Acta Universitatis Latviensis, 2005, Vol. 691, Biology, pp. 121–128

Assessment of the condition of freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus 1758) populations in Latvia

Mudīte Rudzīte*

Museum of Zoology, University of Latvia, Kronvalda Bulv. 4, Rīga LV-1586, Latvia
*Corresponding author, E-mail: mudite.rudzite@lu.lv

Abstract

The freshwater pearl mussel *Margaritifera margaritifera* is a species threatened throughout the world. Pear mussel populations in Latvia were assessed using criteria developed in Sweden. The population size, distribution and density of the four largest *Margaritifera margaritifera* populations in four rivers were determined. For the estimation of pearl mussel population age structure, classes of mussel shell length were used. The most important threat was from dams and other beaver activities, which decreased the viability of the pearl mussel population. Two of the pearl mussel populations of Latvia, according to the Swedish scoring system, correspond to class II with a high nature conservation value, five populations to class I with a lower nature conservation value, and none to the class III, a very high nature conservation value.

Key words: conservation value, *Margaritifera margaritifera*, Latvia, population age structure.

Introduction

Freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus 1758) is a species threatened of becoming extinct throughout the world. Populations with normal chance of reproduction can be found only in a few locations (Araujo, Ramos 2000; Bauer 1989). It is generally accepted that the condition of the European pearl mussel populations are declining due to the isolation of separate local populations (Geist, Kuehn 2005).

The freshwater pearl mussel populations of Latvia are also completely isolated between each other. The pearl mussel populations of Latvia were surveyed in 1999 and 2000. The populations are in the ageing phase (Rudzite 2001; Rudzite 2004). Possible reasons of the population decline are: pearl fishing in the 17th and 18th centuries; eutrophication and siltation of the rivers caused by intensive agriculture during the 1950s and 1960s, and drainage management. In all of the known pearl mussel populations in Latvia, the water quality is too low for the survival of juvenile pearl mussels (Rudzīte 2004). An additional threat to the mussel populations of Latvia is the activities of European beaver *Castor fiber* L. – a reintroduced species in Latvia. Beavers were reintroduced since 1927, and during the Soviet period their dispersal was specially planned and stimulated (Balodis 1990). During recent years, beavers have spread to all of the pearl mussel rivers.

Six criteria are used to assess the long-term viability of the *M. margaritifera* population used in Sweden (Erikson et al. 1998): (i) population size; (ii) population density; (iii)

distribution – length of stream or river inhabited by a coherent population; (iv) smallest size of found mussel; (v) the proportion of mussels shorter than 2 cm; (vi) the proportion of mussels shorten than 5 cm. Each criterion is scored 0 to 6 points. It is desirable to develop the model and test it on other mussel populations, in Sweden as well as in other countries (Erikson et al. 1998).

In Latvia it is necessary to determine the density of the population and population age structure for evalution of the conditions of the pearl mussel populations of Latvia. For this purpose, the criteria worked out in Sweden (Erikson et al. 1998) was used, which was previously applied only in Sweden. The aim of the present paper was to evaluate the conditions of seven pearl mussel populations in Latvia and to estimate their probability of survival.

Materials and methods

From 1999 to 2004 pearl mussels in seven rivers were studied using the method of total counting of mussels, where all the mussels were counted in a part of the particular river (Rudzīte 2001; Rudzīte 2004). This method is also used in Sweden (Erikson et al. 1998). In four of the largest populations, in Pērļupe, Ludze, Tumšupe, Rauza, the census was done in a five-meter-long river stretches selected in the middle part of the population area . In every stretch, the average river width was measured and all the mussels where counted. The population density (mussels per m^2) for every single river part was calculated. For the whole river, the average population density, standard deviation and standard error were calculated. In three smaller populations, found in the rivers Dadžupe, Dzirnupe, Mergupe, the density of populations was calculated using the total number of mussels and the average river width. The length of the river was estimated from topographical maps 1:10 000.

For the estimation of pearl mussel population age structure, classes of mussel shell length were used, according to the method of Erikson et al. (1998). Sliding calliper and ruler were used for measuring. In total, 2731 mussels were measured in the Rauza river basin.

There are six criteria of importance regarding sustainability of long-term viability of the pearl mussel population in Sweden. Each criterion is scored 0 to 6 points (Erikson et al. 1998; Table 1).

Table 1. Criteria and scores for the assessment of nature conservation value for *Margaritifera margaritifera* populations (Erikson et al. 1998)

No	Criterion	Score (points)					
		1	**2**	**3**	**4**	**5**	**6**
1	Population size (× 1000)	<5	5 - 10	11 - 50	51 - 100	101 - 200	>200
2	Mean density (mussels m^{-2})	<2	2 - 4	4.1 - 6	6.1 - 8	8.1 - 10	>10
3	Distribution (km)	<2	2 - 4	4.1 - 6	6.1 - 8	8.1 - 10	>10
4	Smallest mussel found (cm)	>50	41 - 50	31 - 40	21 - 30	11 - 20	≤10
5	Proportion of mussels <2 cm (%)	1 - 2	3 - 4	5 - 6	7 - 8	9 - 10	>10
6	Proportion of mussels <5 cm (%)	1 - 5	5 - 10	11 - 15	16 - 20	21 - 25	>25

Table 2. The density of *Margaritifera margaritifera* populations in four rivers of Latvia

River	Mean width of the surveyed part (m)	Surveyed area (m^2)	Individuals found (number)	Population density (mussels m^{-2})		
				Mean	Minimum in 5-m strech	Maximum in 5-m strech
Pērļupe	3.6	545.1	112	0.21	0	1.51
Ludze	7.9	1190.0	2584	2.17	0.32	6.26
Tumšupe	7.0	1047.5	318	0.30	0	1.96
Rauza	8.8	1313.0	1486	1.13	0.06	2.99

With reference to the total number of points, the populations are classified, to evaluate their conservation value. The total number of points is used for classifying the investigated mussel populations into three classes. A score at 1 to 7 points indicates class I "Site of nature conservation value", 8 to 17 points – class II "High nature conservation value", and 18 to 36 points – class III "Very high nature conservation value" (Erikson et al. 1998). The values of long-term viability criteria were calculated and the overall population condition was assessed for seven pearl mussel populations in Latvia.

The following maps were used: Latvia Republic Satellite map of scale 1 : 50 000, the Soviet Union army topographical maps of scale 1 : 50 000 and 1 : 10 000.

Results

The density of *Margaritifera margaritifera* was determined for the four largest populations, in four rivers. The recording was conducted in 5-meter-long stretches. The mean width and surveyed area in the four investigated rivers varied from 3.6 m and 545.1 m^2 to 8.8 m and 1313.0 m^2, respectively (Table 2). The lowest number (112) of mussel individuals was found in Pērļupe and the highest (2584) was found in Ludze, which also had the highest population density (0.32 to 6.26 mussels m^{-2}, mean 2.17 mussels m^{-2}, in 5-m stretches). In Pērļupe the mean density was 0.21 mussels m^{-2}, in Tumšupe 0.30 mussels m^{-2}, and in Rauza 1.13 mussels m^{-2} (Table 2). Additional study was carried out on the population age structure in the middle part of Rauza population (Rauza A, Fig. 1), in the lower reaches of the river (Rauza B, Fig. 1), as well as at the middle of the tributary (Ludze A, Fig. 1) and at the upper reaches inhabited by beavers (Ludze B, Fig. 1).

The upper part of Ludze river is strongly affected by beavers. The beaver dams cause silting, warm water, increased eutrofication and shading. There is a lower influence of beaver in the other three parts.

Seven pearl mussel populations of Latvia here evaluated using the population criteria developed in Sweden (Erikson et al. 1998; Table 1). The average *M. margaritifera* population density in Latvia was 0.58 mussels m^{-2} (Table 3). The maximum observed density was 2.27 mussels m^{-2}, and the lowest – less than 0.00001 mussels m^{-2}. None of the pearl mussel populations corresponded to the third class, two corresponded to the second class, with a good viability level and probability of survival (Table 4). The others corresponded to the first class and their existence is endangered.

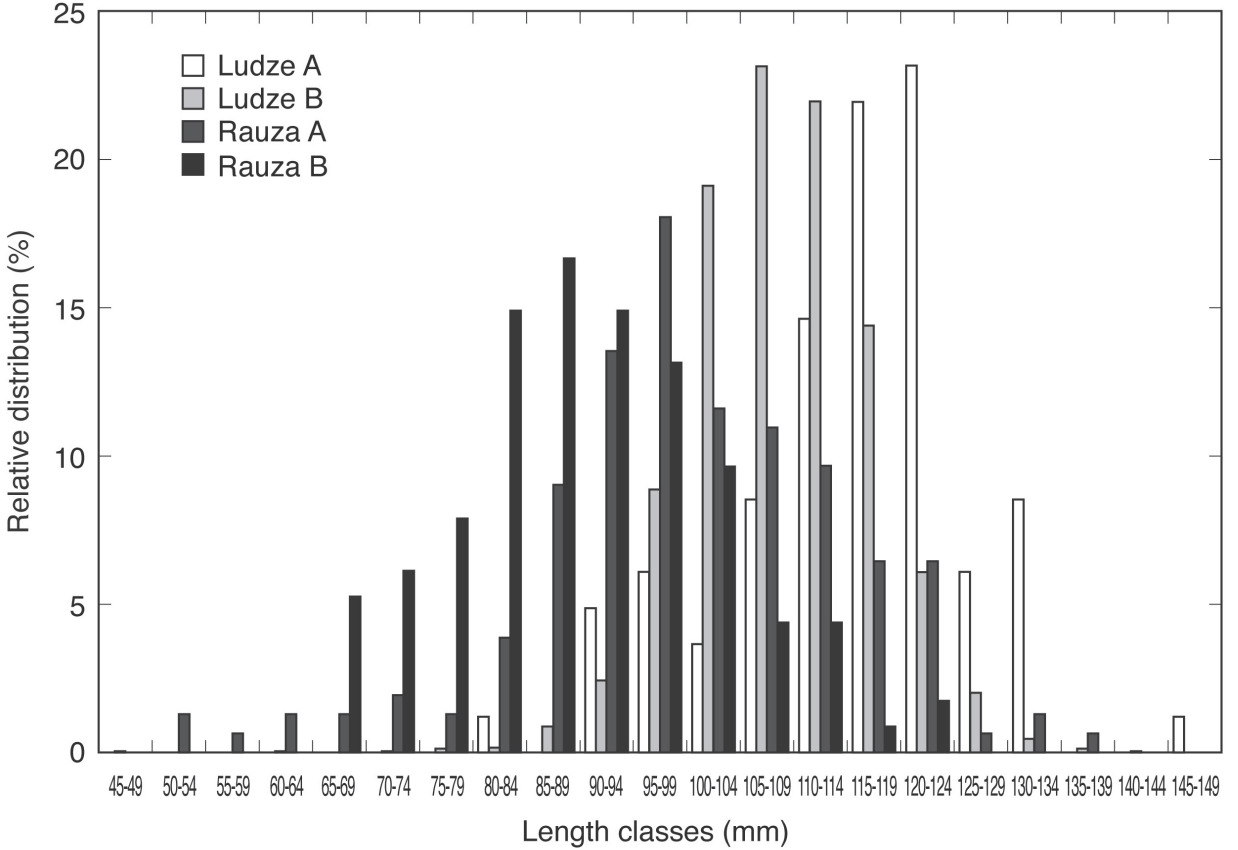

Fig. 1. The population age structure of *Margaritifera margaritifera* in Rauza river basin (in length classes). Ludze A - upper part of Ludze river; Ludze B - lower part of Ludze river; Rauza A - upper part of Rauza river; Rauza B - lower part of Rauza river. Classes of length were used, because there is a linear connection between the age of individuals and their length (Eriksson, et al. 1998).

Table 3. The characteristics of *Margaritifera margaritifera* populations in seven localities of Latvia

No	Criterion	Pērļupe	Ludze	Tumšupe	Rauza	Dadžupe	Dzirnupe	Mergupe
1	Population size	570	20000	1200	3000	200	20	7
2	Mean density	0.21	2.17	0.30	1.13	0.01	0	0.00001
3	Distribution (km)	2	7	4	24	2.5	1.2	1
4	Smallest mussel found (cm)	8.4	4.8	6.3	5.3	8.6	7.6	7.0
5	Proportion of mussels < 2 cm (%)	0	0	0	0	0	0	0
6	Proportion of mussels < 5 cm (%)	0	0	0	0	0	0	0

Table 4. The assessment of seven pear mussel *Margaritifera margaritifera* populations of Latvia after the population evaluation system used in Sweden (Erikson et al. 1998)

No	Criterion	Pērļupe	Ludze	Tumšupe	Rauza	Dadžupe	Dzirnupe	Mergupe
1	Population size (× 1000)	1	3	1	1	1	1	1
2	Mean density (mussels m^{-2})	1	2	1	1	1	1	1
3	Distribution (km)	1	4	2	6	2	1	1
4	Smallest mussel found (cm)	1	2	1	1	1	1	1
5	Proportion of mussels < 2 cm (%)	0	0	0	0	0	0	0
6	Proportion of mussels < 5 cm (%)	0	0	0	0	0	0	0
	Total points	4	11	5	9	5	4	4
	Class	I	II	I	II	I	I	I

Discussion

From 1999 to 2004 about two-thirds of the former pearl production area in Latvia (Rudzīte 2004) was surveyed systematically. None of the pearl mussel populations demonstrated good probability of survival, as they did not correspond to the third class in the population evaluation system. Additionally, all populations were in the aging phase (Rudzīte 2001).

The most aged populations were found in the localities with a beaver population (Ludze A, Fig. 1). The poor conditions likely existed already 60 to 70 years ago as this river is one of the first beaver reintroduction locations (Balodis 1990).

The population density of pearl mussels in Latvia is very low compared with the typical population density of 1000 to 2000 mussels m^{-2} (Baumgärtner, Heitz 1995). In Sweden, for

example, the maximum density is 33.7 mussels m^{-2}, and minimum 0.2 mussels m^{-2}, with a mean value 5.2 mussels m^{-2} (Erikson et al. 1998). However, other studies in Sweden mention population densities as low as 0.032 and 0.045 mussels m^{-2}, compared to a mean 0.52 mussels m^{-2} in Central Europe (Bauer 1988). In Finland, 100 mussels m^{-2} is a high density (Valovirta 1998). In Sweden, a high density of population is considered to be above 10 mussels m^{-2}, which corresponds to a value of 6 points (Erikson et al. 1998; Table 1). In Latvia there is only one population with a population density corresponding to two points, and the others – only one point (Table 3, Table 4). The condition of the two most highly valuable populations – in Rauza and its tributary Ludze – differ. The Rauza population is smaller but occupies a larger part of the river than the population in the tributary, which supports the smallest, youngest pearl mussels in Latvia (Table 4).

By 1999, beavers have dispersed to all freshwater pearl mussel rivers of Latvia (Rudzīte, unpublished data). Beavers destroy the habitat of pearl mussels and salmon fish by building dams. Behind the dam, a pond with still and warm water is formed, with raised nitrogen concentrations. Silting of substrates for mussel attachment is enhanced and the water quality does not correspond to suitable living conditions for the mussels (Rudzīte 2004).

The population age structure in the Rauza river basin (Fig. 1) is similar to that of other populations in Latvia (Rudzīte 2001), but is the largest in Latvia and includes also younger pearl mussels. This increases the value of this population greatly according to the evaluation criteria (Table 4).

The main reason for the bad condition of pearl mussel population is obviously the high level of dissolved inorganic nitrogen, which does not allow the survival of mussels in the first years (Lande, Lande 2000; Moorkens et al. 2000; Buddensiek 2001; Rudzīte 2004). Juvenile pearl mussels smaller than 2 and 5 cm are not found in Latvia (Table 2, Table 4). The age structure of Rauza population in 2004 is the same as in 1999 (Rudzīte 2001). It can be expected that, in the Rauza as well at its tributary, in ten years the pearl mussel population will still exist and some separate mussels may live till 80 or even 100 years. However, the population age structure indicates gradual extinction. Therefore actions must be taken to lover the nitrogen level to create favourable conditions for juvenile pearl mussels. The low density of juvenile pearl mussels (Table 3, Fig. 1) indicates that even when the probability of survival has worsened some individuals are still able to find favourable conditions for survival.

Conclusions

The population density of pearl mussels of Latvia is very low compared with other populations in Europe, with the maximum density of 2.27 mussels m^{-2} and minimum 0.00001 mussels m^{-2}, mean 0.58 mussels m^{-2}. Additional studies on the age structure of the population does not change the previous conclusion from a study in 1999 where it was found that the population is severely aging and is becoming extinct. Beaver is a threat for the pearl mussel population and therefore unacceptable in streams inhabited by *M. margaritifera*. The pearl mussel populations of Latvia, according to the Swedish evaluation system, corresponds to the classes I and II. The condition of two populations corresponding to class II may have high nature conservation value, and there is a high probability that it will survive.

Acknowledgements

Financing for projects on pearl mussels from the Latvian Environmental Protection Fund are gratefully acknowledged. I would like to thank very much all participants of the projects who took part in investigating the rivers: Māris Rudzītis, Kārlis Vītols, Normunds Kukārs. I would like to acknowledge the help and encouragement of many people whose support was critical during the preparation of the manuscript, especially, Dr. Andris Andrušaitis.

References

Araujo R., Ramos A. 2000. *Action Plan for* Margaritifera margaritifera *in Europe*. Museo Nacional de Ciencias Naturales, Madrid. 32 p.

Balodis M. 1990. *The beaver. Biology and the Importance in the Economy.* Rīga. 271 p. (in Russian)

Bauer G. 1988. Threats to the freshwater pearl mussel *Margaritifera margaritifera* L. in Central Europe. *Biol. Conserv.* 45: 239–253.

Baumgärtner D., Heitz S. 1995. Grossmuscheln. Lebensweise, Gefährdung und Schutz. *Arbeitsblätter zum Naturschutz* 21: 1–39.

Buddensiek V. 2001. Ökologie der jungen Flussperlmuschel. In: *Die Flussperlmuschel in Europa: Bestandssituation und Schutzmassnahmen*. Ergebnisse des Kongresses. Hof, pp. 63–68.

Erikson M.E.G., Henrikson L., Söderberg H. 1998. *The Freshwater Pearl Mussel* Margaritifera margaritifera *in Sweden.* Naturvardsverket Forlag, Stockholm. 121 p. (in Swedish)

Geist J., Kuehn R. 2005. Genetic diversity and differentiation of central European freshwater pearl mussel (*Margaritifera margaritifera* L.) populations: implications for conservation and management. *Molec.Ecol.* 14: 425–439.

Lande A, Lande E. 2000. Water quality and population state of the freshwater pearl mussel *Margaritifera margaritifera* L. in Boelva river, Telemark, Norway. *Verh. Internat. Verien. Limnol.* 27: 971–975

Moorkens E.A., Valovirta I., Speight M.C.D. 2000. *Towards a Margaritiferid Water Quality Standard*. Switzerland. 14 p.

Rudzīte M. 2001. Strategy for conservation of the Freshwater Pearl Mussel *Margaritifera margaritifera* L. populations in Latvia. *Acta Biol. Univ. Daugavpil.* 1: 38–44.

Rudzīte M. 2004. Distribution of the freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus 1758) in Latvia in relation to water quality. *Acta Univ. Latv.* 676: 79–85.

Valovirta I. 1998. Conservation methods for poopulations of *Margaritifera margaritifera* (L.) in Finland. *J. Conchol.* 2: 251–256.

Ziemeļu upespērlenes *Margaritifera margaritifera* (Linnaeus 1758) stāvokļa novērtējums Latvijā

Mudīte Rudzīte*

Latvijas Universitātes Zooloģijas muzejs, Kronvalda bulv. 4, Rīga LV–1586, Latvija
*Korespondējošais autors, E-pasts: mudite.rudzite@lu.lv

Kopsavilkums

Ziemeļu upespērlenes *Margaritifera margaritifera* (Linnaeus 1758) Latvijas populāciju stāvokļa vērtēšanai izmantota Zviedrijā izstrādātā metode. Pētīts populācijas blīvums četrās lielākajās upespērleņu populācijās. Analizēta arī populāciju vecuma struktūra izmantojot garuma klases. Visās pērleņu upēs ir sastopami bebri, vērtēta to negatīvā ietekme uz pērleņu populācijas vecuma struktūru. Atbilstoši Zviedrijā izmantotajai populāciju vērtēšanas sistēmai neviena no Latvijas pērleņu populācijām neatbilst visaugstākajam vērtējumam – III klasei (populācija ar ļoti augstu saglabāšanās pakāpi). Divas atbilst II klasei (populācija ar augstu saglabāšanšs pakāpi), pārējās piecas atbilst I klasei (populācija ar zemāku saglabāšanās pakāpi), tātad, to izdzīvošanas iespējas ir apdraudētas.