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Short research contribution

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THE IMPORTANCE OF PEAT EXCAVATION WATER BODIES FOR BIODIVERSITY AND CONSERVATION: A CASE OF THREE UNIONIDAE (BIVALVIA) MUSSEL SPECIES

ABSTRACT: This paper presents populations of *Anodonta cygnaea* (L.), *Anodonta anatina* (L.) and *Unio pictorum* (L.) inhabiting an artificial pond (area 0.3 ha, depth 4 m) formed at a peat excavation site 13 years prior to the collection of the data. The mussels probably colonized the pond as glochidia attached to host fish introduced for angling or migrating with flood waters. The mussel populations were characterized by high densities, high average and maximum shell lengths and high proportions of young individuals. Our study shows that man-made ponds can become favorable habitats for freshwater mussels, and that relatively short time is needed to establish their viable populations. Active conservation of unionid mussels in man-made habitats may require human help at the dispersal stage.

KEY WORDS: *Anodonta cygnea*, *Anodonta anatina*, *Unio pictorum*, man-made ponds, invertebrate conservation, freshwater mussels

The fresh waters of the world are under immense and rapidly increasing human pressures. As a result, freshwater biota are highly endangered and their conservation faces huge challenges (Hillbricht-Ilkowska 1998, Strayer 2006). Until recently, scientific research, environmental protection and conservation efforts tended to focus on large water bodies, mainly rivers and lakes. There is however a growing recognition of the role of small and shallow water bodies. They have been shown to support a very high proportion of the total freshwater biodiversity present in a range of landscape types (Hillbricht-Ilkowska 1998, 2002, Williams *et al.* 2003, Davies *et al.* 2008a, 2008b). This concerns natural but also man-made water bodies in anthropogenically impacted landscapes. Some such water bodies were made specially for nature conservation (*e.g.* Williams *et al.* 2008), but most have other functions, from recreation or visual amenity to livestock watering or mineral extraction. Recent research has shown that such secondary habitats can contain rare and threatened plants and plant communities (*e.g.* Nowak *et al.* 2007) and efficiently sustain invertebrate diversity (*e.g.* Buczyński 1999, Wood *et al.* 2001, Lewin and Smoliński 2006, Céréghino *et al.* 2008). Man-made ponds and pools provide breeding habitats for amphibians, are used for breeding and/or feeding by many species of birds and their banks are inhabited by reptiles (*e.g.* Hazell *et al.* 2004, Santoul *et al.* 2004, Lewin and Smoliński 2006, Mazerolle *et al.* 2006, Williams *et al.* 2008). The general conclusion from those and many other studies is that artificial water bodies, by offering refuges for wild species, can significantly contribute to saving freshwater biodiversity.

Newly created fresh water habitats can be colonized very quickly by species with good dispersal abilities (Solimini *et al.* 2003, Mazerolle *et al.* 2006, Williams *et al.* 2008). Poor dispersers and species relying on passive transport usually take longer time. Sometimes the inability to reach a site excludes such species, even from very suitable habitats. This certainly concerns unionid mussels. They belong to the most imperiled freshwater animals (Lydeard *et al.* 2004). The reasons include habitat loss, point and nonpoint pollution, eutrophication, sedimentation and siltation of freshwater habitats (Piechocki and Dyduch-Falniowska 1993, Lydeard *et al.* 2004). Unionid mussels are exceptional in that their life cycle involves an obligate parasitic stage on the gills or fins of host fish. The consequence is that factors negatively affecting populations of host fish directly lead to reproductive problems in mussel populations. Also, as larvae (glochidia) attached to host fish are the only dispersive phase in the life cycle of unionid mussels, their dispersal depends primarily on the migration of fish.

In this paper we present a preliminary report on three species of unionid mussels: *Unio pictorum* (L.), *Anodonta cygnea* (L.), and *Anodonta anatina* (L.) which colonized a young artificial pond formed at a peat excavation site.

The study was carried out in an artificial pond originated as a peat pit dug in 1994. It is located in a flood terrace of a brook (N52°50′18″, E16°22′04″), local name Gulczanka, a left side tributary of the River Noteć. The pond is surrounded by extensively utilized meadows located within Notecka Forests (Puszcza Notecka). In 2007 the surface area of the pond was approximately 0.3 ha, and a maximum depth was about 4 m. The bottom was muddy with a thick layer of loose sediments; for recreational purposes part of the bottom was covered with sand. The banks were surrounded by emergent macrophytes: *Phragmites australis* (Cav.) Trin. ex Steud., *Typha latifolia* L., *Equisetum palustre* L., *Schoenoplectus* sp., and *Nymphea* sp. In deeper parts, *Cerathophyllum demersum* L. was very abundant. The pH of the water was 8.1, and calcium content was 57.8 mg L^{-1}. High values of those parameters are generally favorable for mussel growth. Low level of nitrogen (NO_2^- 0.023 mg L^{-1}, NO_3^- 0.0 mg L^{-1}, NH_4^+ 0.078 mg L^{-1}) reflects extensive agricultural use of the surrounding land. High phosphorus content (PO_4^{-3} 2.1 mg L^{-1}) may indicate some leakage from farm or household sewage permeating into ground waters. The conductivity of the water was 300 µS. Soon after the pond was filled with water, local anglers stocked it with fry of several fish species, including bream *Abramis brama* L., perch *Perca fluviatilis* L., and pike *Esox lucius* L. Throughout its existence, the pond was in moderate recreational use (bathing and angling).

We collected mussel samples in July 2007. In order to establish the densities and relative abundances of the species, we took samples from eight 1 m^2 plots using a 0.25 m^2 frame. We collected all the mussels within a frame by hand, visually and tactilely, wading and snorkeling. The pond had very steep banks so in most places collecting of the material was possible only close to the shore. The plots were placed along the shore of the pond, at distances of approximately 20 m from each other. We counted the mussels of each species and released them in the places they were collected. The qualitative sample used for measuring the shells and estimating age was collected from the most accessible part of the pond. There, the mussels were collected at random, visually and tactilely, by hand and hand net, wading and snorkeling to the depth of about 1m. We measured the length of shells of live mussels to the nearest 1 mm and estimated their age by counting external annual rings. Immediately after taking the measurements we released the mussels in the place of collection.

In the eight 1 m^2 plots we collected the total of 300 mussels. Overall, there were 161 (54%) individuals of *Anodonta cygnea*, 88 (29%) of *Anodonta anatina*, and 51 (17%) of *Unio pictorum*. *Anodonta cygnea* and *Anodonta anatina* occurred in all plots, *Unio pictorum* was present in only three of them. In places where *Unio pictorum* was present, the bottom was less muddy and at least partly covered with sand or gravel. The density of *Anodonta cygnea* ranged from 3 to 65 ind.

m^{-2}, *Anodonta anatina* from 1 to 28 ind. m^{-2}, and *Unio pictorum* from 5 to 17 ind. m^{-2}.

The densities we observed were rather high. In water bodies in the Pilica River flood terrace the maximum density recorded in *Anodonta cygnea* was 16 ind. m^{-2}, in *Anodonta anatina* 4 ind. m^{-2}, and in *Unio pictorum* 35 ind. m^{-2} (Abraszewska-Kowalczyk 2002). The average density of unionid mussels in Lake Mikołajskie was 0.4 ind. m^{-2}. Locally, the highest density was 7 ind. m^{-2} in 1972, and 4 ind. m^{-2} in 1987 (Lewandowski and Stańczykowska 1975, Lewandowski 1991). In the lakes along the Szeszupa River, the maximum density of *Anodonta cygnea* was 27 ind. m^{-2}, of *Anodonta anatina* 20 ind. m^{-2}, and of *Unio pictorum* 6 ind. m^{-2} (Lewandowski 1990). In Budworth Mere the maximum density of *Anodonta cygnea* was 22 ind. m^{-2} and of *Anodonta anatina* 6 ind. m^{-2} (Stone *et al.* 1982). High densities of *Anodonta anatina* (6–58 ind. m^{-2}) were observed in a eutrophic Norwegian lake (Ökland 1963). In special circumstances, such as the inflow of ground waters rich in humic substances, densities of unionid mussels can reach 256 ind. m^{-2} (Widuto and Kompowski 1968).

Mussel populations in our study were characterized by high average and maximum shell lengths (Table 1). Search and feel methods tend to be biased towards larger individuals (Miller and Payne 1988), so the average values in our study are probably overestimates. Maximum values, on the other hand, are independent of the collection method, and they also inform about the condition of populations. The maximum shell length of *Anodonta cygnea* recorded in our study was 200 mm. In this species, shell lengths reaching or exceeding 200 mm are known from historical records (Feliksiak 1930), but presently are found very rarely (*e.g.* Abraszewska-Kowalczyk 2002). Maximum shell lengths recorded in most of the recent studies range from 120 to 180 mm (*e.g.* Stone *et al.* 1982, Libois 1988, Lewandowski 1990, Müller and Patzner 1996, Aldridge 1999, Abraszewska-Kowalczyk and Przybylski 2005). The maximum shell length of *Anodonta anatina* in our study was 136 mm. In other populations of this species longest shells are often less than 100 mm (Lewandowski and Stańczykowska 1975, Lewandowski 1991, Saarinen and Taskinen 2003), and to our knowledge the greatest shell length recorded was 116 mm (Ökland 1963, Tudorancea 1972, Aldridge 1999). Similarly, the maximum shell length of *Unio pictorum* in our study (130 mm) was higher than any recorded earlier (*e.g.* Tudorancea 1972, Lewandowski 1990, Abraszewska-Kowalczyk 2002).

In all three populations young mussels predominated (Table 2); differences in age structures probably reflect actual differences among populations. There is also a possibility that they result from different detectability of young individuals in different species or from the fact that mistaking non-annual rings for annual ones is more likely in *Anodonta* species, especially *Anodonta anatina*. Although counting external annual rings is not a very reliable method of estimating mussel age (Neves and Moyer 1988), it is nevertheless widely used and for many purposes is sufficiently accurate (*e.g.* Müller and Patzner 1996, Aldridge 1999, Saarinen and Taskinen 2003). The data obtained in our study certainly allow to state that the proportions of young individuals were high, and the populations had favourable age structures.

The main result of this study is that unionid mussels, including endangered and protected *Anodonta cygnea* (Zając 2005, Dziennik Ustaw 2004), can inhabit recently formed artificial water bodies. High densities, large sizes and high proportions of young individuals recorded in the study pond indicate that such water bodies

Table 1. Shell length (mm) of *A. cygnea, A. anatina* and *U. pictorum* in the study pond.

Shell length	*A. cygnea* n = 263	*A. anatina* n = 183	*U. pictorum* n = 254
Mean	112.3	89.9	73.9
SD	31.7	23.1	15.1
Min.	41	51	33
Max.	200	136	130

Table 2. Age structure of *A. cygnea, A. anatina* and *U. pictorum* in the study pond.

Age	*A. cygnea* n = 263	*A. anatina* n = 183	*U. pictorum* n = 254
1–3 years	50%	64%	87%
4–5 years	40%	20%	12%
6–8 years	10%	16%	1%

can become very favorable mussel habitats, and a relatively short time is needed for establishing viable mussel populations.

In the face of the dramatic speed with which small and shallow natural water bodies disappear from the landscape (Hillbricht-Ilkowska 1998, Oertli *et al.* 2002), man-made habitats become valuable substitutes. Such habitats can efficiently sustain freshwater biodiversity, also when they were created for other purposes and have other functions than nature conservation (Wood *et al.* 2001, Céréghino *et al.* 2008). High proportion of regional freshwater biodiversity supported by ponds and other small water bodies combined with their typically small catchment areas put them amongst potentially the easiest and most cost-efficient types of water bodies to protect (Oertli *et al.* 2002, Davies *et al.* 2008b). Creation of new ponds along with the protection of existing ones can relatively quickly provide benefits for aquatic biodiversity at a landscape scale (Williams *et al.* 2003, Davies *et al.* 2008a,b, Williams *et al.* 2008).

Active conservation of unionid mussels may require human help at the dispersal stage, which involves migration of fish infected with glochidia. In our study, the fish infected with glochidia migrated with flood waters, or were introduced for angling. As we did not find any unionid mussels in the brook, the latter explanation is more likely. Release of mussels together with appropriate host fish and/or of fish infected with glochidia are routinely used in population augmentation and reintroduction programs of endangered mussel species (*e.g.* Neves 2004). Those methods can also be used to establish new populations of unionid mussels in man-made freshwater habitats, such as suitable ponds or mineral extraction pits.

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