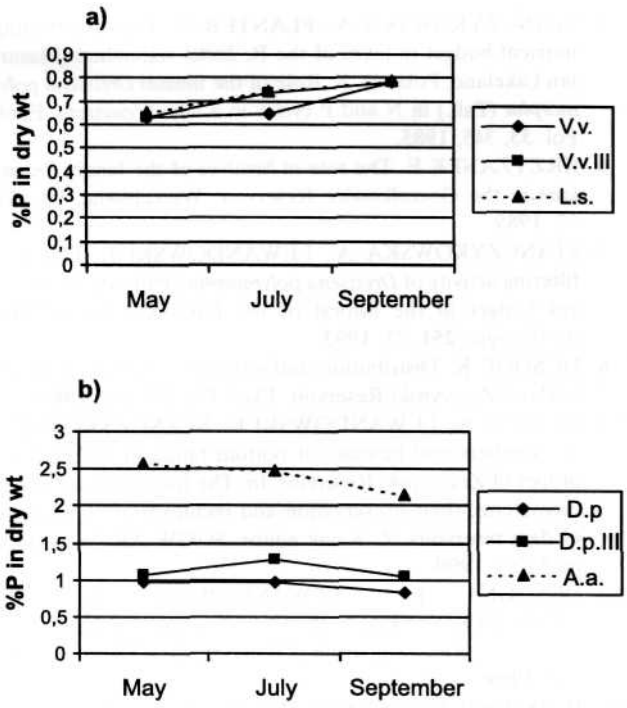


Fig. 2. Temporal differentiation of P level in the soft tissues of snails (a) and bivalves (b); for V. v., L. s., D. p. and A. a. explanations see Fig. 1., V. v. III and D. p. III - specimens belonging to the 3rd size class (i.e. 20.1 - 25 mm).

## Discussion

Data on phosphorus concentration in molluscs are relatively sparse and they concern mainly bivalves [e.g. 1, 5, 16]. As follows from a comparison of the P level in *D. polymorpha* obtained in the present work with data from several Mazurian lakes [5], P content of this bivalve is similar and relatively independent of the trophic status of a given water reservoir, at least within the range found in the habitats mentioned. P concentration in the soft tissues and shells of *D. polymorpha* from the Zegrzynski Reservoir was also comparable to the corresponding data reported by Kuenzler [1] for *Modiolus demissus* Dillwyn, a bivalve similar in body size and habits. Exceptionally high P content in the soft tissues *otAnodonta* spp, similar to the values obtained in the present work, was reported from 3 Mazurian lakes [16]. P concentrations found in the bodies of *Lymnaea* spp and *V. viviparus* from the Zegrzynski Reservoir were comparable to those in the specimens from 2 rivers near Siedlce [17].

The lack of statistically significant spatial diversity of P concentration in the tissues of the molluscs investigated seems to confirm the species' specificity concerning P accumulation, at least within a certain range of P concentration in water (mean annual values from 0.057 to 0.115 mg TP $dm^{-3}$, author's unpublished data). P level was characteristic of particular species and didn't vary significantly within a given reservoir. The P concentration values in the tissues of the species investigated were similar to these obtained by the author in the years 1980 - 1981 [11]. The P level in the water of the Zegrzynski Reservoir was similar in the early '80s and late '90s, although in the meantime strong eutrophication was reported [18].

Far higher P concentrations in tissues than in shells and significant interspecific differences among P level in bodies may result mainly from the essential role of the body fraction of P in metabolic processes, species specific demand for this element, and different P assimilation efficiency (higher in bivalves). Owing to substantial contribution of shells to the total biomass of molluscs [11] the amounts of P contained in shells are considerable despite a low percent content.

Fluctuations in P concentrations in bodies of the molluscs investigated in the period from May to September seem to reflect the influence of the reproductive cycle on P content. An intensive accumulation of P in the period preceding reproduction due to gametogenesis results in a higher content of this element in the soft tissues, which then decrease during the breeding season as a result of the release of phosphorus-rich gametes [1,5] or embryos.

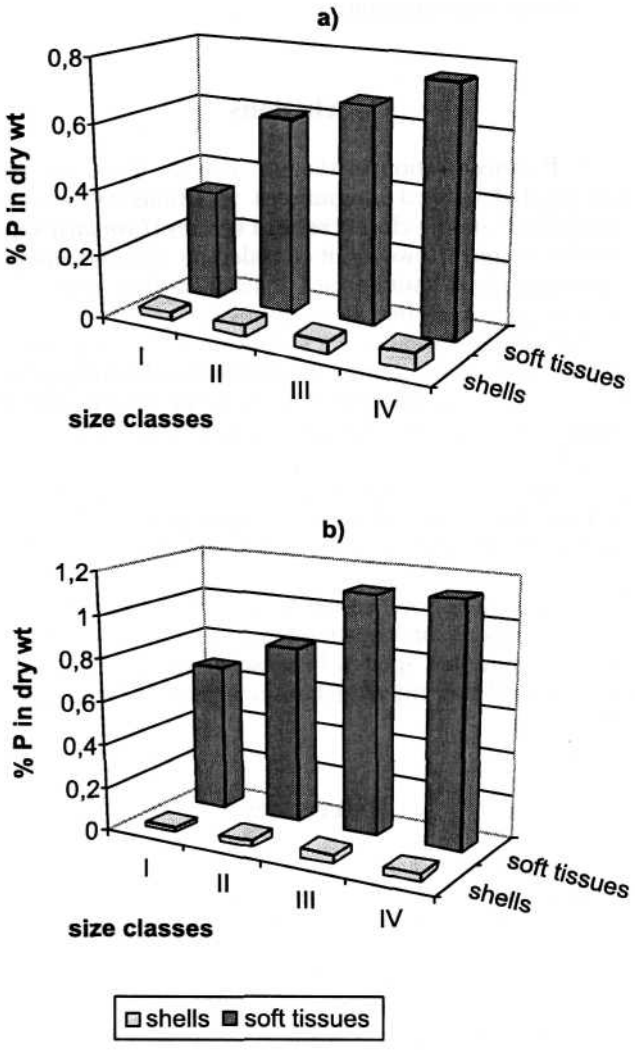


Fig. 3. Size dependence of P concentration in the soft tissues and shells of *Viviparus viviparus* (a) and *Dreissena polymorpha* (b).

The highest P concentration in bivalve bodies was found in May in *Anodonta* spp and in July in *D.polymorpha* i.e. in the period preceding reproduction [19, 20]. The increase of P level in the soft tissues of gastropods from May to September seems to be related to gametogenesis following the spring reproduction (for *V. viviparus* a culmination of a long-lasting breeding season), [21].

Significantly lower P content in the tissues of small specimens of *V. viviparus* and *D. polymorpha* when compared to the corresponding values for the other ones could result from a low participation of sexually mature individuals within the size class up to 15 mm. A similar regularity concerning shells could be related to a greater share of conchiolin in the dry weight of shells of large specimens [22, 23] because phosphorus in shells is probably mostly contained in conchiolin and a smaller fraction may occur in the form of calcium phosphate [1]. As follows from the above-mentioned regularities, the size-frequency relationships can influence the amount of P accumulated by a population. Some authors [e.g. 24, 25] showed an impact of size-frequency distributions of abundant populations on matter cycling in freshwater ecosystems (consumption, excretion, faeces and pseudofaeces production).

## Conclusions

1. P concentration in the soft tissues of the species investigated showed insignificant variations within one species and among closely related species *(Lymnaea* spp, *Anodonta* spp). However, it considerably differed among taxonomically distant species. P level in shells was rela tively similar in all the species investigated.

2. P concentration in the shells was at least one order of magnitude lower than in the soft tissues. However, due to substantial contribution of shells to the total weight of molluscs the amounts of P accumulated in shells are con siderable.

3. Species composition and dominance patterns of malacocenoses will influence the accumulation of P ow ing to interspecific diversity of P concentration in mol luscs.

4. The amount of P accumulated in mollusc communi ties will depend on size-frequency relations in popula tions of dominant species because of significant differ ence in the P concentration between small and large indi viduals.

## References


1. KUENZLER E. J. Phosphorus budget of a mussel popula tion. Limnol. Oceanogr. **6,** 400, **1961.**
2. STANCZYKOWSKA A., LAWACZ W., MATTICE J., LEWANDOWSKI K. Bivalves as a factor effecting circula tion of matter in Lake Mikotajskie (Poland). Limnologica (Berlin), **10,** 347, **1976.**
3. STANCZYKOWSKA A. Molluscs and an eutrophication of waters. Wiad. Ekol. **29,** 127, **1983.**
4. STANCZYKOWSKA A. Role of bivalves in the phosphorus and nitrogen budget in lakes. Verh. int. Ver. Limnol. **22,** 982, 1984.
5. STANCZYKOWSKA A., PLANTER M. Factors affecting nutrient budget in lakes of the R. Jorka watershed (Masur ian Lakeland, Poland). X. Role of the mussel *Dreissena poly morpha* (Pall.) in N and P cycles in a lake ecosystem. Ekol. **Pol. 33,** 345, **1985.**
6. KRZYZANEK E. The role of bivalves of the family *Union-idae* in the Goczalkowice Reservoir. Wszechswiat, 90, (3), 57, **1989.**
7. STANCZYKOWSKA A, LEWANDOWSKI K. Effect of filtering activity *of Dreissena polymorpha* (Pall.) on the nutri ent budget in the littoral of the Lake Mikolajskie. Hydrobiologia, **251,** 73, **1993.**
8. DUSOGE K. Distribution and structure of benthos in the lowland Zegrzynski Reservoir. Ekol. Pol. **37,** 281, **1989.**
9. DUSOGE K., LEWANDOWSKI K., STANCZYKOWSKA A. Numbers and biomass of bottom fauna in different bi-otopes of Zegrzynski Reservior. In: The functioning of water ecosystems, their preservation and recultivation. I. Ecology of dam reservoirs. Z. Kajak editor. SGGW-AR, Warszawa, pp 57-85, **1990.**
10. DUSOGE K., LEWANDOWSKI K. B., STANCZYKOWSKA A. Benthos of various habitats in the Zegrzynski Reservoir (central Poland). Acta Hydrobiol. **41,** 103, **1999.**
11. JURKIEWICZ-KARNKOWSKA E. The occurrence and role of molluscs in chosen rivers and reservoirs of the Mazowiecka Lowland. Ph.D. Th., IE PAN, Dziekanow Lesny, **1986.**
12. JURKIEWICZ-KARNKOWSKA E. Occurrence of mol luscs in the littoral zone of the Zegrzynski Reservoir and in the pre-mouth and mouth zones of supplying rivers. Ekol. Pol. **37,** 319, **1989.**
13. JURKIEWICZ-KARNKOWSKA E. Long-term changes in mollusc communities in shallow biotopes of a lowland reser voir (Zegrzynski Reservoir, central Poland). Pol. J. Ecol. **46,** 43, **1998.**
14. JURKIEWICZ-KARNKOWSKA E. Long-term changes and spatial variability of mollusc communities in a lowland reservoir (Zegrzynski Reservoir, central Poland). Folia Malacologica, **9,** 137, **2001.**
15. STANISZ A. An accessible course of statistics based on STATISTICA PL on the examples from medicine, StatSoft Polska Sp. z o.o., Krakow, **1998.**
16. MARKOWSKA J. The role of *Dreissena polymorpha* (Pall.) and *Anodonta anatina* (L.) in accumulation of heavy metals and phosphorus. Msc Th., University of Podlasie, Siedlce, **2000.**
17. KROLAK E. Accumulation of phosphorus in molluscs from waters in the vicinity of Siedlce town. XVII Meeting of Pol ish Hydrobiologists, Abstracts, Poznan, 205, **1997.**
18. KAJAK Z., DUSOGE K. Temporal and spatial diversity of trophy-indicators in a lowland dam reservoir - Ekol. Pol. **37:** 211-233, **1989.**
19. ALIMOV A. F. Functional ecology of freshwater bivalve molluscs. Tr. Zool. Inst. AN SSSR, **96,** 1, **1981.**
20. PIECHOCKI A., DYDUCH-FALNIOWSKA A. Molluscs. Bivalves. Freshwater fauna of Poland, 7A. PWN, Warszawa, **1993.**
21. PIECHOCKI A. Molluscs. Snails. Freshwater fauna of Po land, 7. PWN, Warszawa - Poznan, **1989.**
22. MACKIE G. L. Shell structure in freshwater Sphaeriaceae (Bivalvia: Heterodonta). Can. J. Zool. **56,** 1, **1978.**
23. CAMERON C. J., CAMERON I. F., PETERSON C. G. Contribution of organic shell matter to biomass estimates of unionid bivalves. Can. J. Zool. **57,** 1666, 1979.

24. YOUNG B. L., PADILLA D. K., SCHNEIDER D. W, HEWETT S. W. The importance of size-frequency relationships for predicting ecological impact of zebra mussel populations. Hydrobiologia, 332, 151, 1996.

25. JAMES W. F., BARKO J. W, DAVIS M., EAKIN H. L, ROGALA J. T., MILLER A. C. Filtration and excretion by zebra mussels: implications for water quality impacts in Lake Pepin, upper Mississipi River. J. Freshw. Ecol. 15, 429,2000.