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SHORT COMMUNICATIONS

Freshwater Pearl Mussels of the Genus *Margaritifera* (Mollusca: Bivalvia) Described as *M. elongata* (Lamarck, 1819) and *M. borealis* (Westerlund, 1871) Should Be Classified with *M. margaritifera* (Linnaeus, 1758)

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Abstract—The shells of Pearl mussels from the basins of the Solza, Keret', and Umba rivers flowing into the White Sea have been measured to determine the ratio of shell convexity to its maximum height. This ratio is the main character that, according to Bogatov et al. (2003), allows one to distinguish between three species of the genus *Margaritifera: M. margaritifera, M. elongata*, and *M. borealis*. It has been found that the above ratio gradually increases as the shell grows. Therefore, this character is unsuitable for species diagnosis, the more so that no hiatus in it between the three forms of pearl mussels has been revealed in any of the samples studied. On this basis, it may be concluded that Northern Europe, including Russia, is inhabited by only one species of pearl mussels, *M. margaritifera.*

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INTRODUCTION

Until recently, the fact that northern Europe is inhabited by only one species of freshwater pearl mussels, the European pearl mussel *M. margaritifera*, was indisputable (Zyuganov et al., 1993; Nagel et al., 1998). However, Bogatov et al. (2003) distinguished two more mollusk species of this genus, *M. elongata* and *M. borealis*, in Russian rivers, and this finding has already been included in some monographs (*Opredelitel'…*, 2004; Kantor and Sysoev, 2005). However, the results of our study cast doubt on the existence of these two species.

MATERIALS AND METHODS

The material was collected in rivers of the White Sea basin, the Keret' (Morskoi and Varatskii rapids, where well-preserved shells of dead pearl mussels were collected) and the Solza (more precisely, the Kazanka, its tributary, where living mollusks were measured and then returned to the river). Studies were performed from 2005 to 2006. A total of 208 shells from the Solza and 80 from the Keret' were measured. Biological characteristics of pearl mussel populations from these rivers are described elsewhere (Zyuganov et al., 1993; Bolotov and Semushin, 2003; Bespalaya et al., 2007).

In 2006, we additionally studied the shells collected by V.I. Zhadin in the Muna River (the basin of the Umba River, Kola Peninsula) in 1938 (n = 43). This collection is kept at the Zoological Institute, Russian Academy of Sciences (St. Petersburg), with the shells being designated either *M. margaritifera* (boxes nos. 13, 15, and 16) or *M. elongata* (boxes nos. 9 and 12). Judging from marks on the shells, all mollusks were used in the experiment on pearl cultivation described by Zhadin (1939). The same paper provides data on specific biological features of pearl mussels from the Muna River.

The cells were measured with sliding calipers to determine their length (L), maximum height (Hm), and convexity (B) with an accuracy of 0.1 mm (Skarlato et al., 1990). Measurements were made by three persons, each operating with the sample from one river. Thereafter, the B/Hm ratio was calculated for each shell. This character, according to Bogatov et al. (2003), allows differentiation between pearl mussel species: it does not exceed 0.56 in *M. margaritifera*, ranges from 0.58

to 0.62 in *M. elongata*, and is no less than 0.65 in *M. borealis.*

To estimate dimensional variation in the B/Hm character, its dependence on L was plotted, the coefficient of correlation between these two parameters was calculated, and the significance of its difference from zero was determined by standard methods (Ivanter and Korosov, 2003). Calculations were made and plots were constructed using the Excel and CurveExpert 1.3 program packages.

RESULTS

The results of this study are graphically presented in Fig. 1. They clearly show that in the populations from the Keret' and Solza rivers there is no hiatus in the distribution of the "B/Hm ratio" character between pearl mussels assigned to *M. margaritifera* and *M. elongata*. A considerable number of individuals have intermediate values of the character (0.56–0.58).

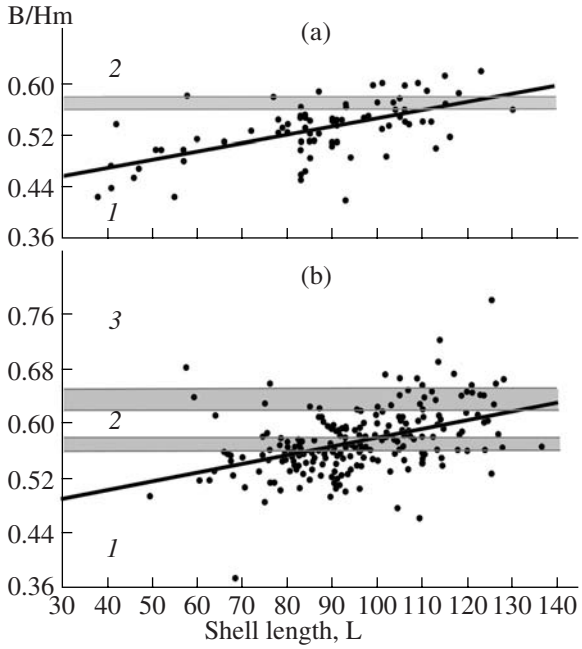
No shells corresponding to *M. borealis* in the diagnostic character were found in the Keret' River. However, such shells were fairly numerous in the sample from the Solza River, and this allowed us to reveal a gradual transition between *M. elongata* and *M. borealis*: a considerable number of shells had intermediate values of the character (0.62–0.65).

All shells from the Muna River kept under the name *M. elongata* corresponded to the characters of this form. However, during the analysis of the entire pearl mussel sample from this river, we found not only the forms *elongata* (25 specimens), *margaritifera* (five specimens), and *borealis* (two specimens) but also shells with characters intermediate between *margaritifera* and *elongata* (seven specimens) and between *elongata* and *borealis* (four specimens) Thus, as in the previous case, no hiatus between the three forms of the pearl mussel was detected in the sample from the Muna River.

Moreover, the B/Hm ratio in all samples showed a tendency to increase along with an increase in shell length, the length of a shell, and the relationship between these characters could be approximated with a straight line (i.e., described by a linear equation). The coefficient of correlation between L and B/Hm was 0.596 in the sample from the Keret' River, 0.443 in the sample from the Solza River, and 0.150 in the sample from the Muna River. In the first two samples, the coefficient of correlation significantly differed from zero ($p < 0.01$).

DISCUSSION

Thus, it may be concluded that *M. elongata* and *M. borealis* are not independent species. The observed differences in the B/Hm character between mollusk shells is a manifestation of size variation in *M. margaritifera*. In the course of growth, mollusks of this species first acquire the characters of the *elongata* form, and then some individuals "transform" into the *borealis* form. It is noteworthy that mollusks with the character typical of *M. borealis* were not found in the Keret' River, where large individuals are scarce because of commercial pearl mussel harvesting that was performed in this river until the 1970s (Figure a).



Dependence of the B/Hm ratio in shell length (L) in pearl mussels from the populations of (a) the Keret' River and (b) the Solza River. Horizontal lines show the B/Hm values diagnostic for three species of pearl mussel distinguished by Bogatov et al. (2003). Gray color indicates the zones of putative hiatuses. The zone of values characteristic of (*1*) *M. margaritifera*, (*2*) *M. elongata*, and (*3*) *M. borealis* are shown.

In the sample from the Muna River, the relationship between B/Hm and shell length is also manifested, but it lacks statistical significance because this sample is small (43 shells). In addition, the largest and smallest individuals are not represented in it: the length of these shells varies from 74.4 to 107.6 mm.

Specific features of this sample are apparently explained by the fact that older mollusks in the Muna River were commercially harvested, as in the Keret' River (this trade was widespread in the north of European Russia in the early 20th century), and the absence of small shells is related to the purpose for which this material was collected. As Zhadin writes in his memoirs (1991), his studies on the Kola Peninsula were aimed mainly at estimating the prospects for pearling in this region, and pearls suitable for jewelry occur only in shells longer than 80 mm (Golubev and Esipov, 1973).

Our assumption that all three forms of the pearl mussel belong to the species *M. margaritifera* is also

confirmed by the analysis of papers where the forms *elongata* and *borealis* were first described. For instance, Lamarck (1819), describing the species *Unio elongata*, states that it is probably identical to *Unio margaritifera* (modern *Margaritifera margaritifera*).

Westerlund (1871) considers that the form *elongata*, similar to the form *borealis* described by him, belongs to the species *M. margaritifera*. It is noteworthy that the specimen that he used for characterizing the form *borealis* was large (127 mm). Moreover, this author found in the rivers of Sweden pearl mussels with characters intermediate between the forms *elongata* and *borealis.*

Note that changes in some characters accompanying an increase in shell size are typical of many mollusk species (Alimov, 1981). In particular, several relevant dimensional dependencies were observed in freshwater pearl mussels, including that between shell convexity and height near the apex (Hendelberg, 1960; Bjork, 1962; Eagar, 1977; Zyuganov et al., 1993).

As shown in our study, the ratio between shell convexity and its maximal height changes as pearl mussels grow. This means, in turn, that this character is inappropriate for species identification, the more so that no hiatus with respect to it was revealed between three forms of the pearl mussel assigned by some researchers to different species.

Bogatov et al. (2003) refer to still another character that differentiates between three forms of pearl mussels, namely, the contour of the frontal section of the shell. However, these authors do not specify whether this character conforms to conditions allowing the shape of the shell to be used for species identification. In particular, is should satisfy a criterion such as the absence of transitions between forms regarded as different. Therefore, it is necessary to perform a comprehensive analysis of joint occurrence of such forms and the distribution of each form (Skarlato et al., 1990).

In our opinion, the fulfillment of all these requirements in the case of pearl mussels is hardly probable, since the character of interest can be determined in only a very small proportion of mollusks, especially in large individuals. The first difficulty is in the necessity to superpose the points of the onset of shell growth; otherwise, this method is inapplicable. Second, the method involves the study of the shell near its apex, while this part of the shell is corroded in the majority of large pearl mussels. On this basis, we consider that the contour of the frontal shell section cannot be a diagnostic character for different forms of pearl mussels.

Thus, the available data allow us to assert that the north of Europe, including Russia, is inhabited by only one species of freshwater pearl mussels, *Margaritifera margaritifera.*

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