


OCCURRENCE AND DISTRIBUTION OF THE ENDANGERED FRESHWATER MUSSELS *UNIO CRASSUS* AND *PSEUDANODONTA COMPLANATA* (BIVALVIA: UNIONIDA) IN THE PISA RIVER, NORTH-EASTERN POLAND


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ABSTRACT: Unionid mussels are among the most threatened groups of organisms globally. Habitat loss is one of the major drivers of their declines and local extinctions. In Poland six native species occur, but data on their present distribution are limited. The aim of this study was to assess unionid mussel species composition and distribution in the Pisa River, protected as part of Natura 2000 areas but currently threatened by plans of modification of its discharge regime and transformation into a navigable waterway. Twenty-one sites were surveyed using the timed-search method. The strictly protected *Unio crassus* was present at 86% of the sites and showed continuous distribution throughout the river. Young mussels constituted 26% of *U. crassus* individuals, indicating successful recruitment. *Pseudanodonta complanata* was found at three sites, suggesting that the Pisa River provides an important habitat also for this endangered species. Additionally, *Anodonta cygnea*, *A. anatina*, *U. pictorum*, and *U. tumidus* were recorded. Such multispecies unionid mussel communities are increasingly rare and need to be protected. The Pisa River is characterised by natural flow regime and a meandering channel with diversified depth and flow speeds. Conservation of *U. crassus* and other unionid mussels requires that its natural character is maintained and no changes are introduced into its channel.

KEY WORDS: endangered species, freshwater conservation, Natura 2000, the Pisa River, unionid distribution

INTRODUCTION

Freshwater mussels (Bivalvia: Unionida) suffer rapid population declines and range contractions throughout the world and belong to the most endangered groups of organisms globally (LYDEARD et al. 2004, LOPES-LIMA et al. 2017). The most important threats to their survival are habitat modification and pollution (LOPES-LIMA et al. 2018). Freshwater mussels are filter-feeding, relatively large-bodied,

bottom-dwelling animals, with a larval stage (glochidium) that requires appropriate host fish. They play important roles in the functioning of aquatic ecosystems, contributing to water filtration and purification, nutrient cycling and storage, and bottom bioturbation (LUMMER et al. 2016, VAUGHN 2018, JOHNSON et al. 2019). Additionally, they are important ecosystem engineers modifying and creating



habitats (VAUGHN & HAKENKAMP 2001, GUTIÉRREZ et al. 2003, VAUGHN 2018). Declines and loss of unionid mussel populations lead to severe deterioration of the quality of freshwater habitats (HAAG & WILLIAMS 2014, VAUGHN 2018).

In Poland, six species of native unionid mussels occur, three of which are legally protected: the thick shelled river mussel *Unio crassus* Philipsson, 1788, the depressed river mussel *Pseudanodonta complanata* (Rossmässler, 1835), and the swan mussel *Anodonta cygnea* (Linnaeus, 1758). *U. crassus* is strictly protected with the requirement of active conservation (ROZPORZĄDZENIE 2014). All three species are listed in the Polish Red Data Book of Animals with the EN category – endangered (ZAJĄC 2004a, b, c). In the IUCN Red Data List, *U. crassus* is listed with the EN category and a decreasing population trend (LOPES-LIMA et al. 2014), and *P. complanata* with the VU category (vulnerable) and an unknown population trend (VAN DAMME 2011); *P. complanata* is regarded as one of the most sensitive European unionid mussel species (ĆMIEL et al. 2019). *U. crassus* is included in Annexes II (species requiring designation of special protection areas) and IV (species requiring strict protection) of the Habitats Directive of the EU. Although the remaining three species: *A. anatina* (Linnaeus, 1758), *U. pictorum* (Linnaeus, 1758), and *U. tumidus* Philipsson, 1788 are not legally pro-

tected in Poland, in light of ongoing global declines of unionid mussels, changes in their distributions need to be documented as well. Some data on historical occurrence of unionid mussels in Poland are available (PIECHOCKI & DYDUCH-FALNIOWSKA 1999, ZAJĄC 2004a, b, c, PIECHOCKI & WAWRZYŃIAK-WYDROWSKA 2016), but the knowledge of their current distribution is limited.

Efficient protection and conservation of endangered species require that their distributions, abundances and changes in population condition are recognised (FERREIRA-RODRÍGUEZ et al. 2019). This concerns especially the species that face an immediate threat of local extinctions resulting from habitat loss. In view of the increasing human pressure on freshwater habitats, documentation of the occurrence and distribution of freshwater biota is of the highest conservation priority. The current study was undertaken in response to the recently published plans of major hydrotechnical works on the Pisa River, including modifications of its discharge regime and transformation of the river into a navigable waterway (POLISH WATERS 2019). The aim of this paper is to document the occurrence and distribution of unionid mussels in the Pisa River with a focus on two endangered and legally protected riverine species: *U. crassus* and *P. complanata*.

MATERIAL AND METHODS

STUDY AREA

The study was carried out in the southern section of the Pisa River, between its outflow from Lake Roś and the confluence with the Narew River (Fig. 1). The Pisa River is the main watercourse that drains waters from the catchment area of the Great Masurian Lakes. It originates in Lake Kisajno at the altitude of 158.9 m a. s. l. and flows into the Narew River at the altitude of 95.7 m a. s. l. (HYDROPORTAL 2019). The overall length of the Pisa is 147 km, and its drainage basin covers an area of 4,507 km². The width of the river channel varies from 10 m to 37 m, and the average slope of the riverbed is 0.22‰. In its upper course the Pisa River flows through several Masurian Lakes and the riverine sections are relatively short. In its lower (southern) course, between Lake Roś and the Narew River, it is a largely natural, meandering, fast-flowing river, with diversified depth and flow-speeds. The length of this section of the Pisa is 82 km, and the area of its drainage basin is 3,024 km². The riverbed cuts into alluvial sediments, and the bottom is predominantly sandy or sandy with gravel and stones. The mean annual discharge recorded over the last five decades at the

gauging station in Ptaki village (approximately in the middle of the study area) is 21.2 m³ s⁻¹. Basic physicochemical parameters of the surface water of the Pisa River were assessed in the summer 2014. The mean (\pm SD) pH was 7.4 \pm 0.36 and the electrical conductivity was 389 \pm 64.0 μ S cm⁻¹ (n = 32, Hach Lange HQ40D). Water transparency was high, with Secchi depth equal to water depth at all sites (AK, unpublished data). In the second half of the 20th century, the tributaries of the lower course of the Pisa River (e.g. Rybnica, Wincenta, Skroda, and Turośl) were regulated and their valleys were drained. Fortunately, the Pisa River was left in its natural state, and it is currently protected as part of PLH280048 and PLH200023 Natura 2000 areas. Additionally, PLB280008 Nature 2000 area includes part of its course (Fig. 1). In spite of this, according to the “Drought Effects Counteracting Plan” of the National Agency Polish Waters, major hydrotechnical works are planned, including the construction of at least one weir damming the outflow from Lake Roś; ultimately, transformation of the Narew and Pisa Rivers into navigable waterways is planned (POLISH WATERS 2019).

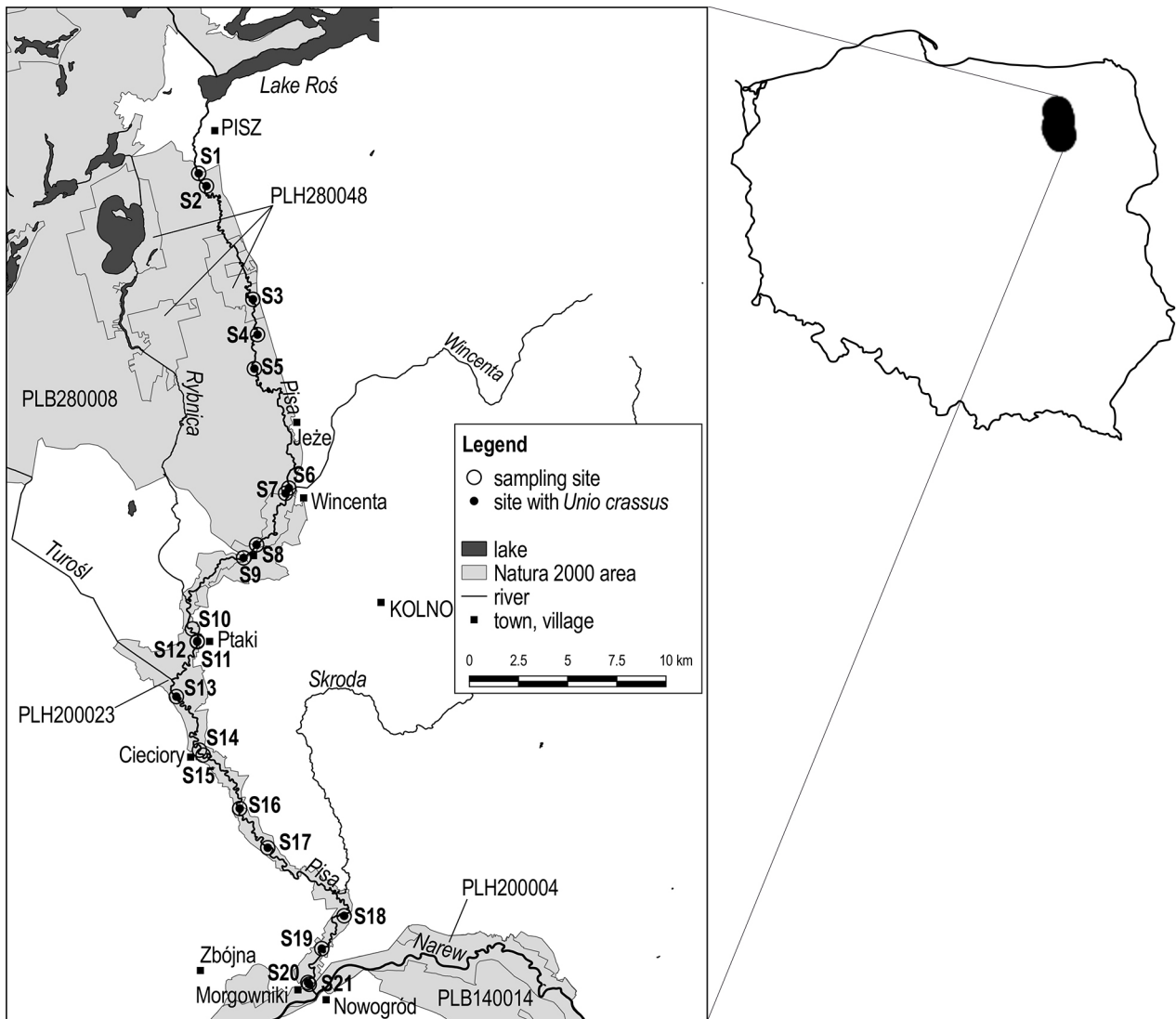


Fig. 1. Location of the study sites and results of the survey on the occurrence of *U. crassus* in the southern part of the Pisa River

MUSSEL COLLECTION AND DOCUMENTATION

The data were collected at study sites located along the southern section of the Pisa River, between its outflow from Lake Roś and its confluence with the Narew River (Fig. 1). The survey was carried out in August 2015 and August 2019. Mussels were collected by hand-sampling to a sediment depth of about 15 cm in places with water depth up to about 70 cm,

using the timed-search method (0.5 person-hour per site). In 2015, mussels were photographed on-site and species were identified from photographs. In 2019, species were identified on site. In *U. crassus* and *P. complanata*, individuals with four or less discernible annual growth rings were assigned to the young age-category. All mussels were returned to the places of collection. The position of the study sites was determined with a hand-held Garmin GPS receiver.

RESULTS AND DISCUSSION

U. crassus occurred throughout the studied area and was present at 86% of the study sites (Table 1). Figure 2 shows an example survey site and *U. crassus* individuals collected there. Young mussels, with up to four annual growth rings, were found at 46% of the sites in which *U. crassus* occurred, and con-

stituted up to 26% of all of collected individuals of this species. *U. crassus* is a long-lived, slow-growing animal, with an individual life-span of up to 80 years (ZAJĄC 2004a). Counting external growth rings as a method of age estimation tends to underestimate the age of older individuals, but is reliable up to the



Table 1. Number of individuals of *U. crassus* (Uc), *P. complanata* (Pc) and *A. cygnea* (Ac) found during 0.5 person-hour searches at each site; + indicates the presence of other unionid mussel species: *A. anatina* (Aa), *U. pictorum* (Up) and *U. tumidus* (Ut)

Site	Study year	Coordinates	Uc	Pc	Ac	Aa	Up	Ut
S1	2019	53°36'24"N 21°48'27"E	2			+	+	+
S2	2015	53°36'03"N 21°48'47"E	20	2		+	+	+
S3	2015	53°32'54"N 21°50'43"E	3		3	+		+
S4	2019	53°31'56"N 21°50'52"E	3	2		+	+	+
S5	2015	53°30'60"N 21°50'39"E	1				+	+
S6	2015	53°27'41"N 21°52'01"E	4			+	+	+
S7	2019	53°27'33"N 21°51'51"E	1			+	+	+
S8	2015	53°26'11"N 21°50'26"E	3			+		+
S9	2019	53°25'50"N 21°49'49"E	3			+	+	+
S10	2015	53°23'56"N 21°47'20"E				+	+	+
S11	2019	53°23'36"N 21°47'32"E	3			+	+	+
S12	2015	53°23'35"N 21°47'32"E	3			+		+
S13	2015	53°22'06"N 21°46'29"E	2			+	+	+
S14	2019	53°20'37"N 21°47'27"E				+	+	+
S15	2015	53°20'29"N 21°47'36"E						+
S16	2015	53°18'59"N 21°49'11"E	2				+	+
S17	2015	53°17'52"N 21°50'24"E	3					+
S18	2015	53°15'55"N 21°53'46"E	3			+	+	+
S19	2015	53°15'03"N 21°52'40"E	3			+	+	+
S20	2015	53°14'08"N 21°51'59"E	1			+		+
S21	2019	53°14'05"N 21°52'02"E	1	1		+	+	+



Fig. 2. The Pisa River at site S11 (August 2019). Photo: M. URBAŃSKA

8th annual ring (NAGEL et al. 2015), and individuals with four or fewer annual growth rings can be safely assumed to represent recent recruiters in the population. Thus, the findings of this study documenting the wide distribution and ongoing processes of population renewal indicate a favourable conservation status of *U. crassus* and point to the high conservation importance of the Pisa River.

The presence of *U. crassus* was not detected at sites S10, S14 and S15. At sites S14 and S15 the densities of all mussel species were low, with only single individuals of *A. anatina*, *U. tumidus* and *U. pictorum* found at site S14, and of *U. tumidus* at site S15. This contrasted strongly with other river stretches surveyed in this study, where abundant unionid mussel com-

munities were observed. Both these sites are within the river section close to Ciecioro village, where bank revetments were carried out in 2013 (Fig. 4). This suggests that even a relatively mild intervention in the river channel can have long-lasting negative effects on the unionid mussel communities.

P. complanata was found at three of the study sites. This species usually occurs at low densities and lives buried deep in the sediments (SAARINEN & TASKINEN 2003). As its detectability is generally low, the fact that it was found at three dispersed sites suggests that it probably also has a wide distribution in the Pisa River.

Unionid mussels show extensive inter- and intra-specific differences in their vertical distribution

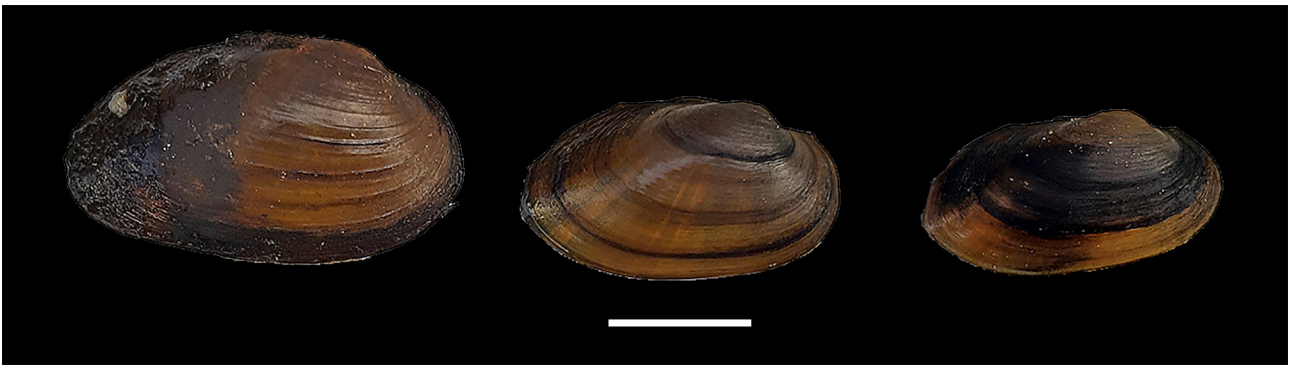


Fig. 3. *U. crassus* collected at site S11 (Ptaki on Pisa River, August 30th, 2019). Scale bar 20 mm. Photo: M. URBAŃSKA



Fig. 4. Riverbank revetments made up of armour rock in the vicinity of Ciecioro village (July 2014). Photo: A. KAMOŃKI



within sediments (SCHWALB & PUSH 2007, PFEIFFER & NAGEL 2010, ZIERITZ et al. 2014). In the 2019 survey, the majority of *U. crassus* and all *P. complanata* individuals were buried deep in the sediments, so that their siphons were not visible with an aquascope nor were they detectable by hand on the sediment surface. Such mussel behaviour may lead to an underestimation of their actual abundances.

CONCLUSIONS

The occurrence and favourable condition of *U. crassus* and *P. complanata* populations indicates a high conservation value of the Pisa River. This is further supported by the abundant occurrence of other unionid mussels: on the scale of Europe such multispecies mussel communities are increasingly rare, and need to be protected. The planned hydrotechnical works on the Pisa River are bound to have negative effects on the hydrology of the entire valley, and strong negative impacts on the ecological structure and functions of the habitats and species in the formally protected riverine ecosystems. In particular, the survival of the endangered species: *U. crassus* and *P. complanata* will be threatened.

Transformation of a natural river into a navigable waterway indispensably involves deepening of the river bed and straightening of the water course. Such river engineering has multiple, interconnected, often unintended and undesired socio-economic consequences, including increased downstream flooding risk, reduced fish productivity, and reduced aesthetic and recreational values (AUERSWALD et al. 2019). These consequences have to be considered and in-

cluded in the calculation of the costs of such investments. On the other hand, restoration of destroyed river habitats is complex, difficult and extremely expensive (AUERSWALD et al. 2019). Often the original state cannot be achieved, and only some of the ecosystem services can be recovered. Conserving high-quality near pristine habitats with their natural biodiversity and ecosystem processes is the best and the most cost-efficient option (GEIST & HAWKINS 2016). Protection of the endangered mussel species, especially *U. crassus*, which is strictly protected in Poland and in Europe, requires that no changes are introduced into the river channel. This provides an additional argument for preserving the Pisa River in its natural state.

ACKNOWLEDGMENTS

We thank two anonymous reviewers for their helpful comments. The study was carried out in full compliance with the ethical codes and legislation of the Republic of Poland.

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Received: October 22nd, 2019

Revised: December 2nd, 2019

Accepted: December 5th, 2019

Published on-line: February 21st, 2020

