FOLIA MALACOLOGICA
Folia Malacol. 26(3): 177–182
ISSN 1506-7629 (print) • ISSN 2300-7125 (on-line)
The Association of Polish Malacologists
Faculty of Biology, Adam Mickiewicz University
Bogucki Wydawnictwo Naukowe
Poznań, September 2018
https://doi.org/10.12657/folmal.026.017

INFESTATION OF UNIONIDS NATIVE TO POLAND BY *DREISSENA POLYMORPHA* (PALLAS, 1771) IN LITTORAL ZONE OF TWO LOWLAND LAKES

ANNA MARSZEWSKA[1]*, ANNA CICHY[2]

Nicolaus Copernicus University in Toruń, Gagarina 11, 87-100 Toruń, Poland
(e-mail: anna@doktorant.umk.pl; anna.cichy@umk.pl)

*corresponding author

ABSTRACT: *Dreissena polymorpha* (Pallas, 1771) is an alien bivalve species that has successfully spread in lotic and lentic water habitats of Poland. The aim of the study was an assessment of differences in the level of colonisation of zebra mussel individuals residing on the shell surface of Unionidae gathered from the shore zone of water bodies both between Unionidae species and the two lakes of central Poland that were sampled. The lakes are surrounded by forest, and have silty-sandy bottoms that are poor in hard surfaces, but these water bodies vary in size and wave exposure. Specimens of two Unionidae species, *Anodonta anatina* (Linnaeus, 1758) and *Unio tumidus* Philipsson, 1788, were collected from both lakes and numbers of colonizing *D. polymorpha* individuals fixed to their shells noted. The majority of collected unionids were inhabited by *D. polymorpha*. Our results suggest that Unionidae living in the smaller lake were more exposed to colonisation by *D. polymorpha*, and that *A. anatina* in both lakes was more likely to be used as a substrate for *D. polymorpha* colonies than *U. tumidus*.

KEY WORDS: zebra mussel, *Anodonta anatina*, *Unio tumidus*, shell size, littoral zone

INTRODUCTION

The decline of Unionidae populations has been recorded globally and has become a major problem of conservation biology (LOPES-LIMA et al. 2017). Interactions with other organisms, especially those of alien origins, have had a negative impact on Unionidae communities (COLOMBA et al. 2013). One of the most successful invertebrate colonizers of worldwide waters is the zebra mussel *Dreissena polymorpha* (Pallas, 1771), a Ponto–Caspian species accidentally introduced to water habitats of Poland at the beginning of the 19th century (LEWANDOWSKI 2001). This species significantly differs from mussels native to Poland in aspects of life history and ecological traits (MACKIE 1991, BURLAKOVA et al. 2000, PIECHOCKI & WAWRZYNIAK-WYDROWSKA 2016). An important feature which enables *D. polymorpha* individuals to colonise new areas is their high reproductive potential (MACKIE 1991, SPRUNG 1993), resulting in very high densities of populations that can exceed 110,000 individuals m^{-2} in favourable conditions (WIKTOR 1969). However, the zebra mussel larvae need to attach to a stable, preferably hard surface for further development (LEWANDOWSKI 2001, SCHLOESSER & SCHMUCKAL 2012). This larval period is often characterised by a large reduction in the number of mussels due to the lack of adequate substrate in the habitat (STAŃCZYKOWSKA 1977, LEWANDOWSKI 1982, BURLAKOVA et al. 2000). The surface of Unionidae shells is a suitable surface used by *D. polymorpha* colonies (LEWANDOWSKI 1976, SCHLOESSER et al. 1996, 1998, BURLAKOVA et al. 2000). *D. polymorpha* residing on Unionidae shells significantly influence the biology and physiology of hosts, including reduction of their survival, impaired movement and shell deformation, also causing the host to sink into the muddy substrate (SCHLOESSER & NALEPA 1994, BURLAKOVA et al. 2000, GRIZZLE & BRUNNER 2009, BÓDIS et al. 2014). The preferred location of zebra mussel aggregation

Ministry of Science and Higher Education
Republic of Poland
Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland, under agreement no 534/P-DUN/2018 of April 4th, 2018 allocated to the activities for disseminating science:
Task 1: Preparation of English versions of publications (sum funded by DUN 12,000 PLN) and
Task 2: Digitalisation of publications and scientific monographs to enable their open access in the Internet (sum funded by DUN 11,070 PLN).

on Unionidae shells is near the posterior, siphonal part. Such aggregation causes competition for food (Hörmann & Maier 2006) or even may contribute to strangulation of the host (Grizzle & Brunner 2009). The purpose of the research was an assessment of differences in the overgrowth of native Unionidae species by *D. polymorpha* in the littoral zone areas of lakes in terms of 1) Unionidae species and 2) research areas.

MATERIAL AND METHODS

The samples were gathered in July 2014 from Bachotek (53°17'18"N, 19°28'27"E) and Dębno lake (53°23'01"N, 19°24'50"E) (Fig. 1) in Central Poland. Both study sites were characterised by macrophyte-rich littoral zones and silty–sandy bottoms, which are poor in stones, branches as well as other hard surfaces (except for Unionidae shells). The mean values of physical and chemical parameters of Bachotek and Dębno lake water were: conductivity (360 or 323 μS/cm, respectively), oxygen (9.8 or 8.9 mg/l), pH (8.3 or 8.2) and water temperature (23.6 or 24.6 °C) were measured during the study with the core sampler and a MultiLine P4 (WTW) Universal Pocket Sized Meter. The features which significantly differentiate both lakes are their wave exposure and size. Bachotek is a mid–forest, post–glacial, gutter lake with a shape elongated from north to south, while Dębno is a mid–forest lake with a poorly developed high bank line. Lake Bachotek (volume: 15,394.2 m^3, surface: 211.0 ha) is much larger than Lake Dębno (volume: 3,281.6 m^3, surface: 59.6 ha) (Choiński 1991).

The two Unionidae species found in the lakes, *Anodonta anatina* (Linnaeus, 1758) and *Unio tumidus* Philipsson, 1788, were collected in the littoral zone under stable weather conditions. The collection sites were areas of 0.5 ha each. To standardise efforts across both sites, two person-hours of collection time was used at each research site, following Burlakova et al. (2014). The sampling of mussels in each site was carried out manually by wading in shallow water (up to a depth of 1.5 m) and using tactile searches. The mussels were transported to the laboratory in containers with lake water. Piechocki & Wawrzyniak-Wydrowska's (2016) key was used for morphological identification of bivalve species. *D. polymorpha* individuals were gently detached from Unionidae shells and counted. Unionidae shell sizes (shell length, height and width) were measured with the use of an electronic caliper. The wet weight (in

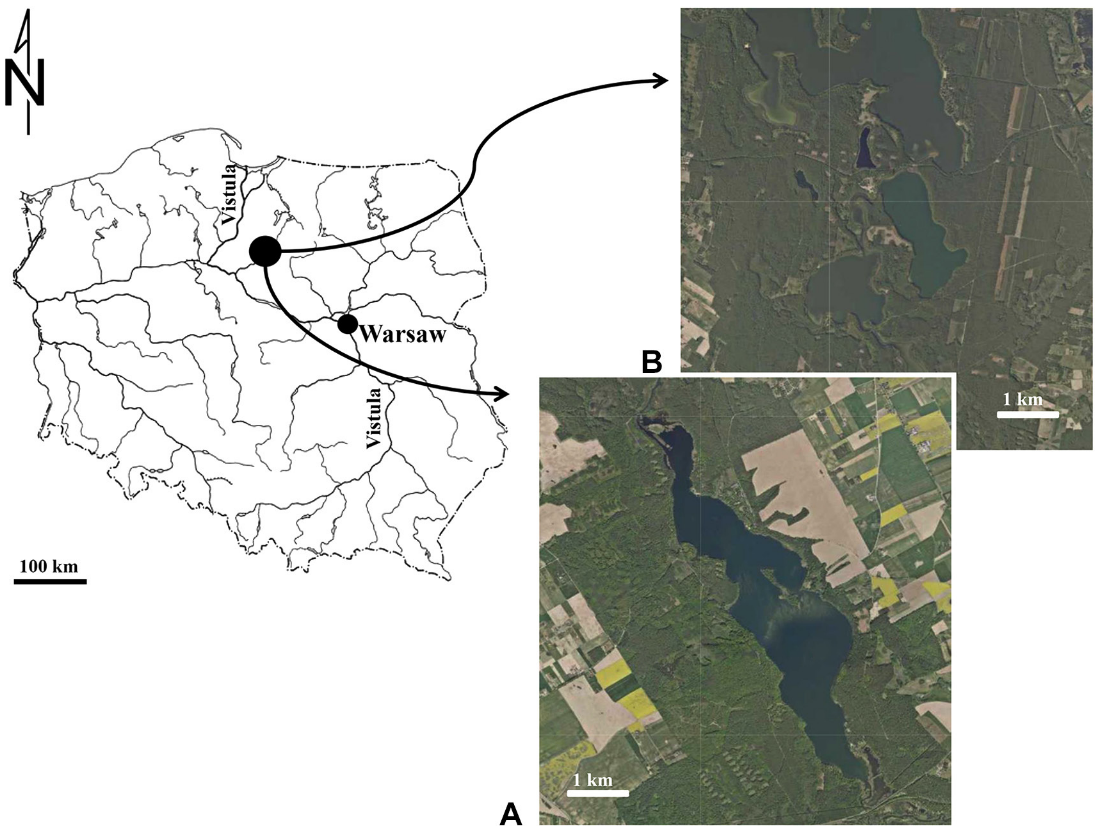

Fig. 1. Study sites: A – Lake Bachotek, B – Lake Dębno

grams) of each Unionidae individual and all *D. polymorpha* individuals residing on its shell were measured with the use of a digital weight scale.

A Chi–square test of contingency table was used to compare the number of Unionidae inhabited and non–inhabited by *D. polymorpha* in terms of the study sites and the unionid mussel species. A Mann–Whitney *U* test was used to compare: 1) the number of *D. polymorpha* on Unionidae shells between study sites, 2) the number of *D. polymorpha* and the weight of their colonies between two Unionidae species, and 3) the wet weight and the shell sizes of the studied Unionidae species.

RESULTS

A total of 239 individuals of Unionidae (Lake Bachotek: 62 *A. anatina*, 40 *U. tumidus*; Lake Dębno: 80 *A. anatina*, 57 *U. tumidus*) and 2,608 individuals of the zebra mussels from their shells were collected. The mean shell size and weight of *A. anatina* was higher than *U. tumidus* (P<0.001) (Fig. 2). *D. polymorpha* was found on 74.9% of the collected unionids. The number of Unionidae with *D. polymorpha* significantly differed between study sites (χ^2=387.6; df=1; P<0.001). Unionids were more frequently colonised by the zebra mussels in Lake Dębno compared to Lake Bachotek (86.7% and 58.8%, respectively). Similarly, more individuals of *D. polymorpha* on Unionidae shells were noted in Lake Dębno (Mann–Whitney *U* test, P<0.001). There was a significant difference

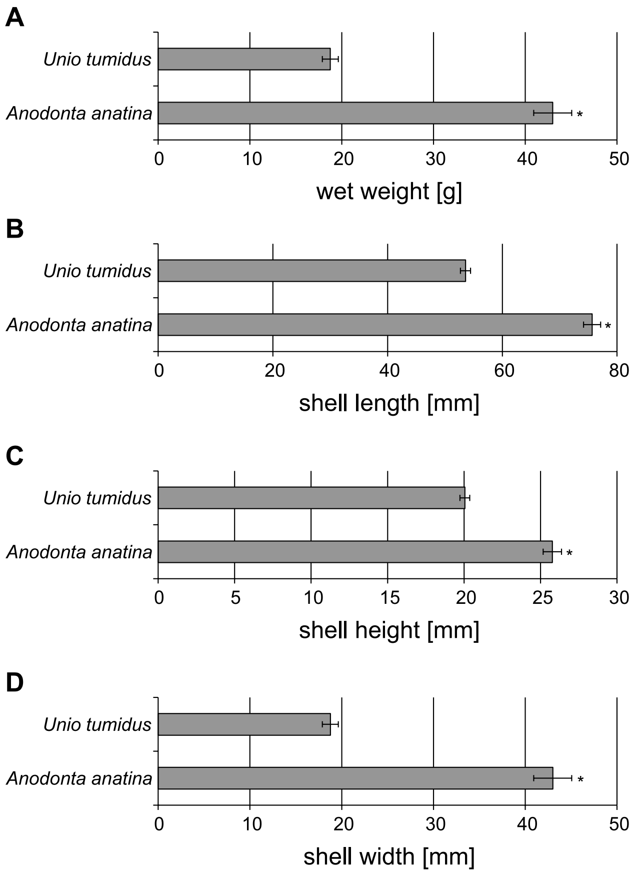

Fig. 2. Average size parameters (± SE) of Unionidae species: A – wet weight, B – shell length, C – shell height, D – shell width. (*) the Mann–Whitney *U* test (P<0.001)

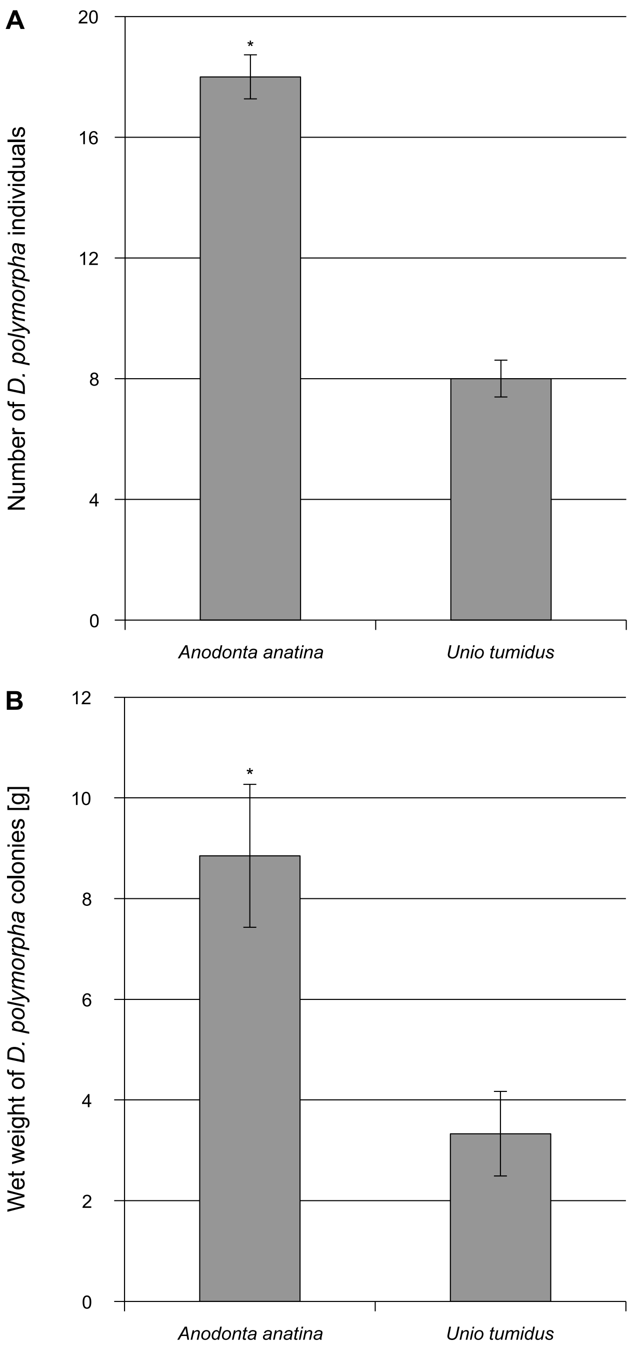

Fig. 3. Average parameters (± SE) of *Dreissena polymorpha* colonies from unionid shells: A – number of individuals per one Unionidae, B – wet weight of colonies from one Unionidae. (*) the Mann–Whitney *U* test (P<0.001)

between species in the number of Unionidae individuals inhabited by the zebra mussels (χ^2=414.30; df=1; P<0.001). *A. anatina* individuals were more often colonised by *D. polymorpha* (83.1%) than *U. tumidus* (62.9%). In addition, colonies on the surface of *A. anatina* shells were more numerous (Mann–Whitney *U* test, P<0.001) and heavier (Mann–Whitney *U* test, P<0.001) (Fig. 3). The biggest colonies of *D. polymorpha* found on *A. anatina* and *U. tumidus* shells were composed of 86 and 27 individuals, respectively. In both these cases the weight of *D. polymorpha* colonies (33.0 g on the *A. anatina* shell and 14.0 g on the *U. tumidus* shell) was higher than the weight of the hosts (28.8 g for *A. anatina* and 3.2 g for *U. tumidus*).

DISCUSSION

Our research confirms that the surface of Unionidae shells is a suitable habitat for *D. polymorpha* (Lewandowski 1976, Burlakova et al. 2014, Dzierżyńska-Białończyk et al. 2018), especially in the absence of other hard substrates available, even in habitats characterised by high waviness. The percentage of unionids inhabited by *D. polymorpha* in our study is comparable to the results noted in other European lakes (Lewandowski 1976, Karatayev 1983, Burlakova 1998, Burlakova et al. 2000). Pilotto et al. (2016) indicate that *D. polymorpha* does benefit from an association with unionid species.

The differences between study sites regarding the number of Unionidae colonised by *D. polymorpha* may be caused by different densities of dreissenids in varied sized lakes, as well as the different exposure of both lakes to the wind. In the larger Lake Bachotek, the population of *D. polymorpha* may reflect the dilution effect (Stańczykowska 1964), in addition, the high banks of the smaller Lake Dębno, which protect the molluscs' habitat against wind, provided better conditions for colonisation by zebra mussels. Both a larger area, and wind exposure of a lake contribute to stronger wave action, which has a negative impact on the biomass of *D. polymorpha* colonies as well as the number of individuals in the colonies (Karatayev et al. 2006). The dilution effect referred to above also affects Unionidae populations. As a result, more dense populations of *A. anatina* and *U. tumidus* are found in the small Lake Dębno than in the much larger Lake Bachotek. As a consequence, the littoral of Lake Dębno is characterised by a greater area of Unionidae shell surface available to *D. polymorpha* for colonisation than in the Bachotek lake. While other physical and chemical properties of lake waters may influence the development and density of molluscs (Lodge et al. 1987, Hincks & Mackie 1997, Matthews & McMahon 1999, Horsák 2006, White et al. 2015), those measured were very similar in each lake. We cannot, however, discount possible differences between lakes, for example in levels of predation (Thorp et al. 1998).

The shell size of the host species was the factor that differentiates the settling of *D. polymorpha* on the shell surface of *A. anatina* and *U. tumidus*. These results confirm the observations of Aldridge (2010) and Sousa et al. (2011) indicating that larger shells of *A. anatina* compared to *U. tumidus* provide larger surfaces for colonisation by zebra mussels. These authors additionally pointed out that the factor differentiating the size of *D. polymorpha* colonies inhabiting *A. anatina* and *U. tumidus* can be different behavior of the hosts (e.g. *A. anatina* can burrow in a lake bottom more deeply than *U. tumidus*). In addition, experimental research carried out by Dzierżyńska-Białończyk et al. (2018) showed that *D. polymorpha* colonises different Unionidae species to variable extent because of their active substratum selection. All data cited above and our results remain in opposition to research by Bódis et al. (2014) who stated that *Unio* species could be equally infested by *D. polymorpha* as other Unionidae species such as *A. anatina* and *Sinanodonta woodiana*, because shells of sedentary zebra mussels are equally good substrate for further settlers. In addition, Burlakova et al. (2014) found no evidence to suggesting a preference of Dreissenidae infestation among unionid species depending on life strategies or tribes. However, as Burlakova et al. (2014) emphasise, it may be the result that their hypotheses were tested on species that were adapted to the specific nearshore habitats which they examined.

As can be seen from the quoted papers, there is no unambiguous answer to the question about the most important factor determining the intensity of settling of *D. polymorpha* on Unionidae shells. Significant differences in this respect were recorded between populations inhabiting lakes of different surface area and wave exposure, so we assume that effective colonisation of Unionidae shells by *D. polymorpha* individuals depends, to a large extent, on physical factors in the environment inhabited by these species. Moreover, due to the considerable colonisation of native bivalves by invasive species of mollusc as well as their possible negative effect on Unionidae biology, further research should focus on the experimental study of the life span of unionids inhabited and non-inhabited by *D. polymorpha*.

ACKNOWLEDGEMENTS

We would like to thank KATARZYNA GAŁKA, MA, for language support and proofreading of an English version of the manuscript. This research was financed by the Faculty of Biology and Environmental Protection of the Nicolaus Copernicus University in Toruń as Individual Research Grants No. WBiOŚ 1917–B/2014.

REFERENCES

ALDRIDGE D. 2010. *Dreissena polymorpha* in Great Britain: history of spread, impacts and control. In: VAN DER VELDE G., RAJAGOPAL S., BIJ DE VAATE A. (eds). The zebra mussel in Europe. Backhuys Publishers, Weikersheim, pp. 79–92.

BÓDIS E., TÓTH B., SOUSA R. 2014. Impact of *Dreissena* fouling on the physiological condition of native and invasive bivalves: interspecific and temporal variations. Biological Invasions 16: 1373–1386. https://doi.org/10.1007/s10530-013-0575-z

BURLAKOVA L. E. 1998. Ecology of *Dreissena polymorpha* (Pallas) and its role in the structure and function of aquatic ecosystems. Candidate Dissertation, Zoology Institute of the Academy of Science Republic Belarus, Minsk.

BURLAKOVA L. E., KARATAYEV A. Y., PADILLA D. K. 2000. The impact of *Dreissena polymorpha* (Pallas) invasion on unionid bivalves. International Review of Hydrobiology 85: 529–541. https://doi.org/10.1002/1522-2632(200011)85:5/6<529::AID-IROH529>3.0.CO;2-O

BURLAKOVA L. E., TULUMELLO B. L., KARATAYEV A. Y., KREBS R. A., SCHLOESSER D. W. PATERSON W. L., GRIFFITH T. A., SCOTT M. W., CRAIL T., ZANATTA D. T. 2014. Competitive replacement of invasive congeners may relax impact on native species: interactions among zebra, quagga, and native unionid mussels. PLoS One 9(12): e114926. https://doi.org/10.1371/journal.pone.0114926

CHOIŃSKI A. 1991. Katalog jezior Polski. Cz. 3. Fundacja „Warta", Poznań.

COLOMBA M. S., LIBERTO F., REITANO A., GRASSO R., DI FRANCO D., SPARACIO I. 2013. On the presence of *Dreissena polymorpha* Pallas, 1771 and *Sinanodonta woodiana woodiana* (Lea, 1834) in Sicily (Bivalvia). Biodiversity Journal 4: 571–580.

DZIERŻYŃSKA-BIAŁOŃCZYK A., JERMACZ Ł., MAĆKIEWICZ T., GAJEWSKA J., KOBAK J. 2018. Mechanisms and impact of differential fouling of the zebra mussel *Dreissena polymorpha* on different unionid bivalves. Freshwater Biology 63: 687–699. https://doi.org/10.1111/fwb.13107

GRIZZLE J. M., BRUNNER C. J. 2009. Infectious diseases of freshwater mussels and other freshwater bivalve mollusks. Reviews in Fisheries Science 17: 425–467. https://doi.org/10.1080/10641260902879000

HINCKS S. S., MACKIE, G. L. 1997. Effects of pH, calcium, alkalinity, hardness, and chlorophyll on the survival, growth, and reproductive success of zebra mussel (*Dreissena polymorpha*) in Ontario lakes. Canadian Journal of Fisheries and Aquatic Sciences 54: 2049–2057. https://doi.org/10.1139/f97-114

HORSÁK M. 2006. Mollusc community patterns and species response curves along a mineral richness gradient: a case study in fens. Journal of Biogeography 33: 98–107. https://doi.org/10.1111/j.1365-2699.2005.01359.x

HÖRMANN L., MAIER G. 2006. Do zebra mussels grow faster on live unionids than on inanimate substrate? A study with field enclosures. International Review of Hydrobiology 91: 113–121. https://doi.org/10.1002/iroh.200510834

KARATAYEV A. Y. 1983. Ecology of *Dreissena polymorpha* Pallas and its effects on macrozoobenthos of the thermal power plant's cooling reservoir. Candidate Dissertation, Zoology Institute of Academy of Science Belarussian SSR, Minsk.

KARATAYEV A. Y., BURLAKOVA L. E., PADILLA D. K. 2006. Growth rate and longevity of *Dreissena polymorpha* (Pallas): a review and recommendations for future study. Journal of Shellfish Research 25: 23–32. https://doi.org/10.2983/0730-8000(2006)25[23:GRALOD]2.0.CO;2

LEWANDOWSKI K. 1976. Unionidae as a substratum for *Dreissena polymorpha* (Pall.). Polskie Archiwum Hydrobiologii / Polish Archives of Hydrobiology 23: 409–420.

LEWANDOWSKI K. 1982. The role of early developmental stages in the dynamics of *Dreissena polymorpha* (Pall.) (Bivalvia) populations in lakes. II. Settling of larvae and the dynamics of number of sedentary individuals. Ekologia Polska 30: 223–286.

LEWANDOWSKI K. 2001. Development of populations of *Dreissena polymorpha* (Pall.) in lakes. Folia Malacologica 9: 171–213. https://doi.org/10.12657/folmal.009.020

LODGE D. M., BROWN K. M., KLOSIEWSKI S. P., STEIN R. A., COVICH A. P., LEATHERS B. K., BRONMARK C. 1987. Distribution of freshwater snails: spatial scale and the relative importance of physicochemical and biotic factors. American Malacological Bulletin 5: 73–84.

LOPES-LIMA M., SOUSA R., GEIST J., ALDRIDGE D. C., ARAUJO R., BERGENGREN J., BESPALAYA Y., BÓDIS E., BURLAKOVA L., DAMME D. VAN, DOUDA K., FROUFE E., GEORGIEV D., GUMPINGER C., KARATAYEV A., KEBAPÇI Ü., KILLEEN I., LAJTNER J., LARSEN B. M., LAUCERI R., LEGAKIS A., LOIS S., LUNDBERG S., MOORKENS E., MOTTE G., NAGEL K.-O., ONDINA P., OUTEIRO A., PAUNOVIC M., PRIÉ V., PROSCHWITZ T. VON, RICCARDI N., RUDZĪTE M., RUDZĪTIS M., SCHEDER C., SEDDON M., ŞEREFLIŞAN H., SIMIĆ V., SOKOLOVA S., STOECKL K., TASKINEN J., TEIXEIRA A., THIELEN F., TRICHKOVA T., VARANDAS S., VICENTINI H., ZAJAC K., ZAJAC T., ZOGARIS S. 2017. Conservation status of freshwater mussels in Europe: state of the art and future challenges. Biological Reviews 92: 572–607. https://doi.org/10.1111/brv.12244

MACKIE G. L. 1991. Biology of the exotic zebra mussel, *Dreissena polymorpha*, in relation to native bivalves and its potential impact in Lake St. Clair. Hydrobiologia 219: 251–268. https://doi.org/10.1007/BF00024759

MATTHEWS M. A., MCMAHON R. F. 1999. Effects of temperature and temperature acclimation on survival of zebra mussels (*Dreissena polymorpha*) and Asian clams (*Corbicula fluminea*) under extreme hypoxia. Journal of Molluscan Studies 65: 317–325. https://doi.org/10.1093/mollus/65.3.317

PIECHOCKI A., WAWRZYNIAK-WYDROWSKA B. 2016. Guide to freshwater and marine Mollusca of Poland. Bogucki Wydawnictwo Naukowe, Poznań.

PILOTTO F., SOUSA R., ALDRIDGE D. C. 2016. Is the body condition of the invasive zebra mussel (*Dreissena polymorpha*) enhanced through attachment to native freshwater mussels (Bivalvia, Unionidae)? Science of the Total Environment 553: 243–249. https://doi.org/10.1016/j.scitotenv.2016.02.119

SCHLOESSER D. W., KOVALAK W. P., LONGTON G. D., OHNESORG K. L., SMITHEE R. D. 1998. Impact of Zebra and Quagga Mussels (*Dreissena* spp.) on freshwater unionids (Bivalvia: Unionidae) in the Detroit River of the Great Lakes. The American Midland Naturalist 140: 299–313. https://doi.org/10.1674/0003-0031(1998)140[0299:IOZAQM]2.0.CO;2

SCHLOESSER D. W., NALEPA T. F. 1994. Dramatic decline of unionid bivalves in offshore waters of western Lake Erie after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Fisheries and Aquatic Sciences 51: 2234–2242. https://doi.org/10.1139/f94-226

SCHLOESSER D. W., NALEPA T. F., MACKIE G. L. 1996. Zebra Mussel infestation of unionid bivalves (Unionidae) in North America. American Zoologist 36: 300–310. https://doi.org/10.1093/icb/36.3.300

SCHLOESSER D. W., SCHMUCKAL C. 2012. Bibliography of *Dreissena polymorpha* (zebra mussels) and *Dreissena rostriformis bugensis* (quagga mussels): 1989 to 2011. Journal of Shellfish Research 31: 1205–1263. https://doi.org/10.2983/035.031.0432

SOUSA R., PILOTTO F., ALDRIDGE D. C. 2011. Fouling of European freshwater bivalves (Unionidae) by the invasive zebra mussel (*Dreissena polymorpha*). Freshwater Biology 56: 867–876. https://doi.org/10.1111/j.1365-2427.2010.02532.x

SPRUNG M. 1993. The other life: an account of present knowledge of the larval phase of *Dreissena polymorpha* In: NALEPA T. F., SCHLOESSER D. W. (eds). Zebra mussels: biology, impacts, and control. Lewis Publishers, Boca Raton, pp. 39–55.

STAŃCZYKOWSKA A. 1964. On the relationship between abundance, aggregations and "condition" of *Dreissena polymorpha* /Pall./ in 36 Mazurian Lakes. Ekologia Polska 12: 653–690.

STAŃCZYKOWSKA A. 1977. Ecology of *Dreissena polymorpha* (Pall.) (Bivalvia) in lakes. Polskie Archiwum Hydrobiologii / Polish Archives of Hydrobiology 24: 461–530.

THORP J. H., DELONG M. D., CASPER A. A. F. 1998. In situ experiments on predatory regulation of a bivalve mollusc (*Dreissena polymorpha*) in the Mississippi and Ohio Rivers. Freshwater Biology 39: 649–661. https://doi.org/10.1046/j.1365-2427.1998.00313.x

WHITE J. D., HAMILTON S. K., SARNELLE O. 2015. Heat-induced mass mortality of invasive zebra mussels (*Dreissena polymorpha*) at sublethal water temperatures. Canadian Journal of Fisheries and Aquatic Sciences 72: 1221–1229. https://doi.org/10.1139/cjfas-2015-0064

WIKTOR J. 1969. Biologia *Dreissena polymorpha* (Pall.) i jej ekologiczne znaczenia w Zalewie Szczecińskim. Studia i Materiały. Morski Instytut Rybacki, Gdynia.

Received: July 10th, 2018
Revised: August 9th, 2018
Accepted: September 20th, 2018
Published on-line: September 29th, 2018