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Distribution of the freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus 1758) in Latvia in relation to water quality

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Abstract

The aim of the present work was to update the distribution of the freshwater pearlmussel *Margaritifera margaritifera* in Latvia. From 1999 to 2003 a total length of about 610 km was surveyed in 163 rivers. The distribution of the species in Latvia is about 40 km of river-parts in eight rivers, with a mussel population of about 25,000 individuals. In six rivers only shells and parts of shells were found indicating that populations occurred here previously and had become extinct. All the Latvia's pearl mussel populations are aging, but the pearl mussels are healthy and able to reproduce. Chemical analyses of water samples showed that the quality of water in Latvian pearl mussel rivers is considerably worse than in other countries where viable populations are found. Therefore, we can expect a rapid population decline and loss during the next 10 - 50 years. The populations could be maintained if the conditions in the rivers were improved for the survival of young pearl mussels.

Key words: ecology, distribution in Latvia, *Margaritifera margaritifera*, water quality.

Introduction

The freshwater pearl mussel *Margaritifera margaritifera* is probably the most abundant bivalve worldwide (Araujo, Ramos 2000). The freshwater pearl mussel has a holarctic circumpolar distribution. In Europe it is now largely restricted to the northern highland zone, to 71° N in Norway (Kerney 1999). It is distributed in the northern part of Asia and the northeastern part of North America (Zadin 1952).

M. margaritifera is a typical oligotrophic water species. Changing the environmental conditions usually endangered the most highly specialized species. *M. margaritifera* is decreasing not only in Latvia but also in its whole geographical distribution (Bauer 1988). In Europe it occurs only in mountain regions, but in the lowlands between agricultural lands and in urbanized areas all of the populations have disappeared (Kinkor et al. 1996; Erikson et al. 1998; Araujo, Ramos 2000).

In spite of rather good survival strategy of *M. margaritifera*, its complicated cycle of development, in which the glochidia must go through a phase of parasitic development, and highly specialized adaptation for living in oligotrophic conditions, make pearl mussel populations especially sensitive against changes in the environment. Therefore, *M. margaritifera* is a very important bioindicator of the general level of pollution (Bauer 1988; Cimdins et al. 1995; Hruska, Bauer 1995).

Already in 1855, E.Wahl (Wahl 1855) wrote that in Latvia's pearl mussel rivers, economic activities on and around the rivers will lead to, if not complete extinction of the species, then certainly to restriction in the pearl mussel to population size, as in ancient pearl fishing times. During the1920s and 1930s the number of pearl mussel populations had decreased because of intensive pearl mussel extraction during the previous centuries (Kawall 1872; Eke 1925; Meder 1925; Pētersons 1933; Schlesch 1942). An action plan for *M. margaritifera* in Latvia and a strategy for conservation of this species was prepared in 1999 (Rudzīte 2001), but full data about its distribution was not clear.

The goal of the work was to update the distribution of the pearl mussel in Latvia.

Materials and methods

The method used was total survey of the whole riverbed and total counts of all mussels. The river were investigated under suitable weather conditions – periods of low water in the river, sunny or partly cloudy weather. The parts of rivers were surveyed in the whole length by walking on the riverbed. Special attention was paid to the deepest parts of the river and disturbance of the surface water layer was avoided as much as possible. Additionally, polaroid glasses and optical underwater tubes were used. In this way the whole riverbed can be observed and all pearl mussels could be found.

From 1999 to 2003 the distribution area of pearl mussel populations and rivers where pearl mussels could be expected were surveyed. At present, two thirds of the areas where pearl mussel populations were possible, according to historical data (Fischer 1791; Groschke 1805; Kawall 1872; Braun 1884; Riemschneider 1908; Eke 1925; Meder 1925; Pētersons 1933; Schlesch 1942), have been checked. Previous investigations by students at the Department of Zoology and Animal Ecology of the Latvian University (V. Bernards, K. Krišāns, I. Maksimova, A. Tukiša, unpublished data) and collections at the Museum of Zoology of the Latvian University were summarized.

All rivers in the Gauja National Park were surveyed in 2000, the Northern Vidzeme Biosphere Reserve in 2002, and in part of the Daugava basin in 2003 (Table 1, Table 2). Data in the Table 2 differ from those published earlier (Rudzīte 2001) due to additional

Table 1. Research conducted in the rivers frm 1999 to 2003. Information is available from a total 610 km length of rivers surveyed during 1999 - 2003

Year	Territory	Surveyed parts of rivers (total km)	Counting of pearl mussels (total km)
1999	Separate places in previously known rivers and surroundings	~ 35	~ 16
2000	Gauja National Park	~ 63	0.3
2001	Investigation of pearl mussel populations and river basins in known areas	~ 87	~ 36
2002	North Vidzeme Biosphere Reserve	147 (59 rivers)	-
2003	A part of the Daugava basin rivers	93 (28 rivers)	~ 12

Table 2. Number of pearl mussels and their shells in populations surveyed from 1999 to 2003. *, data is incomplete, the number of pearl mussels may be larger

Basin	River	Number of pearl mussels and found shells	Years of research
Gauja river	Ludze	20 000	1999 - 2001
basin	Rauza	3 000	1999 - 2001
	Pērļupe (tribulary of Amata)	570	1999 - 2003
	Dadžupe	200	2000, 2003
	Dzirnupe (tribulary of Amata)	20	2000, 2003
	Strīķupe	0	2000, 2001
	Meļļupīte	0	2000
	Lenčupe	Fragments of shells	1999
	Abuls	0	2000
	Pērļupe (tribulary of Gauja)	0	2000
Daugava	Tumšupe	1200	1999, 2001, 2003
river basin	Pededze	30*	1999
	Mergupe	7*	2002, 2003
	Vedze	Shells	1996
	Paparze	Fragments of shells	1999
	Veseta	Shells	2003
	Zaube	Shells	2003
Salaca river	Aģe	Shells	2002
basin and	Korģe	0	2002
Northern	Iģe	0	2002
Vidzeme	Pērļupe (tribulary of Svētupe)	0	2002
rivers of	Ķīšupe	0	1985
Gulf of Riga	Pēterupe	0	1985

survey since 2001.

From 1999 to 2003 a total length of about 610 km of rivers was surveyed.

The distribution area of pearl mussels is about 40 km river length. In some places counting was repeated, therefore the actual distance where counting was conducted was greater (64 km) than the length of the river parts with pearl mussel populations. Systematically and completely 108 rivers were survived, and information was summarized about fragmentary investigations in 55 rivers.

The following maps were used in describing the distribution: Latvia Republic Satellite map (scale 1:50,000); Soviet Union army topographic maps (scales 1:50,000 and 1:10,000). Information on water chemistry was obtained from the Regional Environmental Boards in Valmiera and Lielrīga.

Results and discussion

According to the literature (Fischer 1791; Kawall 1872; Braun 1884; Riemschneider

1908; Eke 1925; Meder 1925; Pētersons 1933; Schlesch 1942) the former pearl mussel distribution in Latvia included Vidzeme and the northwestern part of Latgale. There is only one report about a pearl mussel in Kurzeme, in the river Durbe (Groschke 1805).

From all the surveyed rivers, 23 were chosen (Table 2), which correspond at least to one of the following conditions: there is a pearl mussel population in the river at present; there are no live pearl mussels found, but only shells or there is information from the literature or shells in museum collections that confirm that pearl mussels have been there. The most important collection used was collected by R. Kampe during the 1920s and 1930s, which is currently housed in the Museum of Zoology of the Latvian University. River were not included, if a large part of the river was straightened, destroying the natural habitats where pearl mussels could live, even if the river was mentioned in the literature.

At present, pearl mussels in Latvia have been found in eight rivers (Table 2). In six other rivers shells and fragments of shells have been found (Fig. 1).

In the Gauja river basin, local populations occur in five rivers: Dadžupe in about 800 m, Dzirnupe in about 200 m, Pērļupe (tributary of Amata) in about 2 km, Rauza in about 24 km, Ludze in about 7 km. In Daugava basin *M. margaritifera* occurs in Tumšupe in about 4 km, and about 1 km of Mergupe.

The total distribution of the species in Latvia is about 40 km of river-parts, with total number of mussels of about 25,000. Of the 108 totally surveyed rivers, only eight still contain pearl mussel populations. Only shells and parts of shells found in six rivers proved the populations now are extinct. In about nine other rivers there is enough evidence to conclude that populations did occur and that they have became extinct (Table 2). In the remaining 85 surveyed rivers, there is no evidence of the species, but nevertheless these rivers lay in the described pearl-extraction area (Fischer 1791; Kawall 1872; Braun 1884; Riemschneider 1908; Eke 1925; Meder 1925; Pētersons 1933; Schlesch 1942). Probably, the populations became extinct long ago and therefore even parts of shells can not be found.

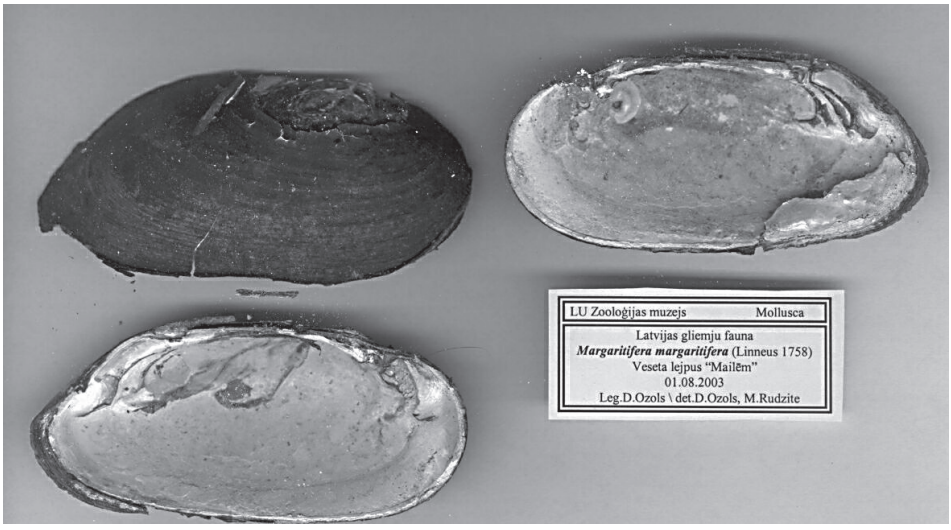

Fig. 1. Pearl mussel shells found in 2003 in the river Veseta.

Table 3. Nitrogen and phosphorus concentrations in river water in different pearl mussel populations in Latvia and Europe. Data obtained from the Latvian Regional Environmental Boards in Valmiera and Lielrīga in 2001 and published literature from Ireland, Norway and Austria (Lande, Lande 2000; Moorkens et al. 2000). n.d., not determined

Populations	Dissolved oxygen (% sat.)	Conductivity (μS cm^{-1})	Oxidised nitrogen (mg l^{-1})	Total ammonia (mg l^{-1})	Total nitrogen (mg l^{-1})	Ortho-phosphate (mg l^{-1})
Ireland	min 9.0	max 1.7	max 1.7	max 0.1	n.d.	max 0.12
	(mg l^{-1})	65 - 129	0.04 - 1.3	0.015 - 0.03		0.005 - 0.06
Norway	n.d.	15.5 - 271	n.d.	n.d.	0.21 - 0.52	0.002 - 0.1
Austria	98 - 131	91 - 110	0.9 - 1.4	< 0.01	n.d.	0.009 - 0.014
Ludze	87 - 95	336 - 367	max 0.007	max 1.17	max 1.38	max 0.024
			med 0.0065	med 0.82	med 0.99	med 0.022
Pērļupe	89	325	0.083	2.07	2.19	0.023
Rauza	77 - 97	368 - 399	max 0.015	max 1.21	max 1.22	max 0.058
			med 0.001	med 0.6	med 1.00	med 0.043
Tumšupe	n.d.	n.d.	max 0.039	max 1.43	max 4.76	max 0.018
			med 0.037	med 1.35	med 3.83	med 0.013

In a previous study of the age structure of the population (Rudzīte 2001) it was found that younger age classes were not represented in any of the populations, meaning that all populations were in the phase of aging. However, the pearl mussel glochidia larva phase has been observed on the gills of young salmonids (Rudzīte, unpublished data).

Pearl mussel health can be estimated by the ability to push out a water trickle, when taken out of water (Bischoff et al. 1986; Baer 1995), as this means pearl mussels are healthy and able to reproduce. This was monitored in all the surveyed populations.

In researche conducted in Germany, it was found that young pearl mussel survival requires a low concentration of nitrogen in the water (Buddensick 2001). In Norway populations with young pearl mussels were found only in rivers with a very low nitrogen concentration (Lande, Lande 2000). The optimal pearl mussels water quality has been estimated: "Towards a margaritiferid water quality standard" (Moorkens et al. 2000).

Comparing the chemical parameters in rivers of Latvian populations with those in Ireland, Norway and Austria (Table 3, Lande, Lande 2000; Moorkens et al. 2000) where the young pearl mussel survival is normal, in Latvia there are significantly increased ammonium, total nitrogen, and phosphorus concentrations and conductivity (Table 3). The amount of dissolved oxygen in water is also low (Table 3).

Thus, water quality in the Latvian pearl mussel rivers is substantially worse than necessary for the survival of pearl mussels.

Aging of populations has been observed not only in Latvia but also in Europe (Kinkor et al. 1996; Erikson et al. 1998; Araujo, Ramos 2000; Moorkens et al. 2000). According to the present age structure of populations (Rudzīte 2001), we may forecast a rapid population decline and loss during the next 10 - 50 years. However Latvia's pearl mussels are not so old to exclude reproduction. Populations could be established and maintained if the conditions in the rivers were improved for the survival of young pearl mussels.

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Margaritifera margaritifera **(Linnaeus 1758) izplatība Latvijā saistībā ar ūdens kvalitāti**

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Kopsavilkums

Pētījuma mērķis bija noskaidrot ziemeļu upespērlenes *Margaritifera margaritifera* izplatību Latvijā. Laika periodā no 1999. gada līdz 2003. gadam apsekoti upju posmi 163 upēs ar kopējo garumu 610 km. Sugas areāls Latvijā aizņem nedaudz vairāk par 40 km upju posmu astoņās upēs. Uzskaitēs konstatētais gliemeņu kopskaits ir ap 25 000 eksemplāru. Sešās upēs konstatētas čaulas un to fragmenti, kas ir pierādījums tam, ka populācijas tajās ir bijušas, bet iznīkušas. Visās Latvijas pērleņu atradnēs konstatētas populācijas novecošanas stadijā. Ūdens ķīmisko analīžu salīdzinājums parāda, ka Latvijas pērleņu upēs ūdens kvalitāte ir ievērojami sliktāka kā vietās, kur dzīvo populācijas, kas nav novecošanas stadijā. Latvijas upespērlenēm draud iznīkšana tuvāko 10 - 50 gadu laikā. Tomēr populācijas varētu atkal atjaunoties, ja upēs būtu pērleņu mazuļu izdzīvošanai labvēlīgi dzīves apstākļi.