Short communication

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Sexual dimorphism of Baikalian amphipoda *Gmelinoides fasciatus* (Crustacea, Amphipoda)

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ABSTRACT. The degree of morphological variability in different groups of Baikal amphipods is different; sexual dimorphism among Baikal amphipods is described in approximately 30% of species by a limited number of morphological characters. There are very few works based on a large number of specimens and many morphological characters. The widespread species *Gmelinoides fasciatus* (Stebbing, 1899) is known from its morphological heterogeneity, but no detailed studies have been carried out. Study of sexual dimorphism of the species *G. fasciatus* is based on a large number of quantitative characters. The purpose of this work is to investigate sexual dimorphism and identify the most significant features. The study revealed the variability of the morphological features of *G. fasciatus* and pronounced sexual dimorphism, as well as the features that characterize it. Comparative analysis of morphological characters showed that in the study of sexual dimorphism it is necessary to use a greater number of characters than previously used.

Keywords: Amphipods, Lake Baikal, *Gmelinoides fasciat*us, morphological characters, sexual dimorphism

1. Introduction

The sexual dimorphism of Baikal amphipods still remains poorly studied (Takhteev, 2000; Kamaltynov, 2001). For example, *G. fasciatus,* a widespread species of Baikal origin, is morphologically very heterogeneous, but a complete morphological analysis based on a large number of characters was not performed. In the descriptions of the Baikal amphipods, mainly meristic and qualitative characters are used, and to a lesser extent quantitative ones. The set of the latter in most cases is limited to body length measurements, antennae length, and the peduncular segments of antennae. More detailed measurement schemes are available in few works, however, the most complete set of quantitative morphological characters (21 in total) was used by Tikhonova (2009) in the study of the sexual dimorphism of the amphipod *Pallasea cancellus* (Pallas, 1772). The aim of this work was to study sexual dimorphism of G. fasciatus by a large number of quantitative characters.

2. Materials and methods

Material for this study was collected evenly around the entire perimeter of Lake Baikal in June – July 2018. Samples were collected at the water's edge using a hydrobiological net and from a depth of 3.5 m by divers. Amphipods were fixed in ethanol. Twenty males and females were randomly selected from each sample. Measurements were performed using an eyepiece ruler (scale for the WF10x eyepiece) of the MSP-1 V.2 stereoscopic microscope (OOO LOMO-Microanalysis) for 21 morphological characters according to the scheme adopted in Tikhonova's work (2009). In order to exclude the influence of the age of individuals and environmental conditions, on the linear dimensions of the morphometric features, all the features of each individual were normalized (divided) by its body length. The overall similarity of the individuals according to the complex of morphometric features was examined using non-metric multidimensional scaling (NMDS). Before NMD analysis initial data were transformed by ranging from zero to one. For NMDS, the distance matrix was calculated using the Euclidean dissimilarity metric. Significant explanatory variables (including gender) on the set of morphometric features *G. fasciatus* were identified using distance based AMOVA analysis. The analysis of the reliability of the influence of individual gender on the values of each morphometric feature was carried out using the ANOVA analysis with the Fisher test. The P-value of the Fisher test was adjusted for the false detection rate (FDR) in multiple comparisons using the Benjamini – Hochberg correction (Benjamini and Hochberg, 1995). Statistical analysis was performed in R, using the "vegan" package (Oksanen and Tulkki, 2010).

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3. Results

The results of AMOVA analysis show that the gender factor has the greatest influence on the set of morphometric features of G. fasciatus individuals (R2 = 0.4700, P_value = 0.000999). The gender factor explains 47% of the variability in the totality of morphometric features of organisms (47% of the difference between individuals depend on their gender). Two-dimensional NMDS plot showing the similarities and differences between individuals *G. fasciatus* in complex of morphometric features are shown in Fig. The figure shows two partially overlapping point clouds. The first cloud in the lower right corner of the graph is from females, the second cloud in the upper left corner of the graph is from males. The small overlap confirms the results of AMOVA analysis, showing that there are pronounced differences between females and males.

Analysis of the feature gradient vectors (see Fig.) allows to divide morphometric features that reliably distinguish females from males into two groups. The first group includes features p_8, p_10, p_7 and p_9. The relative values (normalized to body length) of these features were almost always higher in males than in females. The second group includes features p_13, p_11, p_20, p_21, p_19, p_6, p_15 and p_5. Most of the males are larger than females in terms of the relative values of these features. But at the same time, there were 11 males that had the meaning of these features as in females, and 4 females in these features were similar to males. It can be concluded that the features p_8, p_10, p_7 and p_9 contribute the most to the separation of females and males.

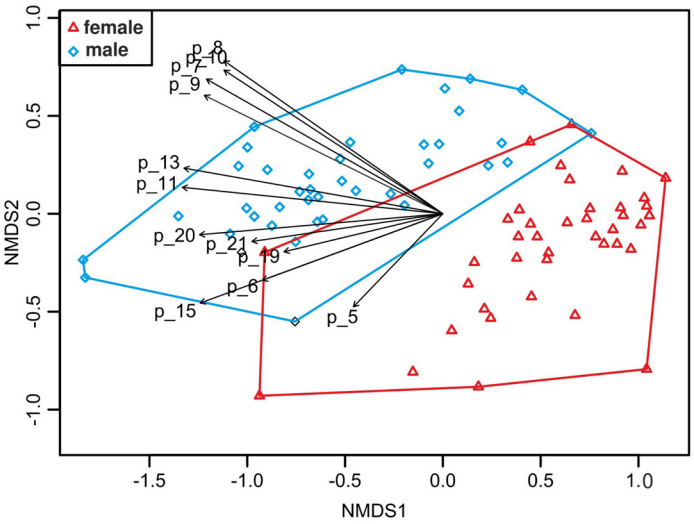

Fig. Two-dimensional NMDS plot. Red and blue lines delineate females and males points of clouds. The vectors show the direction of gradients for features that are significantly different in females and males based on the results of ANOVA analysis: length (p_5) of 4th and (p_6) 5th segments of the peduncule of antenna 2; the length and width of the propodus of the gnatopods 1 (p_7-8) and 2 (p_9-10); length of the basal segment of pereopod 3 (p_11), 4 (p_13), and 5 (p_15); (p_19) length the peduncule of uropod 3; the length of the outer (p_20) and inner ramus (p_21) of the uropod 3.

4. Discussion

The size of the body, its parts and appendages in crustaceans is an important component of sexual dimorphism. Sexual dimorphism of Baikal amphipods is expressed in the larger size of males (e.g. *Acantogammarus grewingkii*, other deepwater species, many species of coastal gammarids), but the opposite also takes place, as, for example, described by Gariaev (1901). As a result of this study, it has been shown that males are significantly larger than females in a large number of measured parameters. This is due to the peculiarities of the division of functions between the sexes and the functions of parts of the body and its appendages. Gnatopods are involved in capturing and holding food, transferring it to the mouthparts, grabbing the substrate, digging, protection from enemies and attacking and for grooming. In males, gnathopods can be noticeably more powerful, since they are used to capture and hold females during pre-copulation and copulation. On antennae 1 and 2 there are various sensory organs - chemosensory and mechanosensory. They play an important role in sexual behaviour. Some amphipods can burrow in the substrate. The ability to burrow into the substrate serves to spread upstream, thus the crustaceans can resist the current and do not drift downstream. Males often have longer antennae with more numerous sensitive organs on them. This is possibly due to the greater activity of males, including in the search for females.

5. Conclusions

It can be concluded that the gender of individuals is the main factor determining the differences between individuals of *G. fasciatus*. The studied amphipod species in Lake Baikal has the pronounced sexual dimorphism.

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