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Letter to Editor

Occurrence of *Unio Crassus* (*Bivalvia, Unionidae*) Depending on Water Chemistry in the Foreland of the Polish Carpathians

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Abstract

Thick shelled river mussel *Unio crassus* (included in IUCN Red Data List) is a benthic, filter-feeding animal very susceptible to any changes of water chemistry. In this paper we report on the new sites of this species in the Małopolska region – an area of strong anthropogenic pressure. Physical and chemical parameters have been compared between 8 rivers inhabited and not inhabited by the mussel. Results indicate that despite economic development of the region, it retains clear rivers; however, subtle differences in water chemistry can influence the occurrence of this endangered species.

Keywords: *Unio crassus*, water quality, bioindicator

Introduction

Chemical pollution is considered to be one of the prime reasons for the reduction of biodiversity in aquatic habitats [1]. This is particularly important to freshwater molluscs of the family *Unionidae*, animals of relatively large biomass, feeding on particles filtered from water. Their ranges in developed countries are shrinking rapidly. This holds true for the Member States of the European Union [2], but also for the United States, a region of the highest species abundance of these animals where particular attention has been paid to stemming this process [3].

The reduction of distribution range and decrease in numbers of freshwater molluscs have been attributed chiefly to changes in the physical and chemical properties of water resulting from contamination by toxic substances such as heavy metals, or resulting from eutrophication [4, 5].

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One of the species that recently attracted the attention of scientists is the thick-shelled river mussel *Unio crassus*. In the past, it has been one of the dominant species in many Polish rivers, reaching very high densities (e.g. in the River Nida [6]) and in recent years its numbers have fallen dramatically, in line with the deterioration of water quality [7]. *U. crassus* was declared a species in need of strict protection and action to preserve its habitats throughout Europe in pursuance of *Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora*, Annexes II and IV. It was also placed on the IUCN World Red List as a species at risk of global extinction [8].

As this mollusc was found to be particularly susceptible to water pollution, it was added to the list of indicator species [bioindicators] as an indicator of clean waters, termed oligosaprobic within the so-called saprobic index [9, 10], or in the scale of susceptibility to water pollution which is based on the occurrence of aquatic molluscs [11, 12, 13].

Table 1. Chosen traits of the studied *Unio crassus* populations.

River name	Density	Mean lenght of shell [mm]	Mean age [years]*	N
Cedron	9 ind./m^2	56.4 (+SD=3.7)	5.32 (+SD=0.2)	78
Skawinka-Harbutówka	No shoals 7 ind./100 m section of river	57.28 (+SD=3.0)	4.7 (+SD=1.4)	76
Wilga	16 ind./m^2	47.06 (+SD=4.1)	5.0 (+SD=1.3)	12
Głogoczówka	No shoals 7 ind./100 m section of river	53.73 (+SD=5.1)	4.6 (+SD=1.1)	7

* 1-year old mussels were not detected by the applied method

The main habitat of *U. crassus* is the upper and middle reaches of clean streams and rivers which are shallow, with sandy-gravel or sandy bottoms and fast-moving clean water. In Poland, the populations of this mollusc are quite often isolated and scattered, and a considerable distance from each other. The objective of this study was to demonstrate the distribution of the species in the Carpathian foreland within the boundaries of the Małopolska voivodship, an area under very strong anthropogenic pressure.

Materials and Methods

Study Area

The studies covered 8 rivers and streams typical of the Carpathian foreland, which generally match the habitat requirements of the studied species. The watercourses were selected from among those which the Voivodship Inspectorate of Environmental Protection covers with tests of water quality. Highly polluted rivers or those with completely regulated beds were avoided. Within the Małopolska voivodship, the water courses studied included the Uszwica, Stradomka, Wilga, Cedron, Głogoczówka, Raba, Skawa and Skawinka-Harbutówka.

Methods

In all the rivers studied, a thorough search for *U. crassus* was conducted in those sections of the watercourses which best meet its habitat requirements, i.e. those of a natural character and far from any built-up areas. The search was continued until the first individuals of the studied species were found. In order to estimate the size of the stand of the species, the search was subsequently continued upstream and downstream up to the point where no more individuals were found (this was usually connected with alterations in the nature of the river bed, or with the presence of hydro-engineering structures). In small watercourses the searched stretches were ca. 100-200 m long (Wilga, Cedron, Skawinka).

The rivers in which mussels were not found had been checked along the course for 5-20 stages (depending on river size) of no less than several hundred meters in all places theoretically suitable for the species.

Because of the high susceptibility of *Unio crassus* to alterations in water chemistry [14], the extreme values of some selected indices of pollution in the watercourses inhabited and not inhabited by these molluscs were analyzed for a period of three years preceding the studies. The analysis was based on the data obtained from the Voivodship Inspectorate of Environmental Protection in Kraków, covering the period 1999-2001 and six measurements every year. The following physicochemical parameters: ammonia levels, nitrates, nitrites, phosphates, mercury, lead, cadmium and dissolved oxygen content in water, as well as pH, suspended solids, BOD_5, saprobic index and electrolytic conductance). The differences between the rivers inhabited by *U. crassus*, compared with those uninhabited by the mussels, were submitted to analysis of variance controlled for the influence of year and month. In the case of phosphate content in water, logarithmically transformed data were used in statistical calculations in order to approximate the normal distribution of the data. If the distribution of the data deviated from the latter (for cadmium, lead and mercury content in water, and for electrolytic conductance), the significance of differences between the watercourses inhabited by thick shelled river mussel and those where the molluscs were not found was tested by using logistic regression examining the relationship between a binary value (1 – presence, 0 – absence of *U. crassus*) and an independent variable: the content of the studied component in water, controlling for the influence of the year and month in which the sample was taken.

Results and Discussion

Occurrence

Living individuals of thick-shelled river mussels were found in the following rivers: Wilga, Głogoczówka, Cedron and Skawinka-Harbutówka (Table 1). *U. crassus* was not found in the Uszwica, Stradomka, Raba and Skawa rivers. The occurrence of this species in these localities seems to be of minor importance to the protection of

Table 2. Differences in water quality parameters between rivers inhabited and uninhabited by *Unio crassus*.

Parameter	Unit	Without Unio crassus			With Unio crassus			Statistics
		average	from	to	average	from	to	
Electrolytic conductance in 20°C	µS/cm	360.51	248.9	473.0	1282.57	409.3	3003.5	B=0.007, W=7.53, p<0.007
Phytoplankton saproby	saprobic index	1.97	1.9	2.1	2.42	2.3	2.5	F(1.84)=126.8, p<0.0001
BOD_5	mg O_2/l	2.43	1.9	2.8	2.92	2.8	3.44	F(1.84)=4.13, p=0.045
Mercury	mg Hg/l	0.00004	0.000	0.038	0.00005	0.000	0.000	B=-85594, W=0.0003, p<0.98
Lead	mg Pb/l	0.0005	0.000	0.001	0.0008	0.000	0.001	B=113, W=0.81, p<0.37
Cadmium	mg Cd/l	0.0010	0. 000	0.003	0.0001	0.000	0.000	B=-1253, W=7.8, p<0.005
Phosphate	mg PO_4/l	0.078	0.03	0.11	0.196	0.11	0.35	F(1.108)=54.8, p<0.0001
Nitrate	mg NO_3/l	1.51	1.2	1.9	1.61	0.9	2.6	F(1.108)=6.88, p=0.01
Nitrite	mg NO_2/l	0.026	0.01	0.05	0.047	0.01	0.11	B=15.0, W=9.6, p<0.002
Amonium	mg NH_4/l	0.20	0.105	0.297	0.48	0.089	1.215	B=57.4, W=22.2, p<0.0001
Suspended solids	mg/l	39.17	8.8	68.3	20.77	10.2	35.8	F(1.108)=3.31, p=0.07
pH	pH	7.853	7.64	8.21	8.001	7.94	8.17	F(1.108)=10.5, p=0.002
Dissolved oxygen	mg O_2/l	10.18	9.3	11.3	10.51	10.0	11.2	F(1.108)=2.29, p=0.13

8 rivers were studied during 3 years, with 6 samples per year. Phytoplankton saproby and BOD_5 were not measured in Skawa and Głogoczówka. B - parameter estimate in logistic regression, W – Wald statistics, F – ANOVA, df in brackets

the species throughout Poland. Within the national territory there are many populations of *U. crassus* with much higher population densities, found chiefly in the northern part of the country. Compared with these northern populations, those found in the study area are relatively small. It should be noted, however, that they occur here at the limits of their vertical distribution and represent a specific ecotype.

Water Chemistry

The rivers included in this study had very low concentrations of heavy metals (Table 2). The concentrations of mercury and lead did not deviate statistically significantly between the watercourses inhabited by thick-shelled river mussel, while cadmium concentration was significantly higher in the courses from which the mussels are absent (Table 2). The data thus indicate that there is no potential threat from contamination by lead or mercury while cadmium might represent a certain danger, at least of potential significance.

Nutrient content (N, P) was also very low. In this case, however, there were significant differences between the watercourses inhabited by mussels which had clearly higher concentrations of phosphate, ammonium, nitrate and nitrite ions than the corresponding concentration waters uninhabited by mussels (Table 2). Thus, in generally clean foreland rivers, mussels thrive more in nutrient-rich waters.

The pH of water preferred by *Unio crassus* was slightly alkaline. In the watercourses covered by this study, this species was also found to occur in waters with slightly increased electrolytic conductivity (Table 2).

The inhabited and uninhabited rivers did not differ in terms of oxygen saturation, because they all have a fairly steep slope and turbulent flow, supporting maximum oxygenation.

The populations of thick-shelled river mussels found during the study live in unpolluted waters which can be classified as oligosaprobic. In general, *U. crassus* prefers waters which are not eutrophicated and pollution-free; and may thus be legitimately considered to be an indicator species for such water, all the more since studies of German populations indicate that the species avoids higher NO_3^- concentrations - healthy populations inhabiting waters where nitrate levels are below 10 $mg \cdot l^{-1}$ [15, 16]. The studies from Germany of interstitial water (i.e. water caught in the substrate of structural elements of the river bed bottom) in the sites where *U. crassus* occurs, showed that near the bottom (i.e. nearest to flowing water) their composition is very similar to the waters inhabited by *U. crassus* in our study area. The similarities are most striking in such parameters as nitrate, nitrite, and phosphate content [17]. Another significant correlation identified is between the occurrence of *U. crassus* and total organic carbon content in the water [15]. Populations in good condition (indicated by a healthy the proportion of young individuals) inhabit watercourses with significantly higher levels of organic carbon ($0.7>TOC>1$ mg $\cdot l^{-1}$).

However, all the stages of watercourses studied in Małopolska, including those where the mussels were not found, are fairly unpolluted (class II and III under *Ordinance of the Minister of Environment of 11 February 2004; Dziennik Ustaw [Journal of Laws] No. 32 of 2004; item 284)*. These are waters of satisfactory quality, which meet the requirements for surface waters used to supply the population with water potable after treatment and manifest only a moderate impact of anthropogenic effects with respect to biological indicators.

The results also make it possible to state that among the foreland rivers studied, *U. crassus* shows a distinct preference for waters with slightly elevated levels of phosphates and nitrogen compounds (ammonium, nitrate and nitrite ions). The preferred waters also have higher BOD_5 (i.e. they are slightly richer in organic matter) and a higher saprobic index. The data support the conclusion that these waters are somewhat more nutrient-rich than those foreland watercourses where the mussels have not been found. Thus it seems that among the rivers studied, *U. crassus* prefers waters slightly richer in nutrients.

In conclusion, it can be stated that in foreland watercourses *U. crassus* occurs in waters which are more nutrient-rich but pollution-free. Although these waters are fairly similar in terms of their physical and chemical properties, the occurrence of *U. crassus* may be determined by subtle differences in trophic levels. Thus its populations will function well when the parameters of the aquatic environment stay within certain optimum ranges. It is likely that extremely nutrient-poor, oligotrophic waters do not support the occurrence of this species.

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