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Stridulatory organs in Asian *Holotrichia* species (Coleoptera: Melolonthidae: Melolonthinae)

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Abstract

Elytral stridulatory organs in the Asiatic genus *Holotrichia* Hope are described. Structure and position of such organs suggest that sound is produced by males and females by rubbing the internal edge of the hind femur (*plectrum*) on the ridge elytral epipleura (*pars stridens*). Similar stridulatory structures were also found in some species of the closely related genera *Sebakwe* Péringuey, *Microtrichia* Brenske, *Octoplasia* Brenske, *Heptelia* Brenske, *Amphitrichia* Brenske, *Heptophylla* Motschulsky, *Latipalpus* Moser and *Eotrichia* Medvedev.

Keywords: Scarab, stridulation, *pars stridens*, *plectrum*, morphology

1. Introduction

All stridulatory organs produce sound or vibration by friction and share the same basic structure, consisting of two body parts moving against each other [1]. The mechanism of stridulation involves a system that consists of two primary organs: a usually elevated fine parallel ribs (*pars stridens*) and a scraper (*plectrum*), which is essentially a mobile sharply confined ridge that rubs against the *pars stridens* [2].

Stridulation has been documented in many insect orders including Orthoptera, Odonata, Lepidoptera, Hymenoptera and Coleoptera. As with many insect adaptations, stridulation is believed to have evolved from different activities such as feeding, flight and other forms of locomotion and can involve any number of body parts including: wings, legs, elytra, and abdomen [1].

Sound production is widespread and common in many beetles [3] and the diversity of sound-producing organs is copious and unmatched by any other known order of hexapods. Beetles have achieved a number of fundamentally different (and in some respects evolutionarily independent) means of producing sounds by stridulation [2, 4, 5] were the first who accurately described the stridulatory apparatus of some beetles (Cerambycidae, Chrysomelidae and Scarabaeidae). Stridulatory organs to the date are registered to around 30 beetle families [2] and sound-producing organs in Melolonthidae have been used as autapomorphies at supraspecific levels in Dynastinae by [6], Rutelinae by [7], and at specific level in *Golofa* Hope by [8].

The terminology used to describe the various stridulatory organs is based upon the location of the part regarded as *pars stridens*, which is morphologically easier to recognize than *plectrum*. At least 14 types of stridulating organs have been described in adult beetles [9] and the most common types in Melolonthidae are: apical border of elytra as *plectrum* against *pars stridens* on propygidial surface as in dynastine *Oryctes* [10] and *Golofa* species [8]; apex of metafemur as *plectrum* against lateral sides of first sternite as *pars stridens*, as in ruteline *Macraspis* species [11]; dorsal surface of the last tergites as *plectrum* rubbed against ventral denticles near the costal wing margin as *pars stridens*, as in melolonthine *Polyphylla* species [12]; border of mesocoxa as *plectrum* against inner surface of mesocoxa cavity as *pars stridens* as in dynastine *Xyloryctes* species [13].

Genus *Holotrichia* Hope 1837, belongs to tribe Melolonthini of subfamily Melolonthinae (Coleoptera: Melolonthidae) widely distributed in Southeastern Asia and its taxonomic status has been described by [14] in detail. With more than 230, species *Holotrichia* form a common group of chafers frequently cited as pests damaging groundnut, soybean, sugarcane, neem, *Prosopis*, wild rose, apple, walnut, plum, apricot, pigeon pea crops, etc. [15, 16, 17]. Adults of *Holotrichia* are medium to large size (length 18-28 mm), with robust, cylindrical or ovate body; dorsal surface brownish, blackish brown or reddish brown, moderately haired; elytra

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usually pruinose; antenna ten segmented, three segmented club; claws toothed; and *spiculum gastrale* 'Y' shaped in males.

There are no known descriptions of stridulatory apparatus in species of this genus. The purpose of this study was to document the stridulatory organs in some species of the chafer genus *Holotrichia* and clarify the structures involved.

2. Materials and Methods

The location and rough morphology of the stridulatory organs were first investigated with the aid of a stereomicroscope (Leica MZ8, 15-50x) and later, the fine structure was observed using a Scanning Electron Microscope (Quanta FEG 250, 60-757x). Body measurements were taken using an ocular micrometer.

A total of 22 dried specimens were examined, from those 12 species belonged to *Holotrichia* and 10 species were from genera *Amphitrichia* Brenske, *Eotrichia* Medvedev, *Miridiba* Reitter, *Sebakwe* Péringuey and *Latipalpus* Moser. All specimens studied are located at Museum für Naturkunde der Humboldt Universität zu Berlin, Germany (MNHU), Natural History Museum, London, England (BMNH) and Miguel A. Morón, Xalapa, Mexico (MXAL). The species analyzed were as follows:

1. *Holotrichia iridescens* Moser 1908. TYPE: Vietnam: Tonkin, Than Moi. VI-VII. H. Fruhstorfer (MNHU).
2. *Holotrichia lata* Brenske 1892. Taiwan: Formosa. 20-V-1993 M.A. Morón det. (MXAL).
3. *Holotrichia montana* Moser 1912. TYPE: Vietnam: Tonkin, Montes Mauson. IV-V, 2-3000. H. Fruhstorfer (MNHU).
4. *Holotrichia nigra* (Redtenbacher 1868). China: Qingdao, Prov. Shandong. 24-VI-1987. R. H. McPeak coll. (MXAL).
5. *Holotrichia opacipennis* Moser 1912. TYPE: Vietnam: Tonkin, Laos (MNHU).
6. *Holotrichia repetita* Sharp 1903. TYPE: India: Tamil Nadu, Ootacamund. C.A. Barker. Sharp coll. 1905-313 (MNHU).
7. *Holotrichia rufescens* Moser 1912. HOLOTYPE: China: Chang Yang, near Lehang 4-600 ft. V-VII-VIII. Labelled by MNHU 2011 (MNHU).
8. *Holotrichia rufiflava* Brenske 1894. India: South Coimbatore. X-1976 P. Kuijten det. (MXAL).
9. *Holotrichia serrata* (Fabricius 1781). India: Anamalai Hills. VII-1976 P. Kuijten det. (MXAL).

10. *Holotrichia sororia* Moser 1912. HOLOTYPE: Vietnam: Tonkin, Montes Mauson. III-IV 2-3000. H. Fruhstorfer. Labelled by MNHU 2011 (MNHU).
11. *Holotrichia succedanea* (Matsumoto 2008). PARATYPE: Philippines: Mt. Balocawihay. C. Leyte III-2005. D. Mohagan coll. (MNHU).
12. *Holotrichia urunguensis* Moser 1924. HOLOTYPE: Somalia: Urungu. Bez. Bismarckburg. Zencke coll. J Decelle 1977 det. (MNHU).
13. *Amphitrichia amboinae* (Brenske 1894). HOLOTYPE: Indonesia: Amboina. Brenske coll. labelled by MNHU 2007 (MNHU).
14. *Amphitrichia angulicalcarata* (Itoh 2003). PARATYPE: Philippines: Mt. Halcon, Mindoro Oriental. 1-15-IV-1990. D. Mohagan coll. (MNHU).
15. *Amphitrichia cebuana* (Itoh 2003). PARATYPE: Philippines: Southern Cebu. 10-VII-2002 (MNHU).
16. *Amphitrichia excavaticollis* (Itoh 2003). HOLOTYPE: Philippines: Palawan Island (MNHU).
17. *Amphitrichia sumbawana* (Brenske 1899) LECTOTYPE: Indonesia: Sumbawa Island. Brenske coll. Itoh 2002 det. (MNHU).
18. *Eotrichia biehli* (Brenske 1892). TYPE: India: Sikkim. Darjiling (MNHU).
19. *Eotrichia laticollis* (Moser 1921). TYPE: India: Sikkim. Darjiling (MNHU).
20. *Miridiba tuberculipennis* (Moser 1913). LECTOTYPE: Myanmar (Burmah): A. K. Weld Downing (MNHU).
21. *Sebakwe coriacea* (Péringuey 1904). Zimbabwe: N Rhodesia, N'Changa. 1931-179. C.T. Macnamara col. J. Decelle det. 1977 (BMNH)
22. *Latipalpus fujiokai* Itoh 1999. PARATYPE: N Borneo, E Malaysia. 27-V1988 (MNHU).

3. Results

3.1 Morphology of the stridulatory organs in *Holotrichia*.

All body measurements are presented in Table 1. In the Asiatic genus *Holotrichia* the stridulatory organs are localized in both sexes along the elytral epipleura (*pars stridens*, Fig. 1) and in the hind femora (*plectrum*, Fig. 2). The *pars stridens* covers about 45.5-96.8% of the epipleura (6-15 mm) and has 13.14-47.42 ribs per millimeter (Fig. 3). The rib thickness varies between species, from very narrow and almost imperceptible to partly thick and conspicuous. The *plectrum* is a well-marked diagonal ridge or keel, located on the internal surface of the apex of the hind femora (Fig. 2).

Table 1: Body measurements of all species analyzed.

Species name	Elytral length (mm)	<i>Pars stridens</i> length (mm)	% <i>pars stridens</i> on the epipleura	No. Ribs on <i>Pars stridens</i>	No. Ribs per millimeter	Metatibial length (mm)	Metafemoral length (mm)	Metafemoral width (mm)
<i>H. iridescens</i>	15.5	15	96.8	331	22.07	6.9	7.1	1.9
<i>H. lata</i>	17.6	12.4	70.5	410	33.06	7.5	7	2
<i>H. montana</i>	16.5	14.4	87.3	310	21.53	7.4	7.4	2.1
<i>H. nigra</i>	13.2	6	45.5	170	28.33	5.5	5.3	1.4
<i>H. opacipennis</i>	16	14	87.5	281	20.07	5.9	5.9	2
<i>H. repetita</i>	13.4	11.7	87.3	186	15.90	5.2	5.1	1.8
<i>H. rufescens</i>	13.7	10.3	75.2	207	20.10	5.7	5.7	1.6
<i>H. rufiflava</i>	13	12.4	95.4	588	47.42	5.7	5.6	1.9
<i>H. serrata</i>	19	10.5	55.3	138	13.14	7.2	7.5	2.7
<i>H. sororia</i>	13.4	12	89.6	314	26.17	6.2	5.6	1.8
<i>H. succedanea</i>	11.1	8.8	79.3	250	28.41	5.2	4.8	1.6
<i>H. urunguensis</i>	13.1	11.2	85.5	295	26.34	5.7	5.5	2
<i>A. pretiosa</i>	10.5	8	76.2	172	21.50	4.2	4.4	1.8
<i>A. angulicalcarata</i>	14.9	9.1	61.1	210	23.08	5.2	5.2	1.8

<i>A. cebuana</i>	11.9	8.2	68.9	227	27.68	5.2	5.2	1.9
<i>A. excavaticollis</i>	15.7	9.2	58.6	112	12.17	6.2	5.8	2
<i>A. sumbawana</i>	12.5	10.7	85.6	258	24.11	5.4	5.1	1.7
<i>E. biehli</i>	12.6	11	87.3	454	41.27	5.5	5.2	1.7
<i>E. laticollis</i>	11.9	10	84.0	450	45.00	5.3	5.2	1.5
<i>M. tuberculipennis</i>	14	-	-	-	-	4.5	5.1	2.1
<i>S. coriacea</i>	13	12	92.3	275	22.92	5.3	5	1.7
<i>L. fujiokai</i>	12.5	11	88.0	332	30.18	5.6	5.4	1.8

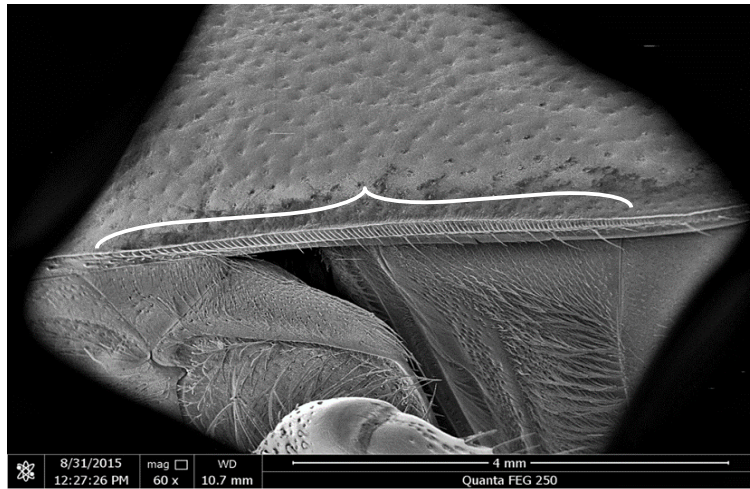


Fig 1: Scanning electron micrograph of the *pars stridens* along the epipleura in *Holotrichia serrata* (♂).

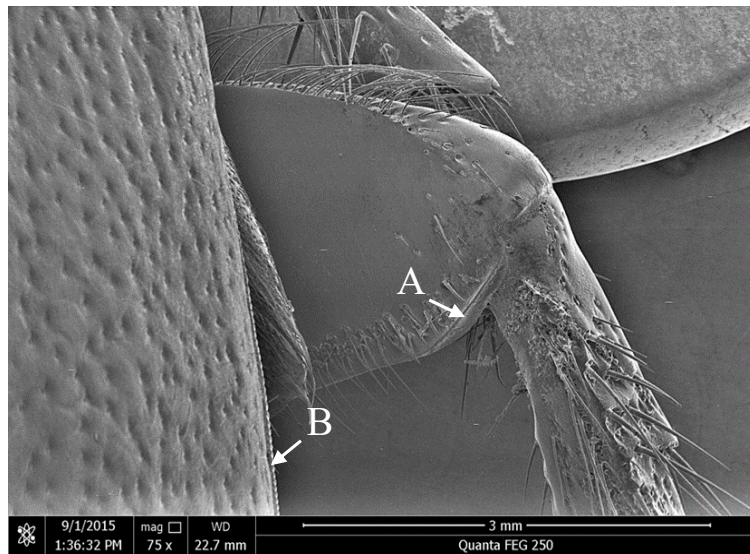


Fig 2: Scanning electron micrograph of (A) plectrum, located on the internal surface of the hind femora in *Holotrichia serrata* (♂) and (B) edge of the *pars stridens* in dorsal view.

4. Discussion

In each of the examined *Holotrichia* species elytro-femoral stridulatory organs were found; sound is produced by both sexes when the keel found at the internal surface of the hind femora are rubbed against the ribbed epipleura. Thus, sound production is obtained when the femora comes into contact with the elytra, while the legs movement determines the signals. Since these observations were made in dried specimens, there is no recorded data regarding the spectra of the sound produced or the syllable modulation pattern. No signs of any sexual dimorphism in the morphology of the *pars stridens* and *plectrum* were observed. Furthermore, the total number of the ribs in the *pars stridens* and their thickness differ among species, however they are quite consistent within species. Therefore, it can be concluded that the

morphological configuration of the stridulatory organs within genus *Holotrichia* is specific, and it becomes imperative to propose hypothesis on the importance of such factor during the reproductive behavior in this group of chafers.

Additionally, similar stridulatory organs were found and analyzed in the closely related genera *Sebakwe* (Afrotropical), *Amphitrichia* (Oriental), *Latipalpus* (Oriental) and *Eotrichia* (Palearctic-Oriental) and they were not found in the genus *Miridiba*, recently revised by [18], who transferred several Palearctic and Oriental species of *Holotrichia* to this genus.

It is noteworthy that during the study in course, an elytro-femoral stridulatory system in some species of the genus *Microtrichia* Brenske, *Octoplasia* Brenske, *Heptelia* Brenske and *Heptophylla* Motschulsky was observed but it was not analyzed.

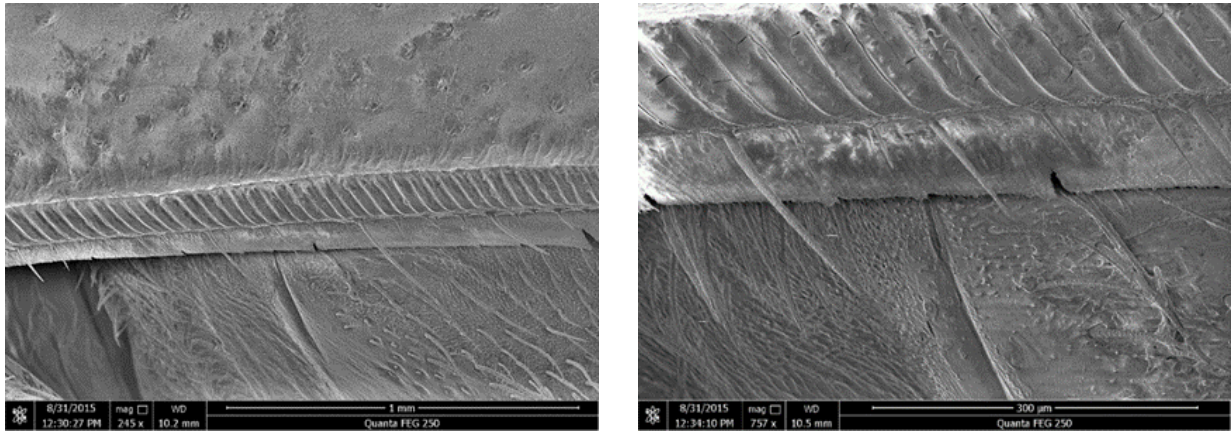


Fig 3: Micrographs showing detail of the ribs on the *pars stridens* in *Holotrichia serrata* (♂) in different magnifications. Left 245x and right 757x.

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