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# Structure of the Stridulatory Apparatus of Some Species Heteroceridae (Coleoptera) †

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**Abstract:** The variegated mud-loving beetles use an acoustic channel to communicate each other. They produce sound by scarping hindleg plectrum over stridulatory file. This study explores, for the first-time difference on these structure for *Augyles* and *Heterocerus*. The research is based on image the sound-producing structures on scanning electron microscope. We measured next parameters: the size of stridulatory file on 100 μm, number of ridges on 50 μm and the size of plectrum. This paper has demonstrated how these parameters depend on each other for 15 species and the stridulatory organ is vary between male and female (*Augyles* genus).

**Keywords:** the variegated mud-loving beetles; stridulatory organs; plectrum; scanning electron microscope

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## 1. Introduction

The family Heteroceridae MacLeay, 1825 (Coleoptera) or variegated mud-loving beetles are wide-spread in the world. The world fauna of Heteroceridae, totals 364 species (pers. data); previous estimates ranged from 320–370 species [1, 2], because the fauna has not been revised. In general, species of the family Heteroceridae occur in temperate, subtropical, and tropical latitudes. Heterocerids have evolved in the unstable habitats of water-land ecotones and show high taxonomic diversity and abundance in semiaquatic communities. Adults and larva of Heteroceridae construct branched networks of tunnels and chambers in a moist soft substrate, which are used for feeding, egg laying and pupation [3]. At high densities with another stratobionts they give a specific microrelief for substrate [4]. The imago often flies to-ward lights (LED's, vapor mercury lamps) at night [5], it can be used as a collection method.

Species of the family Heteroceridae prefer finely dispersed clay and sand types of soil with sufficient moisture, on which colonies are often formed with pronounced biotopic sympatry (cohabitation of species). The variegated mud-loving beetles use an acoustic channel to communicate each over. They produce sound by scraping hindleg ridge (plectrum) over first abdominal ridge (stridulatory file) [6]. The stridulatory file is varied for different genus. For genus *Augyles* Schiödte, 1866 the stridulatory file forms are a complete; for genus *Heterocerus* Fabricius, 1792 stridulatory file is an incomplete [7, 8]. Some articles shows that male and female have different number of ridges: males have more strongly developed ridges and females ridges smoother or with small creases [9, 10], it may be related to sexual behavior. The main works on systematic of family Heteroceridae describes characteristics, such as male genitalia, the basic color pattern of the body, the

humeral angle, types of fascia, the pronotum anterolateral angel etc. [11–15]. Now, modern methods of microscopy allow investigating new features of morphology. And our research shown differences on structure of the hindleg ridge (plectrum) and the stridulatory files for *Augyles* and *Heterocerus* for the first time. The structure of the stridulatory apparatus can vary for this genus and shows difference between species and between sexes.

## 2. Material and methods

### *2.1. Morphology*

To image the sound-producing structures in males and females, beetles were prepared for scanning electron microscopy by separating the abdomen and the posterior leg from the rest of the body. Specimens were mounted on aluminum stubs and coated with palladium (Ion coater IB-5, Eiko Engineering Co., Ltd., Japan) prior to imaging using a variable pressure scanning electron microscope (Hitachi TM-1000, Hitachi, Japan) at Zoology Institute of Russian Academy of Science.

### *2.2. Characteristics of the structure of stridulatory file and plectrum*

The present study has only explored 17 specimens and 15 species. Only two species have male and female specimens. For measurements of stridulatory file of the thirst abdominal segment and plectrum of the posterior femur we used Image Pro (Media Cybernetics, USA). We measurements the following parameters for stridulatory file: the size of stridulatory file on 100 μm, the number of ridges on 50 μm. For the plectrum we measurements the size of plectrum.

## 3. Results and Discussion

The result of measurements different parameters of morphology structure the stridulatory apparatus shown variation between male and female structure (*Augyles* genus). Also, we can see correlation between the size of plectrum and the size of stridulatory file. The results of these measurements are presented in Table 1.

**Table 1.** The different parameters of stridulatory apparatus of Heteroceridae.

| Species | size of stridulatory file (μm) | number of ridges (μm) | size of plectrum (μm) |
|---|---|---|---|
| *Augyles delutissimus* (Reitter, 1887) ♀ | 408.62 | 19 | 441.43 |
| *A. delutissimus* (Reitter, 1887) ♂ | 417.71 | 17 | 366.99 |
| *A. flavidus* (Rossi, 1794) | 383.19 | 53 | – |
| *A. hispidulus* (Kiesenwetter, 1843) ♀ | 413.33 | 19 | 455.22 |
| *A. interspidulus* (Charpentier, 1979) ♀ | 390.00 | 17 | 423.70 |
| *A. interspidulus* (Charpentier, 1979) ♂ | 434.86 | 16 | 408.72 |
| *A. obliteratus* Kiesenwetter, 1843 | – | 19 | 517.80 |
| *A. turanicus* (Reitter, 1887) | 411.76 | 25 | 385.34 |
| *Heterocerus fenestratus* (Thunberg, 1784) | 431.80 | 21 | 389.21 |
| *H. flexosus*, Stephens, 1829 | 426.51 | 25 | – |
| *H. fossor* Kiesenwetter, 1843 ♀ | 475.89 | 17 | 518.18 |
| *H. fusculus* Kiesenwetter, 1843 | 369.23 | 30 | 322.27 |
| *H. heydeni* Kuwert, 1890 ♀ | 468.33 | 20 | – |
| *H. kaszabi* n. sb. | 475.06 | 22 | – |
| *H. marginatus* (Fabricius, 1787) | 392.09 | 24 | 416.42 |
| *H. obsoletus* Curtis, 1828 | 328.91 | 20 | 574.00 |
| *H. parallelism* Gebler, 1830 ♀ | 399.76 | 15 | 505.59 |

Comparing males and females of *Augyles delutissimus* and *Augyles interspidulus*, we concluded that the size of the stridulation file in males is larger than in females. At the same time, the number of teeth less. Also, the size of the plectrum is much smaller for males. The size of plectrum for females of *A. delutissimus* and *A. interspidulus* is 441.43 μm and 423.70 μm against 366.99 μm and 408.72 μm for males of these species. The size of the stridulatory file for species of *Augyles* are vary from 383.19 μm (*A. flavidus*) to 434.86 μm (*A. interspidulus*). But the number of ridges has the inverse proportionality of the size of stridulatory file. The maximum number is 53 for *A. flavidus* and 16 for *A. interspidulus.*

The stridulatory file of *Heterocerus* genus is varied from 328.91 μm (*H. obsoletus*) to 475.89 μm (*H. fossor*). *H. fusculus* has the largest number of ridges (30) and the smallest size of plectrum (322.27 μm). *H. parallelism* has 15 number of ridges, and the size of stridulatory file is 399.76 μm. *H. obsoletus* has the largest size of plectrum (574.00 μm).

## 4. Conclusion

The results of this study show that structure of the stridulatory organ is vary between male and female (*Augyles* genus). Almost all cases the number of ridges has the inverse proportionality of the size of stridulatory file. And the same time the size of plectrum has the same relation. Future research is needed to investigate large specimens' group for each species (male and female). These studied will help us understand the difference at structure of stridulatory organs different species and between sexes within species. Future studies will focus on comparing the morphology of the stridulatory structure with the sound characteristics imago.

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