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INTERRELATION BETWEEN UNIONIDS AND THEIR EPIBIONTS IN THE COOLING POND OF THE KHMELNITSKY NUCLEAR POWER PLANT (UKRAINE)

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Interrelation Between Unionids and Their Epibionts in the Cooling Pond of the Khmelnitsky Nuclear Power Plant (Ukraine). Sylayeva A. A., Protasov A. A., Morozovskaya I. A. — Paper deals with data on interrelation of mollusks of the family Unionidae and *Dreissena polymorpha* (Pallas, 1771) and other epibiotic invertebrates in the cooling pond of the Khmelnitsky nuclear power plant (Ukraine). The quantitative indices of unionids and Dreissena, inhabiting shells of the living Unionidae, size structure of populations, and morphometric indexes of the living Unionidae were analyzed. No significant negative impact of settlements of the zebra mussels on Unionidae was noted.

Key words: Unionidae, zebra mussel, *Dreissena polymorpha*, epibionts, cooling pond, nuclear power plant.

Взаимоотношения между перловицами и их эпибионтами в водоёме-охладителе Хмельницкой атомной станции (Украина). Силаева А. А., Протасов А. А., Морозовская И. А. — Приведены результаты исследований взаимоотношений между двустворчатыми моллюсками семейсва Unionidae, *Dreissena polymorpha* (Pallas, 1771) и другими эпибионтными беспозвоночными в водоёме-охладителе Хмельницкой АЭС (Украина). Проанализированы количественные показатели перловиц и дрейссены, обитающей на живых перловицах, размерная структура популяций моллюсков, морфометрические характеристики живых перловиц. Явно выраженного негативного влияния поселений дрейссены на перловиц не выявлено.

Ключевые слова: Unionidae, дрейссена, *Dreissena polymorpha*, эпибионты, водоем-охладитель, атомная станция.

Introduction

Study of invasion (penetration, see note 1) processes has many environmentally important aspects. These processes along with biogeographical and biocenotic ones are of special significance. The basic issue is: how native and invasive/penetrative organisms cooperate and cohabit? How the ecological niches of new species are formed, and how the biocenosis functions at changes of its structure?

This article is devoted to the study of interrelations between bivalves of the family Unionidae (native organisms) and insider[1] Zebra mussel (*Dreissena polymorpha* (Pallas, 1771)) in the cooling pond of Khmelnitsky nuclear power plant (north-western region of Ukraine).

Material and methods

The joint settlements of Unionidae and their epibionts, first of all *D. polymorpha*, in the cooling pond of Khmelnitsky nuclear power plant (KhNPP) were studied over summer seasons 1998–2009.

The cooling pond of the KhNPP was created in 1986. It is the dam pond on the small river Gniloy Rog (the Prypiat' River basin). The dam length is about 8 km, the pond volume is about 120 million m^3, maxi-

[1] We use a new term of "insider" instead of widespread term "invader" (according to suggestion of Prof. V. V. Anistratenko), because penetration of *D. polymorpha* to the cooling pond occurred within limits of its natural areal.

mum depths — about 19 m. It is shallow water body: 40 % of total area is of depth 3 m and less. Shallow areas are localized mainly in western, eastern and southern parts of the cooling pond. One power unit of the NPP functions since 1987, and since 2004 two power units are in operation.

Western, eastern and partially southern sections are subjected to the influence of the heated waters of NPP, depending on prevailing winds. Over period of studies maximal temperature (32°C) was marked in the southern section in 2006. The summer period of 2007 was characterised by considerable (up to 1 m) decrease of the water level. Water temperature in the pond is usually 3–5°C higher than in natural reservoirs of this region.

Samples were collected from the depths 0.5–6.0 m using the SCUBA equipment with the frame 0.5 X 0.5 m. Additionally, separate specimens of Unionidae with *Dreissena*'s settlement were taken in individual polyethylene bags. The structure of invertebrates' community in *Dreissena*'s druses on Unionid shells was determined.

Shells of living Unionidae with *Dreissena* settlements on the surface were analyzed. The length, height, thickness and weight of Unionidae and *Dreissena* were measured. For this purpose on each specimens of Unionidae number, weight and size structure (size groups with the step 5 mm) of *Dreissena* was determined. For Unionidae shells the form coefficient (K_f) was calculated as: $K_f = ((L + h + d)/3)^3/Lhd$, where L — length, h — height, d — thickness (Protasov, 2004).

In total 210 specimens of living Unionidae were examined, including 143 with settlements of *Dreissena*.

Results

Actually, one species of Dreissenidae — *Dreissena polymorpha* occurs in the cooling pond of the KhNPP. One of substrata for this species are living mollusks and shells of Unionidae (fig. 1, 2). The cooling pond is located within the areal of *D. polymorpha*, however it penetrated into this reservoir only in 2002–2003.

According to data of 1998–2001 (Sylayeva, Protasov, 2002), in the cooling pond 5 species of bivalve mollusks have been noted: *Unio tumidus* Philipsson, 1788; *U. pictorum* (Linne, 1758); *Anodonta cygnea* (Linne, 1758); *A. piscinalis* Nilsson, 1823; *A. stagnalis* (Gmelin, 1791). They occurred in the eastern and southern sections on sand and muddy sand, and also in the intake channel of NPP, where they lived locally on a sandy bottom near the concrete slope of the channel. According to these data length of *Anodonta* amounted to 57–102 mm, length of *Unio* — 32–82 mm.

Maximal numbers and biomass of Unionidae was noted in the intake channel in 1998: 214 ind./m^2 and 5412.8 g/m^2; in 1999 they decreased accordingly to 52 ind./m^2 and 1205.9 g/m^2, and in 2001 — to 14 ind./m^2 and 54.6 g/m^2 at a depth of 4.5 m, but 51 ind./m^2 and 1292.7 g/m^2 — at a depth 6.0 m. On the shallow sites of the southern section numbers and biomass of Unionidae amounted to 20 ind./m^2 and 641.8 g/m^2, *U. tumidus* dominated.

It was established, that since 2005, after start of the NPP second power unit functioning and penetration of *Dreisena*, number of Unionidae species decreased: only *U. tumidus* and *U. pictorum* were noted. Only single specimens of the latter were noted. Live *Anodonta* was absent; only the shells were found in all investigated sites.

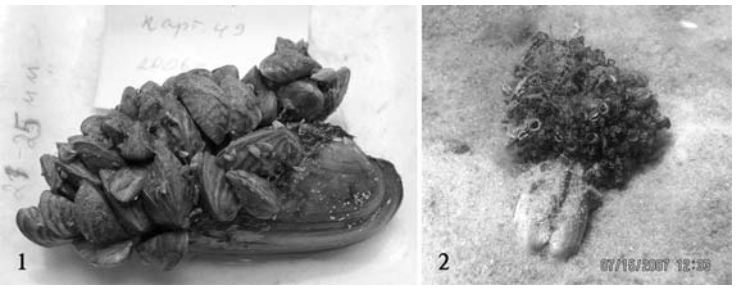

Fig. 1. Druse of *Dreissena polymorpha* on *Unio*, southern section of the cooling pond, depth 0.8 m.

Рис. 1. Друза дрейссены на перловице, южный район водоёма-охладителя ХАЭС, глубина 0,8 м.

Fig. 2. Mollusk *Unio* with druse of *Dreissena polymorpha* on bottom of the eastern section of the cooling pond, depth 1 m (underwater photo).

Рис. 2. Моллюск *Unio* с друзой дрейссены на дне в восточном районе водоема-охладителя ХАЭС, глубина 1 м (подводное фото).

Populations of Unionidae (1999, 2001, 2005–2009) were presented by rather large molluscs. The average size increased from 55.2 mm in 2001 to 80.0 mm in 2009. Young individuals with size less than 20 mm were not noted.

Over the years 2005–2009 number of *Unio* in the cooling pond decreased from 15 ± 3 to 5 ± 2 ind./m^2. The biomass varied from 271.5 ± 104.0 to 490.6 ± 146.0 g/m^2, on average 359.9 ± 49.1 g/m^2. Maximal abundance was detected in the southern section. Number of *Unio* decreased, and biomass remained at same level, because average individual mass increased from 16.8 ± 1.6 g in 2005 to 52.6 ± 2.1 g/ind. in 2009. Maximal size of *Unio* in 2009 amounted to 101.1 mm.

The *Dreissena* settlements (druses) on living *Unio* on the average occupied about 30 % of total surface of the shell. In 2005–2007 its settlements were noted at the depth of 4 m, and in 2008–2009 — only at the depth of 2 m.

In 2005 average biomass of *Dreissena* was 29.1 ± 4.7 g per one specimen of *Unio* (g Dr/spec. U) (within the limits 0.9–91.54). In 58 % of cases the mass of *Dreissena* exceeded mass of the occupied *Unio* on average 2.3 times. In other cases (mainly in the southern section) mass of *Dreissena* amounted to 51.4 % of *Unio*'s mass. In 2005 number of *Dreissena* specimens on average amounted to 149 spec. Dr/spec. U (within the range 5–1026).

In 2005 maximal biomass of *Dreissena* settlements was noted on *Unio* of the length about 60 mm, however maximal individual length was about 80 mm.

In 2006 biomass of *Dreissena* on *Unio* decreased to 16.1 ± 2.1 g Dr/spec. U (limits 3.1–43.0). On 86 % of *Unio* specimens the biomass of *Dreissena* was about 40 % of *Unio* biomass. On the remaining specimens the biomass of *Dreissena* 1.4 times exceeded the biomass of *Unio.* In 2006 average number of *Dreissena* was 49 spec. Dr/spec. U (limits 5–112). In 2007 average biomass of *Dreissena* increased to 33.0 ± 6.8 g Dr/spec. U (limits 4.3–144.9). Maximum was noted on *Unio* specimens of biomass 74.7 g (southern section). In 2007 average number of *Dreissena* per *Unio* specimen was 57 spec. Dr/spec. U (limits 4–185).

In 2008 number of *Dreissena* increased to the level of 2005 — on average 153 spec. Dr/spec. U (limits 7–579). Average biomass decreased to 25.2 g Dr/spec. U (limits 0.8–117.7) and continued to decrease until 2009 — to on average 20.9 g Dr/spec. U (limits 0.4–81.1). In 2009 number of *Dreissena* per *Unio* specimen was on average 28 spec. Dr/spec. U (limits 2–185).

The size structure is an important characteristic of the mollusk's population state. In epibiotic druses of *Dreissena* seven size groups were registered — from 1–5 mm to 31–35 mm. In 2005 on the living *Unio* the size group of 6–10 mm dominated. In 2006 in the western section the group of 11–15 and 16–20 mm dominated, juvenile specimens (1–5 mm) substantially prevailed in southern section.

Maximal size of *Dreissena* specimens on *Unio* over the years increased from on the average 26.1 mm in 2005 to 31.1 mm in 2009.

Possible negative impacts of the *Dreissena* settlements on Unionidae as mollusk-carrier can be assessed, in particular, by the change of size — biomass characteristics. Character of dependence length — biomass of Unionidae over period of studies is close to those given in the literature and obtained in natural conditions (Alimov, 1981).

However, the analysis of morphometric characteristics of the live Unionidae shells showed that after *Dreissena*'s penetration factor K_f increased, mainly due to growth of relation L/h. Thus, after *Dreissena*'s penetration the length of individuals increased, at the same time the height of a shell decreased. However, this also can be a consequence of allometric natural growth of large mollusks.

The *Dreissena* settlements on living *Unio*, as well as on other substrata, represent spatially complex microbiotop occupied by various invertebrates. In druses on the live *Unio* in southern section 11 species of invertebrates were noted (5 species of Naididae, 3 of Chironomidae, Trichoptera and Ceratopogonidae, and a Gastropoda *Ferrissia* sp.). *Limnochironomus nervosus* Staeg. and *Ecnomus tenellus* (Rambur) in particular represent-

ed almost 100 % frequency of occurrence. Number of invertebrates' species in each druse of *Dreissena* on a specimen of *Unio* was low: 2–5.

In the years 2008 and 2009 the taxonomic richness in druses on *Unio* increased: *Hydra*, Ostracoda, *Micronecta* sp. were found. Abundance of co-living invertebrates considerably increased — to hundreds ind./spec. U. Chironomidae, Oligochaeta and *E. tenellus* quantitatively dominated.

Discussion

The phenomenon of settlement of the attached organisms on solid covers and shells of others hydrobionts (or epizoon), creation of epibiotic communities is widespread in different reservoirs. One of examples are settlements of the attached bivalve mollusks (Dreissenidae) on shells of the mobile Unionidae. These settlements can be considered as consortio representing system of interrelations between organisms, where the role belongs to the dominating organism-edificator or "ecosystem-engineer".

Quantitative characteristics of *Dreissena* populations in such communities considerably vary in different reservoirs (Kharchenko, Zorina-Sacharova, 2000; Hunter, Bailey, 1992; Schloesser et al., 1998; Strayer, 1999). According to our data obtained in the Kyiv reservoir in the water bodies inhabited by both species, *D. polymorpha* and *D. bugensis* Andr., the leading position in settlements on Unionidae belongs to *D. polymorpha* (Sylayeva et al., 2005).

Our researches showed that after invasion of *D. polymorpha* and start of second power unit, Unionidae have disappeared only in the intake channel of cooling pond of KhNPP. This is connected to change of hydrodynamic conditions. *Dreissena* attachment to the shells of the living Unionidae can lead to death of the latter because of limiting of their mobility and difficulty of obstruction for filtration. However, in the conditions of the cooling pond mollusks are affected by complex of others biotic and abiotic factors: high temperature, silting of bottom and considerable vegetation of the filamentous algae. The obvious negative impact which could be expressed as mass Unionidae mortality in the cooling pond of KhNPP was not noted, unlike to the Great Lakes (Hunter, Bailey, 1992; Schloesser et al., 1998).

In 2005 (the first, aggressive period of invasion) prevalence of *Dreissena* biomass over Unionidae biomass was registered, but in 2006–2009 the *Dreissena* biomass decreased and did not exceed the biomass of *Unio*, this can testify to some stabilisation of settling processes and joint settlement of two species of the mollusks-filterers (fig. 3). At the same time average mass of the *Unio* specimens over this period has increased (fig. 4).

On the basis of the studies of *Dreissena* settlements on Unionidae in the Kiev reservoir the conclusion has been made, that complex Unionidae + *Dreissena* is stable if the biomass of epibiontic organisms does not exceed the biomass of Unionidae (Kharchenko, Zorina-Sacharova, 2000). According to studies of *Dreissena* settlements in Masurian lakes (Poland), even when *Dreissena* biomass several times exceeded the biomass of Unionidae, negative impact on growth of the latter was not noted (Lewandowski, 1976). However, according to studies of the joint settlements of *Dreissena* and Unionidae in the lotic conditions, *Unio* with settlements were smaller, and the biomass of *Dreissena* 15.1–20.0 g was critical, higher values caused death of Unionidae (Piechocki, 2008). Besides, the portion of the empty Unionidae shells (35 % of all taken) was higher as compared with reservoirs where *Dreissena* was absent. In our studies the portion of the empty shells was somewhat larger (on average 38 % in the years 2005–2007 and 48 % in 2008–2009).

It is possible to accept the reducing of Unionidae shell size as a criterion for estimation of the *Dreissena* settlements' impact. According to our data it is impossible to make a conclusion on decrease of the size under the *Dreissena*'s impact, as average length and mass of Unionidae increased during the studies (fig. 2). It is worth to note that in 2005 the size structure of *Unio* was still close to that noted in 2001.

In the laboratory experiments veliger of *Dreissena* settled on live Unionidae shells more intensively, than on other solid substrata (Lewandowski, 1976; Guseva, Mertl', 2008).

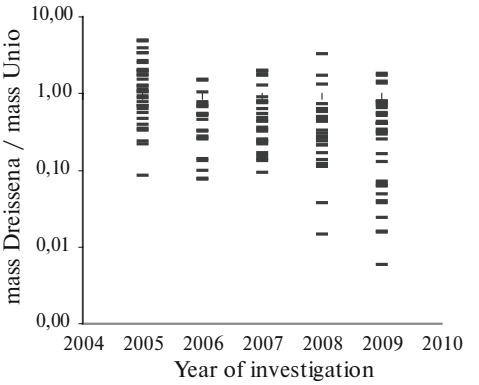

Fig. 3. Ratio of *Dreissena* and *Unio* biomass over the period of investigation.

Рис. 3. Соотношение между массой *Dreissena* и массой *Unio* по годам исследований.

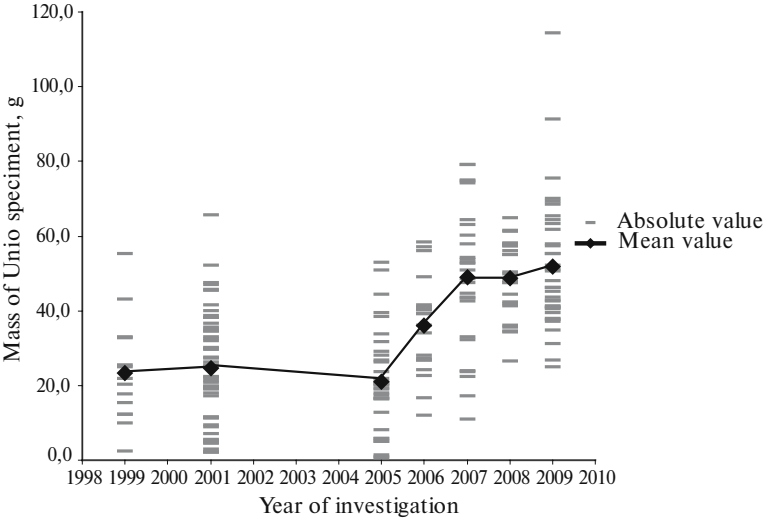

Fig. 4. Absolute and average values of *Unio* specimens mass in the cooling pond of the Khmelnytskiy NPP over period of investigation.

Рис. 4. Абсолютные и средние величины массы *Unio* водоема-охладителя Хмельницкой АЭС по годам исследований.

Creating communities of consortive type, *Dreissena* provides settlement of considerable quantity of invertebrates from different taxonomic groups in the druses. *Dreissena*'s settlement on Unionidae is a consortio with two edificators (Kharchenko, Zorina-Sacharova, 2000). In *Dreissena* communities existing for a long time, invertebrates were absent in the adjacent sections (Karataev et al., 1983). However, according to our previous data (Sylayeva et al., 2006), specific species inhabiting settlement of *Dreissena* in the cooling pond of KhNPP on the ground, on Unionidae and on other substrata were characterized by similar structure of the species–consorts.

In the considered cooling pond, we did not find the Amphipoda prevailing in *Dreissena*'s settlements, for example, in the reservoirs of the Dnieper cascade (Sylayeva et al., 2005; Kharchenko, Zorina-Sacharova, 2000) and in the cooling pond of the Chernobyl NPP (Protasov, Sylayeva, 2006). Population of druses on Unionidae in the cooling pond of KhNPP over the years 2005–2007 was extremely poor. Accurate dependence between number (and biomass) of *Dreissena* and number of invertebrates in druses was not noted — from 20 to 40 specimens number of invertebrates increased, then up to 100 specimens it decreased. In Lukomlsky Lake somewhat different pattern was char-

acteristic: number of invertebrates in druses increased to 80 specimens of *Dreissena*, and then it was stabilized (Karataev et al., 1983).

Conclusion

After *D. polymorpha* penetration and start of the second power unit of the Khmelnitsky nuclear power plan functioning, in the cooling pond some reducing of Unionidae population was noted. Mollusks of the genus *Anodonta* disappeared, abundance of two *Unio* species somewhat decreased. The Unionidae shells serve as one of substrata where *Dreissena* settlements are formed. Over the first years after *Dreissena* invasion its biomass on live Unionidae was 1.5 times higher as compared with biomass of the carrier, later this ratio decreased to 0.5–0.7.

Analysis of the morphometrical characteristics of the shells and ratio biomass/length of live Unionidae after *Dreissena* invasion gives no possibilities to conclude on negative influence of epibiont *Dreissena* on Unionidae in the considered reservoir.

Alimov A. F. Functional ecology of freshwater bivalves. — Leningrad : Science, 1981. — 248 p. — Russian : *Алимов А. Ф.* Функциональная экология пресноводных двустворчатых моллюсков.

Guseva D. O., Mertl' M. Settling of juvenil Dreissena and macroinvertebrates on the shells of different species of bivalves (Proc. Ist Intern. Conf., Oct. 28 — Nov. 1, Borok. — Yaroslavl, 2008. — P. 128–131.

Hunter D., Bailey J. Dreissena polymorpha (Zebra Mussel): colonization of soft substrata and some effects on Unionid bivalves // The Nautilus. — 1992. — **106**, N 2. — P. 60–67.

Karataev A. U., Tishchikov G. M., Karataeva I. V. Population of Dreissena polymorpha Pallas druses as specific communities of the bottom animals // Biology of Inland Water : Inf. Bulletin. — 1983. — N 61. — P. 18–21. — Russian : *Каратаев А. Ю., Тищиков Г. М., Каратаева И. В.* Население друз Dreissena polymorpha Pallas как специфическое сообщество донных животных.

Kharchenko T. A., Zorina-Sacharova E. E. Consortium of bivalves of littoral of flat storage pool as structurally-functional aggregate of hydrobionts // Hydrobiol. J. — 2000. — **36**, N 5. — P. 9–18. — Russian : *Харченко Т. А., Зорина-Сахарова Е. Е.* Консорция двустворчатых моллюсков литорали равнинного водохранилища как структурно-функциональная совокупность гидробионтов // Гидробиол. журн. — 2000. — **36**, N 5. — С. 9–17.

Lewandowski K. Unionidae as a substratum for *Dreissena polymorpha* Pall. // Pol. Arch. Hydrobiol. — 1976. — **23**, N 3. — P. 409–420.

Piechocki A. Negative impact of *Dreissena polymorpha* to *Unio tumidus* in river condition :Abstr. XXIV Seminar. malakol. Gdansk, 2008) — Gdansk, 2008. — P. 49. — Polish :.

Protasov A. A. Some features of phenotipic structure of population of *Dreissena bugensis* Andr. in the cooler pond of Chernobyl NPP. — Zhytomyr : Volyn, 2004. — P. 158–160. — Russian : *Протасов А. А.* Некоторые особенности фенотипической структуры популяции Dreissena bugensis Andr. в водоеме-охладителе Чернобыльской АЭС.

Protasov A. A., Sylayeva A. A. Communities of Invertebrates of the Cooling Pond of the Chernobyl NPS. Report 3. Communities of Zoobenthos, Their Composition and Structure // Hydrobiol. J. — 2006. — **42**, N 3. — P. 3–23.

Schloesser D. W., Kovalak W. P. Longton G. D. et al. Impact of Zebra and Quagga Mussels (Dreissena spp.) on Freshwater Unionids (Bivalvia: Unionidae) in the Detroit River of the Great Lakes // Am. Midl. Nat. — 1998. — **140**. — P. 299–313.

Strayer D. L. Effects of alien species on freshwater mollusks in North America // J. N. Am. Benthol. Soc. — 1999. — **18**, N 1. — P. 74–98.

Sylayeva A. A., Protasov A. A. Zoobentos of cooling pond of Khmelnitskiy nuclear power plant and estimation of water quality on the bottom invertebrates // Hydrobiol. J. — 2002. — **38**, N 6. — P. 46–59. — Russian : *Силаева А. А., Протасов А. А.* Зообентос водоема-охладителя Хмельницкой АЭС и оценка качества воды по донным беспозвоночным // Гидробиол. журн. — 2002. — **38**, N 6. — С. 46–59.

Sylayeva A. A., Protasov A. A., Morozovskaya I. A. Bottom communities of invertebrates of littoral of the Kiev reservoir. — Ternopil : Publ. Ternopil univer. Ser. Biology. Sp. is. Hydroecology. — 2005. — N 3 (26). — P. 397–399. — Russian : *Силаева А. А., Протасов А. А. , Морозовская И. А.* Донные группировки беспозвоночных литорали Киевского водохранилища.

Sylayeva A. A., Protasov A. A., Morozovskaya I. A., Babaryga S. P. Composition and abundance of bivalves and size structure of their population in the cooling pond of Khmelnytskiy NPP. — Zhytomyr : Publ. Zhitomyr univ. — Is. 2. — 2006. — P. 262–265. — Russian : *Силаева А. А., Протасов А. А., Морозовская И. А., Бабарига С. П.* Особенности сообществ дрейссены в донных группировках водоема-охладителя Хмельницкой АЭС.