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Review of the Oriental Monotypic Genus *Pibrocha* Kirkaldy (Hemiptera, Fulgoromorpha, Fulgoridae, Dorysarthrinae)

Zhi-Shun Song[1], Thierry Bourgoin[2], Ai-Ping Liang[1]

1 *Key Laboratory of the Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, No. 1 Beichen West Road, Chaoyang District, Beijing 100101, China* **2** *Département Systématique & Evolution, UMR 7205 MNHN-CNRS, Muséum National d'Histoire Naturelle. Case Postale 50 / Entomologie, 45, Rue Buffon, F-75231 Paris cedex 05, France*

Corresponding author: *Ai-Ping Liang* (liangap@ioz.ac.cn)

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Abstract
The monotypic genus *Pibrocha* Kirkaldy, 1902, known only from Sri Lanka in the Oriental region, is closely related to *Dorysarthrus* Puton, 1895 from southwestern Asia and northern Africa (Palaearctic region). The genus is revised to include a first description of the male genital structures and a discussion of relationships between *Pibrocha*, *Dorysarthrus* and *Dichoptera* Spinola, 1839. A diagnostic key to the three genera and photos of their type species are provided for better comparison in these taxa. *Pibrocha* is assigned tentatively from Dictyopharidae to the subfamily Dorysarthrinae (Fulgoridae).

Keywords
Fulgoridae, Dictyopharidae, Dorysarthrinae, *Pibrocha*, redescription

Introduction

The monotypic genus *Pibrocha* was established by Kirkaldy (1902) to accommodate a peculiar species *Dictyophora* [sic] *egregia* Kirby, 1891 from Sri Lanka. Kirkaldy (1902) stated that "the genus is closely allied to *Dictyophara* Germar, but, beyond other differences, is readily recognizable by the transverse nervure in the clavus, which thus allies it to *Dichoptera* Spin. (Kirkaldy 1902: 51)."

Traditionally, the genus *Pibrocha*, along with other genera *Awaramada* Distant, 1914, *Daridna* Walker, 1858, *Dichoptera* Spinola, 1839 and *Dorysarthrus* Puton, 1905, was placed in the subtribe Dichopterina (Dictyopharidae: Dictyopharinae: Dichopterini) for the presence in the forwings of a short claval crossvein between CuP and Pcu (Metcalf 1946). Among these genera, *Daridna* was transferred to the leafhopper family Cicadellidae by Nielson (1982) and *Awaramada* was synonymized with *Pibrocha* by Liang (2000).

While attempting to clarify the distinction between Fulgoridae and Dictyopharidae, Emeljanov (1979) regarded the short crossvein in the clavus as one of familial diagnostic characters. Emeljanov (1979) elevated Dichopterini (only *Dichoptera*) to subfamily status (Dichopterinae) and established a new monotypic subfamily Dorysarthrinae for *Dorysarthrus*. Both monotypic subfamilies were transferred by Emeljanov (1979), in company with some other dictyopharid taxa, to the lanternfly family Fulgoridae, which is widely accepted to be a sister group of Dictyopharidae in the hypotheses of Fulgoromorpha phylogeny based on either morphological characters or DNA sequence data (Asche 1987; Emeljanov 1990; Bourgoin 1993; Yeh et al. 2005; Urban and Cryan 2009). Thus only *Pibrocha* was not considered and its taxonomic status is not discussed until now.

The speces *Pibrocha egregia* possesses a very elongate cephalic process, which is furrowed and constricted at its basal 1/3, and appears to be 'fractured' and separated into two portions by an articulation (Figs 1, 4). In many dead dried specimens, the distal portion of cephalic process is easily broken, so the species may be easily misidentified. As an example the monotypic genus *Awaramada* Distant was established based on *Pibrocha* specimen that had lost the distal portion of the cephalic process. Its type species *Awaramada fryeri* Distant, 1914 was synonymized with *P. egregia* by Liang based on examination of type material in the Natural History Museum, London, UK (BMNH) (Liang 2000).

This study provides a review of the genus *Pibrocha*, including a first description of the male genital structures and a discussion of relationships between *Pibrocha*, *Dorysarthrus* and *Dichoptera*. A key to three genera and photos of their type species are also provided for better comparison in these taxa. *Pibrocha* is assigned tentatively to the subfamily Dorysarthrinae (Fulgoridae) from Dictyopharidae.

Materials and methods

The male genitalia were cleared in 10% KOH at room temperature for ca. 12 hours, rinsed in distilled H_2O, then transferred to glycerol for examination.

Morphological characters were observed with a Zeiss (Stemi SV II) optical stereomicroscope and illustrated with the aid of a drawing tube; measurements were made with the aid of an eyepiece micrometer.

The specimens studied in the course of this work are deposited in the following institutions whose names are abbreviated in the text as follows:

BMNH the Natural History Museum, London, UK;
MNHN the Museum National d'Histoire Naturelle, Paris, France;
NCSU Department of Entomology Insect Collection, North Carolina State University, Raleigh, North Carolina, USA;
USNM the National Museum of Natural History, Washington, D.C., USA.

The morphological terminology used in this study follows Emeljanov (1988) for external morphology and venation of the forewings, Bourgoin and Huang (1990) for male genitalia.

Taxonomy

Key to the genera *Pibrocha*, *Dorysarthrus* and *Dichoptera*

1 Body very large and stout (large-sized species), body length (including forewings) usually more than 25 mm; head distinctly short, produced in a short or moderately long cephalic process, which is only 1/4 to half as long as pronotum and mesonotum combined (Fig. 3); cephalic process with apical portion before eyes abruptly narrowing to conic and distinctly upturned (Fig. 6); forewings with M vein first branching to MA and MP veins near base, and MP vein branching to MP_1 and MP_2 veins near basal 1/5 or 1/4 before nodal line; Sc+R, M and CuA veins branching to dozens of accessory veins beyond nodal line in forewings (Song and Liang, in prep.).. ....***Dichoptera*** **Spinola (Dichopterinae)**

– Body relatively much smaller and slender (medium-sized species); head very elongate and distinctly stout, produced anteriorly into a cephalic process, which is about twice as long as pronotum and mesonotum combined; cephalic process stout and cylindrical at basal 1/3, and then suddenly furrowed and constricted, which looks like being fractured and separated into two portions by an articulation; the distal remainder 2/3 turned downwards in lateral view (Fig. 8); forewings with M vein only branching to MA and MP veins near middle before nodal line; Sc+R, M and CuA veins branching to less accessory veins beyond nodal line in forewings.............................**2 (Dorysarthrinae)**

2 Cephalic process with distal remainder 2/3 inflated and subcylindrical, which is rounded and bulbous apically in dorsal view (Fig. 2); basal 1/3 of vertex without median carina, along with a broad white median band extending over pronotum and mesonotum; frons nearly parallel before postclypeus; pronotum and mesonotum bicarinate in middle disc, lateral carinae barely visible and median carina absent; hind tibiae with 7 apical black-tipped spines ....***Dorysarthrus*** **Puton**

– Cephalic process with distal remainder 2/3 mostly narrowed and laterally compressed, gradually expanded and dorsoventrally compressed near apex, which is truncate and clavate apically in dorsal view (Fig. 1); basal 1/3 of vertex with median carina distinct and complete; frons widest and obtusely expanded outwards before postclypeus; pronotum and mesonotum tricarinate in middle disc, median and lateral carinae distinct and complete; hind tibiae with 6 apical black-tipped spines ....***Pibrocha*** **Kirkaldy**

Family Fulgoridae Latreille, 1820
Subfamily Dorysarthrinae Emeljanov, 1979

Genus *Pibrocha* Kirkaldy, 1902
http://species-id.net/wiki/Pibrocha

Pibrocha Kirkaldy, 1902: 50; Melichar, 1903: 20; Distant, 1906: 240; Melichar, 1912: 22; Metcalf, 1946: 31. Type species: *Dictyophora* [sic] *egregia* Kirby, 1891; by original designation.

Awaramada Distant, 1914: 412; Distant, 1916: 27; Metcalf, 1946: 31. Type species: *Awaramada fryeri* Distant, 1914; by monotypy. Synonymised by Liang, 2000: 235.

Diagnosis. Cephalic process twice as long as pronotum and mesonotum combined, furrowed and constricted at basal 1/3, where it appears to be 'fractured' and separated into two portions by an articulation; the distal remainder 2/3 mostly narrowed and laterally compressed, gradually expanded and dorsoventrally compressed near apex, which is truncate and clavate in dorsal view, and turned downwards in lateral view; vertex with basal 1/3 broad and moderately arched, median carina distinct and complete; the remainder 2/3 of vertex and frons without median carina; pronotum and mesonotum tricarinate, nearly parallel; forewings elongate and slender, nearly four times as long as broad; M vein only branching to MA and MP veins near front-middle before nodal line and firstly branched before Sc+R and CuA veins near middle; clavus with a short crossvein, connecting CuP with Pcu; legs narrow and moderately long; fore femora not flattened and dilated, hind tibiae with 6 apical black-tipped spines; aedeagus large and symmetrical, with a pair of long and slender endosomal processes extended dorsally; phallobase basally sclerotized and pigmented, without spine.

Redescription. Head very elongate and distinctly stout, produced anteriorly into a cephalic process, which is about twice as long as pronotum and mesonotum combined. Cephalic process stout and cylindrical at basal 1/3, and then suddenly furrowed and constricted, where it appears to be 'fractured' and separated into two portions by an articulation; the distal remainder 2/3 mostly narrowed and laterally compressed, gradually expanded and dorsoventrally compressed near apex, which is truncate and clavate in dorsal view (Fig. 7), and turned downwards in lateral view (Fig. 8). Vertex with basal 1/3 broad and moderately arched, lateral carinae nearly sub-parallel and median carina distinct and complete; the remainder 2/3 narrowly sulcate, nearly parallel, gradually expanded and apically truncate, median carina indistinct in groove.

Frons (Fig. 9) without median carina, intermediate carinae shallowly sulcate, nearly parallel; basal 1/3 widest and obtusely expanded outwards before postclypeus, lateral carinae slightly converging towards apex; the apical remainder 2/3 laterally compressed and abruptly narrowed. Postclypeus and anteclypeus convex medially, median carina indistinct. Rostrum long, reaching beyond abdominal segment V. Eyes oval and large. Ocelli large, reddish. Antennae with scape very small; pedicel large and subglobose, with more than 50 distinct sensory plaque organs distributed over entire surface; flagellum long, setuliform.

Pronotum (Fig. 7) a little shorter than mesonotum medially, narrow anteriorly, broad posteriorly; anterior margin slightly arched centrally, lateral marginal areas straight and sloping with two long lateral carinae on each side between eyes and tegulae, posterior margin very broadly concave; disc tricarinate in middle, median and intermediate carinae distinct and complete, with a big lateral pit at side of median carina, respectively. Mesonotum (Fig. 7) tricarinate in disc, nearly parallel. Forewings (Fig. 10) elongate and slender, nearly four times as long as broad; anterior and posterior margins more or less parallel, apex rounded; M vein only branching to MA and MP veins near front-middle before nodal line and firstly branched before Sc+R and CuA veins near middle; apical area with at least three rows of transverse veinlets, veinlets usually not aligned, but in each field running along its length; clavus with a short crossvein, connecting CuP with Pcu; stigma broad and distinct, with 3–5 cross veins. Legs narrow and moderately long; fore femora not flattened and dilated, hind tibiae with 4 lateral and 6 apical black-tipped spines; hind tarsomeres I with about 8–9 and tarsomeres II with about 6–7 black-tipped apical spines, respectively.

Distribution. Sri Lanka.

Pibrocha egregia **(Kirby, 1891)**

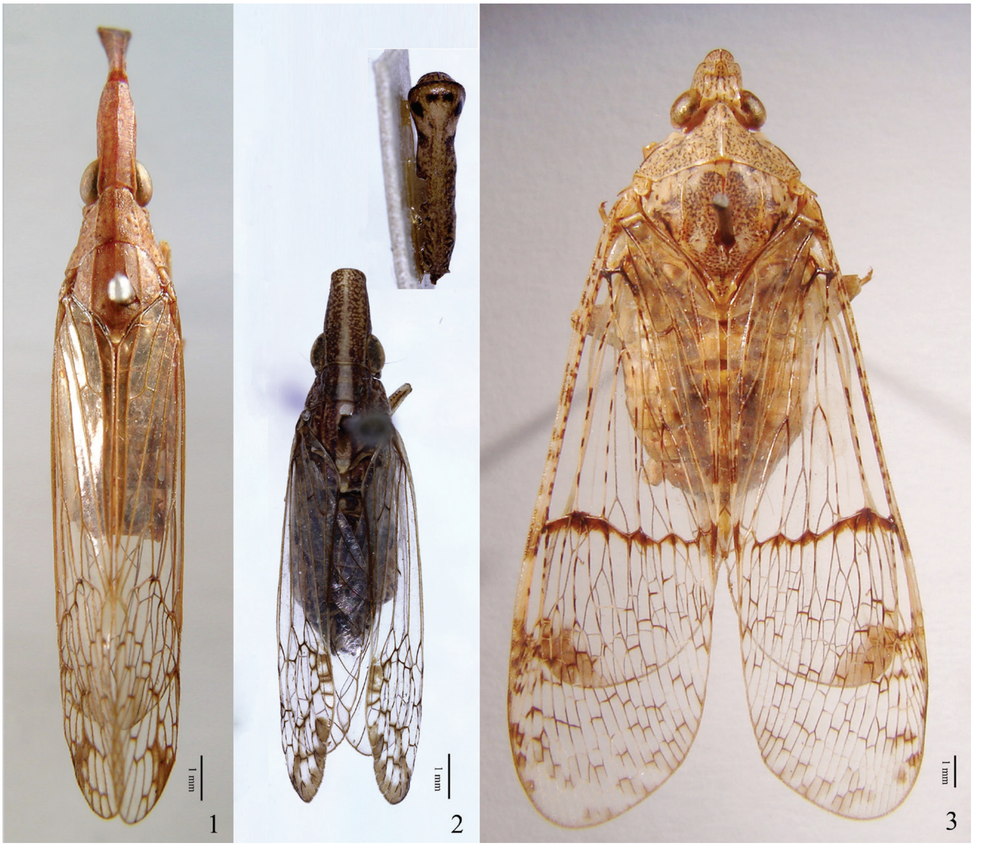
http://species-id.net/wiki/Pibrocha_egregia
Figs 1, 4, 7–16

Dictyophora [sic] *egregia* Kirby, 1891: 135, Pl. 5, Fig.4. Syntype[s] (?sex), Sri Lanka BMNH [not examined].

Pibrocha egregia (Kirby): Kirkaldy, 1902: 51, Pl. B, Fig. 2; Melichar, 1903: 21, Pl. I, Fig. 4; Distant, 1906: 240, Fig. 104; Melichar, 1912: 24, Pl. I, Fig. 10-12; Metcalf, 1946: 31.

Awaramada fryeri Distant, 1914: 413; Distant, 1916: 27, Fig. 14; Metcalf, 1946: 31. Holotype ♂, Sri Lanka (BMNH) [examined]. Synonymised by Liang, 2000: 235.

Redescription. Male, narrow and elongate, body length (from apex of cephalic process to tip of forewings) 21.3–21.5 mm; length of head (including two portions: the former is from apex of cephalic process to curved part, the latter is from curved part to base of eyes) (3.2+5.5)–(3.3+5.4) mm, width (including eyes) 1.8 mm; length of forewings 11.8–12.5 mm.



Figures 1–3. 1 *Pibrocha egregia* (Kirby), ♂, dorsal view **2** *Dorysarthrus mobilicornis* Puton, holotype ♀, dorsal view **3** *Dichoptera hyalinata* (Fabricius), ♂, dorsal view. Scale bars: Figs 1–3 = 1 mm.

Vertex, genae and frons dull brownish-ochraceous, speckled with fuscous, suffused with testaceous-red. Basal 1/3 of frons with some small fuscous spots between intermediate carinae and lateral carinae. Pronotum and mesonotum brownish-ochraceous, tens of punctate spots on each lateral area of pronotum fuscous. Thorax ventrally and legs pale ochraceous. Forewings and hindwings hyaline, venation fuscous, stigma and scattered apical maculate markings on forewings and hindwings fuscous. Abdomen dorsally brownish ochraceous, ventrally paler, with numerous small fuscous spots.

Male genitalia: pygofer slightly broad, nearly rectangular, ventrally distinctly broader than dorsally (about 3.0:1) in lateral aspect (Fig. 12); posterior margin deeply excavated apically to accommodate anal tube, with a long, fingerlike, directed posteriorly process near apex in lateral view (Fig. 12); dorsal margin deeply excavated to accommodate anal tube, dorsal-lateral margins produced posteriorly in dorsal view (Fig. 13). Segment X (anal tube) narrow and elongate, with ratio of length to width near middle about 3.0:1; apical ventral margin protruded an angle on each side, apical dorsal margin deeply excavated to accommodate anal style in dorsal views (Fig. 13); epiproct relatively robust and long. Gonostyles large and broad, without spiniform setae on inner surfaces in basal half; narrow basally, broadest medially and reduced towards apex in lateral view (Fig. 12); upper margin with a small, obtuse process near upper middle, outer upper edge with a ventrally directed, hooklike process near middle in lateral aspect (Fig. 12). Aedeagus (Figs 14–16) large and symmetrical, with a pair of long and slender endosomal processes extended dorsally: basal 2/3 sclerotized and pigmented, apical 1/3 membranous; phallobase basally sclerotized and pigmented, with a pair of ventral angular lamellar processes which its edge membranous, without spine (Figs 15, 16).

Type material examined. Holotype ♂ of *Awaramada fryeri* Distant, **[Sri Lanka]:** (1) Kandy, Ceylon, 7-02; (2) [red label] Type / H.T.; (3) [Distant's handwriting] Awaramada fryeri Distant.

Other material examined. SRI LANKA: 1♂, Ceylon, Udawattekelle, 1966.X.30, no collector; 1♂, Udawattekelle, Kandy, 1966.XI.10–13, no collector (both in USNM); 2♀♀, 1♂, [MNHN(EC)7458, 7459, 7460], Perad (=Peradeniya), Ceylan, Coll. Bugnion, Th. Bourgoin det. 1990; 1♂, Kandy, 7.02. Ceylon, Coll. Bugnion [MNHN(EC)7461], Th. Bourgoin det. 1990; 1♂, Kandy, 6.05. Ceylon, Coll. Bugnion [MNHN(EC)7562], Th. Bourgoin det. 1990 (all in MNHN).

Distribution. Sri Lanka.

Genus *Dorysarthrus* Puton, 1895

http://species-id.net/wiki/Dorysarthrus

Dorysarthrus Puton, 1895: 88; Melichar, 1912: 24; Metcalf, 1946: 29; Emelyanov, 1979: 16. Type species: *Dorysarthrus mobilicornis* Puton, 1895; by monotypy.

Remarks. The genus *Dorysarthrus* was established by Puton in 1895 based on a single species, *D. mobilicornis* Puton, 1895 from Palestine. Now *Dorysarthrus* comprises four species, namely *D. alfierii* De Bergevin, 1923 (not '1924' as stated by Metcalf 1946: 30, see De Bergevin 1923: 173), *D. mobilicornis*, *D. simonyi* Melichar, 1912 and *D. sumakowi* Oshanin, 1908, which are distributed in Egypt, Palestine, Syria, Aden, Arabia, Israel, Turkestan, Turkmen and Iran.

Dorysarthrus mobilicornis Puton, 1895

http://species-id.net/wiki/Dorysarthrus_mobilicornis

Figs 2, 5

Dorysarthrus mobilicornis Puton, 1895: 44; Melichar, 1912: 25; Metcalf, 1946: 30. Holotype ♀, Palestine (MNHN) [examined]

Type material examined. Holotype ♀, **[PALESTINE]:** (1) [Puton's handwriting] Dorysarthrus mobilicornis Put; (2) [Puton's handwriting] Jerusalem; (3) ♀; (4) [red label]

Figures 4–6. 4 *Pibrocha egregia* (Kirby), ♂, lateral view **5** *Dorysarthrus mobilicornis* Puton, holotype ♀, lateral view **6** *Dichoptera hyalinata* (Fabricius), ♂, lateral view. Scale bars: Figs 4–6 = 1 mm.

Type; (5) TH BOURGOIN det. 1990, [Bourgoin's handwriting] Dorysarthrus mobilicornis PUTON, 1895; (6) MNHN-HF-90-106; (7) Museum Paris, MNHN(EH), 452 (MNHN).

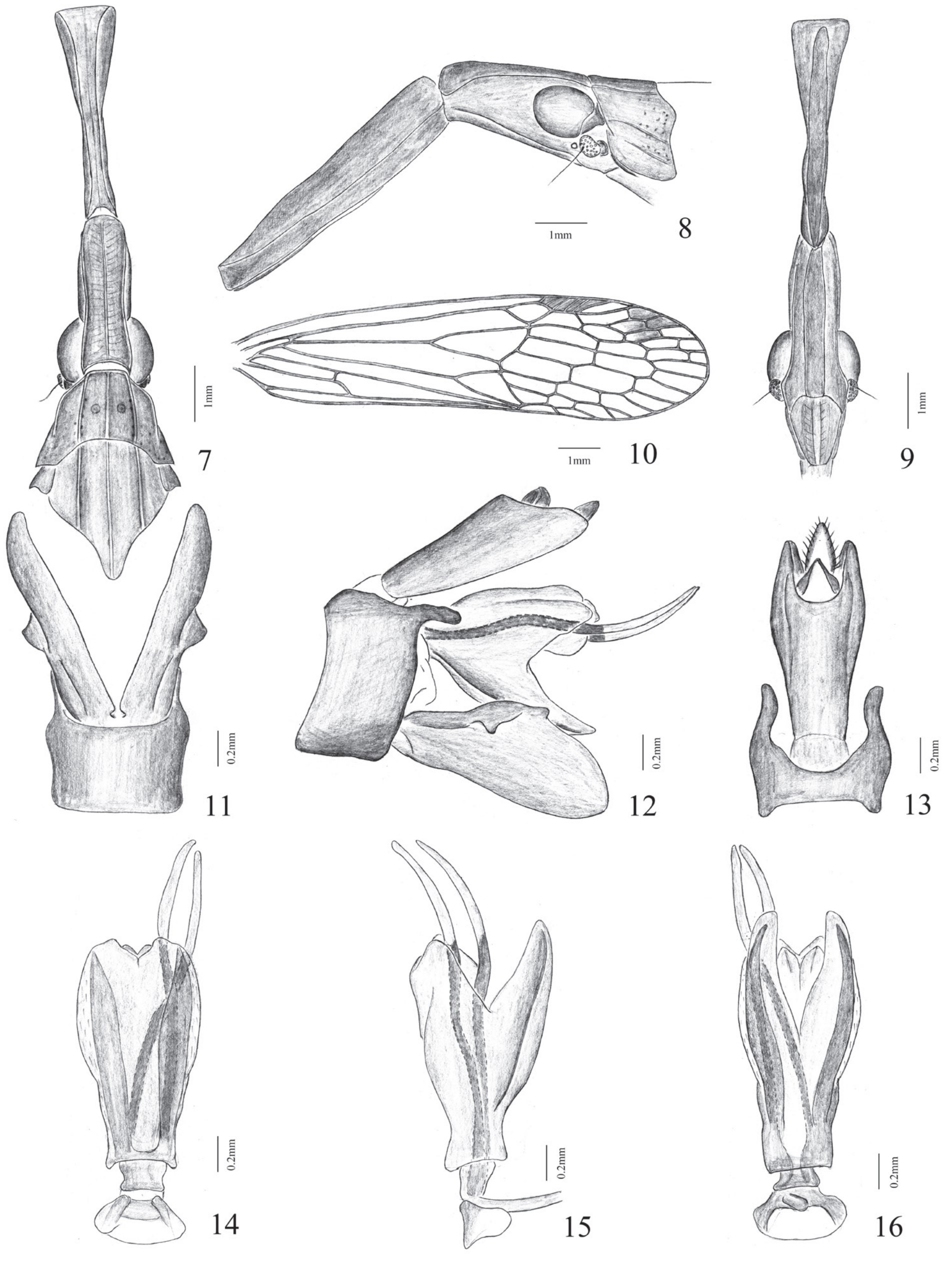
Distribution. Palestine, Syria.

Subfamily Dichopterinae (Melichar, 1912)

Genus *Dichoptera* Spinola, 1839

http://species-id.net/wiki/Dichoptera

Dichoptera Spinola, 1839: 286; Stål, 1862: 487; Kirby, 1891: 147; Kirkaldy, 1902: 50; Melichar, 1912: 41; Metcalf, 1946: 23. Type species: *Fulgora hyalinata* Fabricius, 1781; by monotypy.



Figures 7–16. *Pibrocha egregia* (Kirby, 1891) **7** head, pronotum and mesonotum, dorsal view **8** head and pronotum, lateral view **9** head, ventral view **10** right forewing **11** pygofer and parameres of male, ventral view **12** genitalia of male, lateral view **13** pygofer and anal tube of male, dorsal view **14** aedeagus, dorsal view **15** aedeagus, lateral view **16** aedeagus, ventral view. Scale bars: Figs 7–10 = 1 mm, Figs 11–16 = 0.2 mm.

Clonia Walker, 1858: 60. Type species: *Clonia lurida* Walker, 1858; by monotypy. Synonymised by Stål, 1962: 487.
Thanatophara Kirkaldy, 1904: 280. Nom. nov. for *Clonia* Walker.

Remarks. The genus *Dichoptera* was erected by Spinola in 1939 as one of five dictyopharid genera for the family Dictyopharidae. A total of eleven species are included in the genus, which is restricted in the Oriental region. The genus *Dichoptera* was moved by Emeljanov (1979) from Dictyopharidae to Fulgoridae and a taxonomic review on this group is preparing (Song and Liang, in prep.).

Dichoptera hyalinata **(Fabricius, 1781)**
http://species-id.net/wiki/Dichoptera_hyalinata
Figs 3, 6

Fulgora hyalinata Fabricius, 1781: 315. Syntype[s] (?sex), Bangladesh [not examined].
Flata hyalinata (Fabricius): Germar, 1818:190.
Dictyophara hyalinata (Fabricius): Germar, 1833: 175.
Pseudophana hyalinata (Fabricius): Burmeister, 1835: 160.
Dichoptera hyalinata (Fabricius): Spinola, 1839: 289; Kirby, 1891: 133; Melichar, 1903: 18, Pl. I, Fig. 1; Distant, 1906: 238, Fig. 103; Melichar, 1912: 19; Metcalf, 1946: 25.

Material examined. INDIA: 1♂, Chittoor, 1940.IX., P.S. Nathan (NCSU).
Distribution. Bangladesh, India, Sri Lanka.

Discussion

According to the diagnostic key and photos of the type species of the three genera *Pibrocha*, *Dorysarthrus* and *Dichoptera*, it seem obvious that *Pibrocha* may be more closely related to *Dorysarthrus* than *Dichoptera*. *Pibrocha* and *Dorysarthrus* share some synapomorphies from the following characters: the medium-sized species, much smaller and slenderer than *Dichoptera* species; the very elongate, nearly fractured cephalic process and a similar forewing venation. These distinct characters support well the monophyly of *Pibrocha* and *Dorysarthrus*, and they are assigned together in the subfamily Dorysarthrinae.

Emeljanov (1979) provided eighteen morphological characters for differentiating Fulgoridae from Dictyopharidae. Twelve of them and particularly the short crossvein in the clavus, support that Dorysarthrinae belongs to Fulgoridae. This character is also present in Cladodipterini (Melichar 1912; Metcalf 1946; Emelyanov 1983; Szwedo 2008; Song and Liang 2011; Bourgoin 2011). Thus, by transferring Cladodipterini to Fulgoridae from Dictyopharidae and elevating them to subfamily Cladyphinae (Cladodipterinae), Emeljanov (1979, 2004, 2011) proposed to remove all Dictyopharidae with a claval cross vein to Fulgoridae, versus Melichar (1912), Muir (1930) and Metcalf (1946).

Urban and Cryan (2009) recently performed a first phylogenetic investigation of Fulgoridae based on DNA nucleotide sequence data from five genetic loci. In their phylogenetic analysis, these critical taxa were unfortunately unavailable for analysis. A more comprehensive study employing both molecular and morphological data is now needed, which will include the taxa identified by Emeljanov (1979, 2004, 2011) as intermediate between Fulgoridae and Dictyopharidae.

In view of the problems of defining the distinctiveness between Fulgoridae and Dictyopharidae, Dorysarthrinae is tentatively preserved in Fulgoridae based on Emeljanov (1979) until further taxonomic and phylogenetic analyses in both families can be performed.

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Taxonomic review of the genus *Tambinia* Stål (Hemiptera, Fulgoromorpha, Tropiduchidae) with descriptions of four new species from the Pacific region

Rong-rong Wang†, Ai-Ping Liang‡

Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Road, Chaoyang District, Beijing 100101, China

† *urn:lsid:zoobank.org:author:02FAFFA8-66AA-47D3-AD21-1C9FDF58495A*
‡ *urn:lsid:zoobank.org:author:862BAA85-A5A9-44DE-A6E4-99D30C39B2C9*

Corresponding author: *Ai-Ping Liang* (liangap@ioz.ac.cn)

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Abstract
Four new species of *Tambinia* Stål (Hemiptera: Fulgoromorpha: Tropiduchidae), *T. conus* **sp. n.** (Papua New Guinea), *T. macula* **sp. n.** (Malaysia: Borneo), *T. robustocarina* **sp. n.** (Malaysia: Sabah) and *T. sexmaculata* **sp. n.** (Australia: Kuranda) are described and illustrated from the Pacific region. The diagnostic characters of this genus are redefined. A checklist and a key to the known species of *Tambinia* are provided.

Keywords
Tambinia, Tropiduchidae, Fulgoromorpha, new species, Pacific region

Introduction

The tropiduchid planthopper genus *Tambinia* was established by Stål (1859) for *T. languida* Stål, *T. debilis* Stål and *T. rufoornata* Stål, all from Sri Lanka. The type species, *T. languida* Stål, was fixed later by Distant (1906) by subsequent designation. *Tam-*

binia is currently placed in the tribe Tambiniini Kirkaldy, 1907 (Metcalf 1954; Fennah 1982). The tropiduchid tribe Tambiniini, as redefined by Fennah (1982), comprises ten genera, *Tambinia, Ossoides, Sumbana, Kallitaxila, Kallitambinia, Nesotaxila, Garumna, Paragarumna, Athestia* and *Biruga*. However, in a recent study about tribe Tambiniini, Wang et al. (2009) established one new genus *Garumnella*, and *Paragarumna* was placed as a junior synonym of *Garumna*. O'Brien (2010) also established one new genus *Diambon* in the study of New World Tambiniini from palms. Members of Tambiniini are mainly distributed in the tropical regions of the World.

Although maximum attention has been paid to the monophyly and phylogeny in Fulgoromorpha, relatively little is known about the monophyly of both the Tambiniini and *Tambinia* and their relationships with other tropiduchid taxa in a cladistic sense. Only few papers provided valuable information about *Tambinia*: Wilson (1986) has stated that the Oriental and Australasian genera *Nesotaxila* and *Kallitaxila* appear to be most closely related to *Tambinia*. Asche and Wilson (1989) have indicated that some similarity exists in the aedeagal structure in *Tambinia* species and *Ommatissus* Fieber, 1875 (Trypetimorphini). A cladistic analysis is needed, but is beyond the scope of this paper.

While sorting and identifying Tropiduchidae from material on loan from the California Academy of Sciences, San Francisco, California, USA (CAS), National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (USNM) and elsewhere, we found four new species of *Tambinia* from Papua New Guinea, Malaysia (Borneo, Sabah) and Australia (Kuranda). A revised generic diagnosis and a checklist of all known species of *Tambinia* are provided. A key to known species is also updated.

Materials and methods

Dry pinned specimens were used for the descriptions and illustrations. External morphology was observed under a stereoscopic microscope and characters were measured with an ocular micrometer. Abdomens were removed and macerated in cold 10% KOH overnight. Precise dissections and cleaning of genitalic structures were finished in distilled water. Observations and drawings were done in glycerine under a compound light microscope. Photographs of the types were taken with a Nikon Coolpix 5400 digital camera. The digital images were then imported into Adobe Photoshop 8.0 for labeling and plate composition. Line figures were drawn with the aid of a camera lucida mounted on a Zeiss Stemi SV-11 stereomicroscope.

Specimens of three previously described species of the genus *Tambinia*, i.e. *T. bizonata* Matsumura, 1914, *T. rubrolineata* Liang, 2003 and *T. similis* Liang, 2003, have been examined. No specimens of the other seventeen previously described species were available for examination. However, there is no doubt concerning the identity of those species because the descriptions and illustrations were very clear and detailed. For detailed descriptions and figures of the seventeen previously described species, see Distant (1906, 1916), Fennah (1956, 1970, 1982), Ghauri (1976), Matsumura (1914), Melichar (1914), Metcalf (1946, 1954), Men et al. (2009), Muir (1931), Wilson (1986) and Wilson and Malenovský (2007).

Specimens examined during the course of this study are deposited in the CAS, USNM and Bernice P. Bishop Museum, Honolulu, Hawaii, USA (BPBM). The terminology follows Bourgoin and Huang (1990) and Wang et al. (2009).

Taxonomy

Genus *Tambinia* Stål, 1859
http://species-id.net/wiki/Tambinia

Tambinia Stål, 1859: 316; Distant 1906: 276; Bierman 1910: 26; Muir 1931: 303; Metcalf 1954: 100; Liang and Jiang 2003. Type species *Tambinia languida* Stål by subsequent designation.
Ossa de Motschulsky 1863: 106; Bierman 1910: 26.

Diagnostic characters. Small-sized tropiduchids. Head (Figs 1A–E) with eyes narrowed than pronotum, distinctly produced in front of eyes and apically rounded, usually strongly dorsoventrally depressed and distinctly flattened in lateral view. Vertex (Figs 1A–E, 2–5A) tricarinate, disc of vertex (excluding median carina) depressed, posterior margin straight. Frons (Figs 2–5C) distinctly reclined caudad, somewhat flat and smooth, with or without median carina, rarely covered with sparsely microsetae. Clypeus triangular, relatively convex, with or without median carina, lateral margins not carinate. Rostrum short, not reaching mesotrochanters. Ocelli very small. Antennae with scape very small, pedicel cylindrical, covered with long setulae, sensory plaques present on top surface of pedical. Pronotum (Figs 2–5A) tricarinate, anterior margin straight and hind margin angulately excavate, with a single carina between eye and tegula. Mesonotum tricarinate. Hind titiae each with 2 distinct lateral spines; spinal formula of hind leg (4–5)–(4–5)–2; metatarsal segment II short and small. Forewings (Figs 1A–E) with oblique nodal line, apical portion flexing ventrad at this line, basal portion somewhat sub-hyaline, with or without granulate, thicker than apical portion, costal cell without cross veins.

Male genitalia. Pygofer (Figs 2F–H, 3E, 3G, 3H, 4E–G, 5F–H) symmetrical, dorsal margin deeply excavated to accommodate anal tube. Gonostylus (Figs 2F, 2H, 3E, 3G, 3H, 4E, 4G, 5F, 5H) elongate, bilaterally symmetrical, membranously fused with pygofer at base, with a conical, median process in ventral view, with a dorsally directed process arising from inner side near base and a laminate, inward directed, triangular process arising from inner side near middle. Periandrium (Figs 2F, 3E, 4E, 5F) dorsally connected with ventrobasal margin of anal tube, membranously fused with pygofer at ventral side, tube-like, distinctly sclerotized, surrounding aedeagus subapically or mesially, and visible in lateral view. Aedeagus (Figs 2F, 3E, 4E, 4F, 5F, 5G), asymmetrical, elongate and tubular, shaft of aedeagus (Figs 2F, 3E, 4E, 4F, 5F, 5G) slender and elongate, tubular, and sinuate in lateral view, subapically or mesially embraced in periandrium, endosoma membranous, with or without spines.

Discussion. The genus *Tambinia* comprises twenty-four species and is distributed in Oriental, Australasian and Afrotropical regions (Distant 1906, 1916, Fennah 1956, 1970, 1982, Ghauri 1976, Matsumura 1914, Melichar 1914, Metcalf 1946, 1954, Muir 1931, Wilson 1986, Wilson and Malenovský 2007). The tropiduchid planthoppers are usually weak fliers and have poor ability for long-distance migration by themselves. So, we indicate that new species have formed through geographical isolation over the disjunct distribution of the genus across widely separated island groups.

In external appearance, the genus *Tambinia* is similar to the Oriental and Australasian genera *Nesotaxila*, *Kallitaxila* and *Kallitambinia*. These four genera form a distinct group within tribe Tambiniini. They can be distinguished from the other known genera in the tribe by the head relatively dorsoventrally depressed, produced in front of eyes, but not extreme produced into a linguiform prolongation, apex not broadly rounded to base of frons, and hind tibia with two lateral spines. The four genera can be distinguished as follows:

1 Two carinae on each side of pronotum between eye and tegula and an incomplete carina behind eye.. ***Nesotaxila***

– At most only one complete and one incomplete carina on each side of pronotum between eye and tegula **2**

2 One complete and one incomplete carina on either side of pronotum between eye and tegula; vertex with sublateral carinae distinct and stubby........ .... ***Kallitaxila***

– A single carina laterally on pronotum between eye and tegula; vertex without sublateral carinae, if not, only slender sublateral carinae present.................**3**

3 Forewings with corium granulate; anal tube extreme long, distinctly surpassing terminal of genitalia, aedeagus a simple tube with accompanying spike... ....***Kallitambinia***

– Forewings with corium not granulate, or only obscurely granulation present; anal tube relatively short, not surpassing or slightly surpassing surpassing terminal of genitalia .... ***Tambinia***

Check list of species of *Tambinia* Stål

atrosignata Distant, 1906; Sri Lanka (Paradeniya).
bizonata Matsumura, 1914; China (Taiwan), Japan.
capitata Distant, 1906; Burma, Malay States, India.
conus sp. n.; Papua New Guinea.
debilis Stål, 1859; India, Sri Lanka, Vietnam, South China (Anhui Province, Guangdong Province, Guangxi Zhuang Autonomous Region, Zhejiang Province,

Fujian Province, Hainan Island, Hong Kong, Taiwan), Japan, Malacca, Malaysia, Singapore.
exoleta Melichar, 1914; New Guinea (Moroka).
fasciculosa Melichar, 1914; New Guinea (Moroka).
guamensis Metcalf, 1946; Micronesia (Guam).
inconspicua Distant, 1906; Burma.
languida Stål, 1859; Sri Lanka.
macula sp. n.; Malaysia (Borneo).
menglunensis Men & Qin, 2009; China (Yunnan Province).
pitho Fennah, 1970; Philippines.
robustocarina sp. n.; Malaysia (Sabah).
rubrolineata Liang, 2003; South China (Hainan Island), Laos, Vietnam.
rubromaculata Distant, 1916; Sri Lanka.
rufoornata Stål, 1859; Sri Lanka.
sexmaculata sp. n.; Australia (Kuranda).
similis Liang, 2003; Vietnam.
sisyphus Fennah, 1956; Micronesia (Western Caroline Islands: Palau).
theivora Fennah, 1982; Malaysia (Cameron Highlands).
venusta (Kirkaldy, 1906); Australia (Queensland), New Guinea.
verticalis Distant, 1916; India (Southern India, Coorg, Madras), Zanzibar, Tanga.
zonata Muir, 1931; India (Madras).

Key to species of genus *Tambinia*

1	Vertex shorter in middle than the widest breadth, or about as long as broad... **2**
–	Vertex distinctly longer in middle than the widest breadth........................ **11**
2	Frons with carina obsolete... **3**
–	Frons with carina distinct... **4**
3	Frons about as long as broad, forewings with two black elongate spots near bases of sutural margins, nodal line marked with several fuscous spots (see Distant, 1906: 278) .... ***T. atrosignata* Distant**
–	Frons (Fig. 3C) distinctly longer than broad, forewings (Figs 1B, 3D) with two red elongate marks near bases of sutural margins, many orange or red spots marked from basal part to nodal line, nodal line suffused with one transverse orange to red band.. ***T. macula* sp. n.**
4	Forewings with granulate... **5**
–	Forewings without granulate... **6**
5	Forewings marked without transverse bands (see Distant 1906: 279, Fig. 129; Distant 1906: 277) .... ***T. debilis* Stål**
–	Forewings marked with two brown transverse bands across wing sub-basally, on nodal line and in clavus (Yang et al. 1989: 80, Fig.6) .... ***T. bizonata* Matsumura**

6 Forewings with nodal line near apex **7**
– Forewings with nodal line near middle **9**
7 Forewings with marks and stripes distinct **8**
– Forewings with marks and stripes very pale, nearly absent (Fig. 1C) .... ***T. similis*** **Liang**
8 Forewings with 11 apical cells, 4–5 subapical cells (see Liang 2003: 511; Fig. 1) .... ***T. rubrolineata*** **Liang**
– Forewings with 9 apical cells, 3–4 subapical cells (see Fennah 1982: 641, Fig. 35) .... ***T. theivora*** **Fennah**
9 Body suffused with distinct spots and markings **10**
– Body (Fig. 1D) without spots and markings, median carinae of vertex and pronotum thickened and broad, frons (Fig. 4C) with basal part of median carina strongly broad and thickened, not reaching to frontoclypeal suture, obsolete on level of antennae .... ***T. robustocarina*** **sp. n.**
10 Vertex, pronotum and mesonotum marked with reddish spots, forewings with nodal line suffused with red stripes (see Men and Qin 2009: 263, Figs 1, 2) .... ***T. menglunensis*** **Men & Qin**
– Vertex without spots, pronotum with posterior margin marked with reddish stripes, mesonotum with carinae reddish, forewings with nodal line suffused with fuscous (see Distant 1906: 278) .... ***T. rufoornata*** **Stål**
11 Vertex medially 1.1–1.3 times as long as maximum breadth **12**
– Vertex medially 1.4–1.8 times as long as maximum breadth **18**
12 Body above suffused with marks or different colors **13**
– Body above concolorous, without marks or different colors **16**
13 Vertex with sublateral carinae basally between median carina and lateral margins **14**
– Vertex without sublateral carinae between median carina and lateral margins..15
14 Vertex (Figs 1E, 5A) with six red spots, pronotum and mesonotum without spots, forewings (Figs 1E, 5D) with two pairs of red spots near bases of sutural margins and distad of level of union of claval veins relatively .... ***T. sexmaculata*** **sp. n.**
– Vertex (Figs 1A, 2A) with two short reddish stripes, pronotum with a pair of orange spots outside lateral carinae, carinae on vertex and pronotum orange, mesonotum with a pair of orange spots beside lateral carinae near posterior margin, forewings (Figs 1A, 2D) with many reddish spots marked from basal part to nodal line .... ***T. conus*** **sp. n.**
15 Carinae on vertex, pronotum and mesonotum without pigmentation, mesonotum suffused with ochraceous (see Distant 1906: 276, Fig. 127)............ .... ***T. languida*** **Stål**
– Carinae on vertex, pronotum and mesonotum reddish, mesonotum suffused with dark brown (see Muir 1931: 303) .... ***T. zonata*** **Muir**
16 Head not prominently narrowed anteriorly... **17**

– Head gradually narrowed to apex (see Distant 1906: 278) .... ***T. capitata*** **Distant**

17 Forewings with Cu_1 forking distad of level of union of claval veins, with 12 apical cells, subapical cells less than 5 (see Fennah 1956: 188, Fig. 54 a, d, g)........ .... ***T. guamensis*** **Metcalf**

– Forewings with Cu_1 forking basad of level of union of claval veins, with 14 apical cells, subapical cells more than 6 (see Fennah 1970: 77, Fig. 46)......... .... ***T. pitho*** **Fennah**

18 Body concolorous, without marks or different colors **19**

– Body suffused with marks or different colors..**20**

19 Vertex medially 1.4 times as long as maximum breadth, pronotum without short carinae between median carina and lateral margin (see Distant 1906: 277, Fig. 128)... ***T. inconspicua*** **Distant**

– Vertex medially 1.7 times as long as maximum breadth, pronotum with a pair of short carinae basally between median carina and lateral margins (see Fennah 1956: 189, Fig. 54 e, f, i) ....***T. sisyphus*** **Fennah**

20 Forewings with nodal line suffused with pigmentation..............................**21**

– Forewings with nodal line concolorous, without pigmentation **22**

21 Vertex and pronotum with orange marks, nodal line suffused with fuscous (see Wilson 1986: 386, Figs 1, 3).................................***T. verticalis*** **Distant**

– Vertex, pronotum and mesonotum red, carinae green (see Wilson and Malenovský 2007, Fig. 3) .... ***T. fasciculosa*** **Melichar**

22 Forewings suffused with marks...**23**

– Forewings without marks (see Melichar 1914: 86)......... ***T. exoleta*** **Melichar**

23 Vertex and pronotum finely marked with red spots (see Distant 1916: 48) ... . ***T. rubromaculata*** **Distant**

– Vertex marked with six red spots, pronotum with lateral carinae red (see Melichar 1914: 87) .... ***T. venusta*** **Kirkaldy**

Tambinia conus **sp. n.**
urn:lsid:zoobank.org:act:B4955F97-4D85-485C-8200-345005DD0F1B
http://species-id.net/wiki/Tambinia_conus
Figs 1A, 2A–H

Description. Body length (from apex of vertex to tip of forewings): ♂ 6.5 mm (N=1).

Colour. General colour tawny yellow, vertex (Figs 1A, 2A) with two short reddish stripes, pronotum (Figs 1A, 2A) with a pair of orange spots outside lateral carinae, median carinae on vertex and pronotum orange, mesonotum (Figs 1A, 2A) with a pair of orange spots beside lateral carinae near posterior margin, genae (Fig. 2B) with orange patch between eye and lateral margin of frons, forewings (Figs 1A, 2D) with many reddish spots marked from basal part to nodal line, tips of spines on hind tibiae and tarsi black.

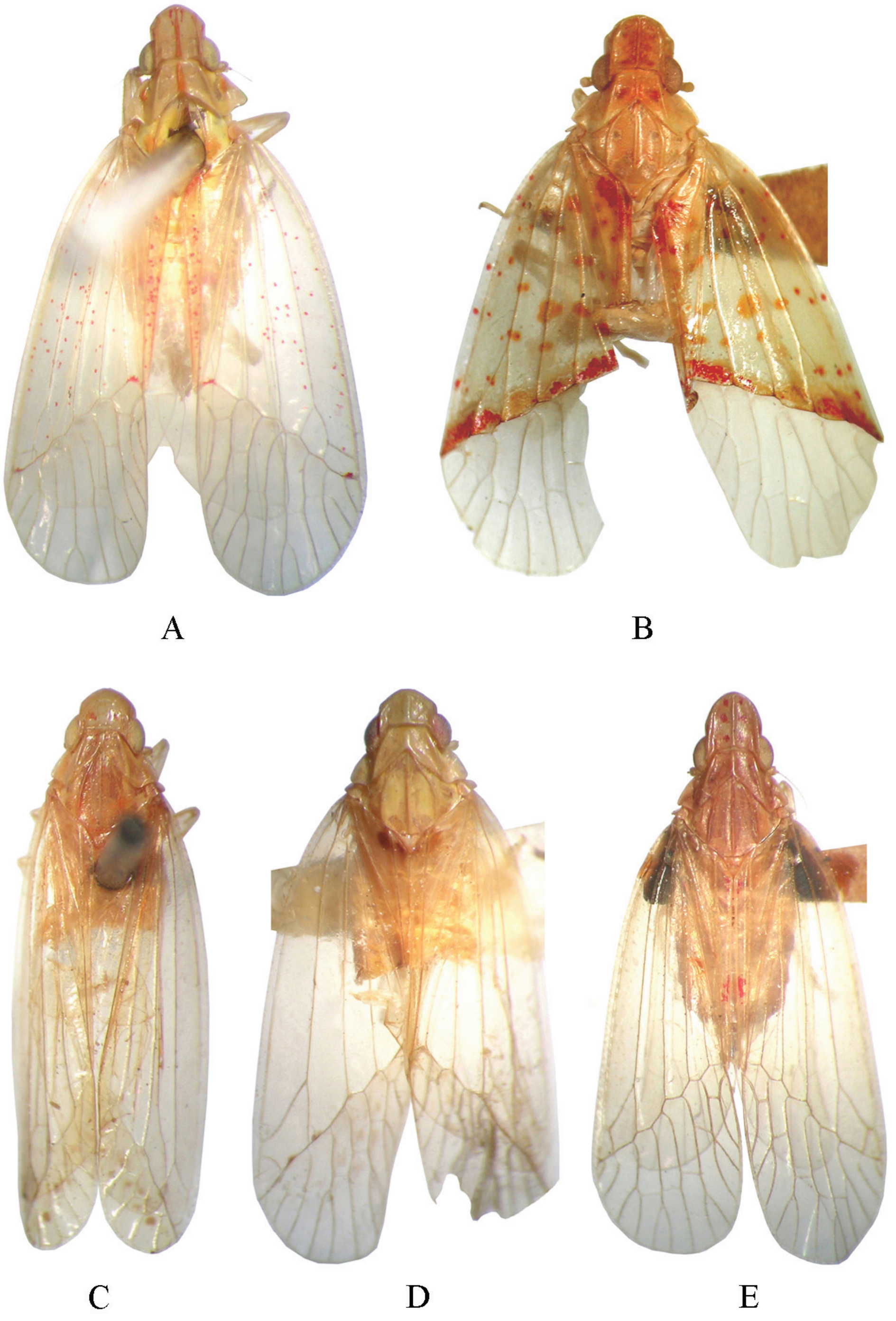

Figure 1. Dorsal habitus of *Tambinia* species **A** *T. conus* sp. n. (male, Papua New Guinea, CAS) **B** *T. macula* sp. n. (male, Malaysia:Borneo, CAS) **C** *T. similis* Liang (male, Vietnam, BPBM) **D** *T. robustocarina* sp. n.(male, Malaysia: Sabah, USUM) **E** *T. sexmaculata* sp. n.(male, Australia:Kuranda, CAS).

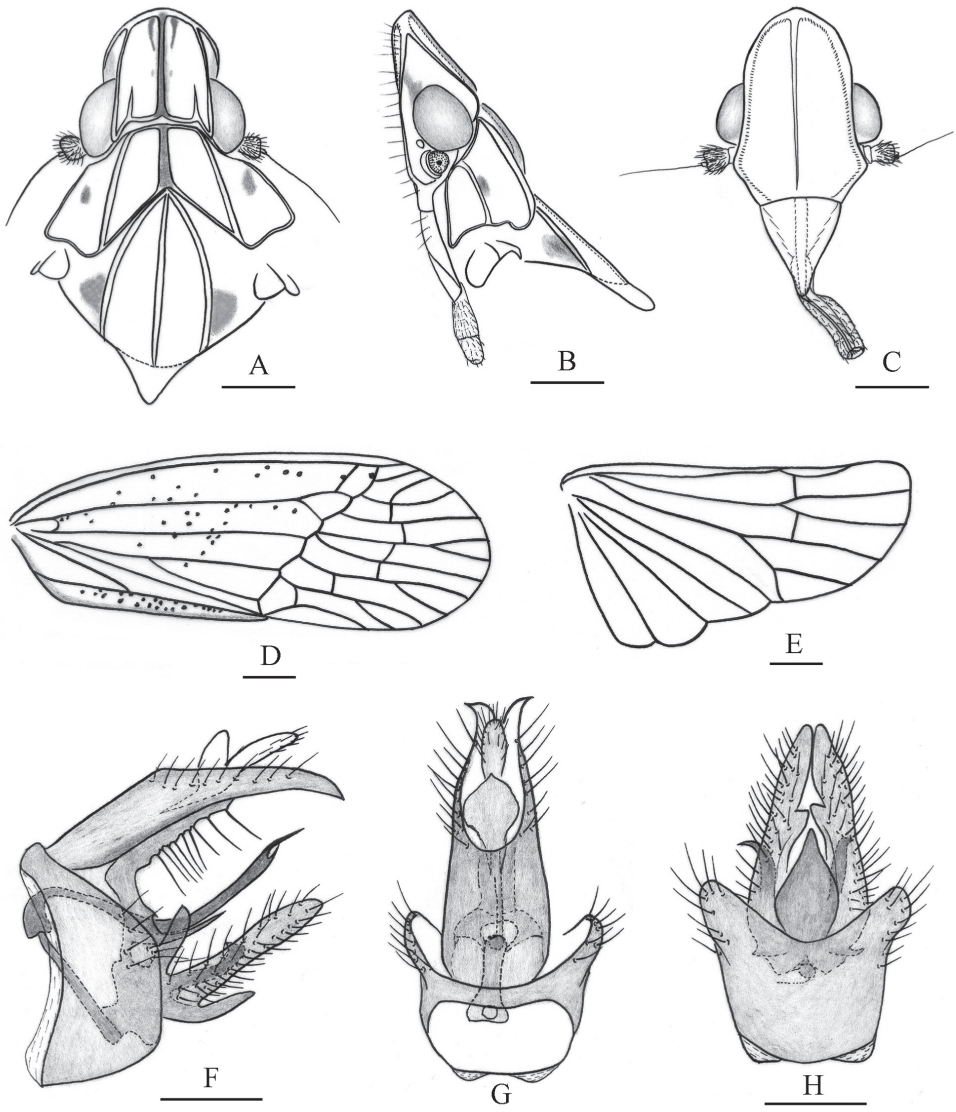

Figure 2. *Tambinia conus* sp. n. **A** head, pronotum and mesonotum, dorsal view **B** head, pronotum and mesonotum, lateral view **C** head, ventral view **D** right fore wing **E** right hind wing **F** male genitalia, left view **G** anal segment and pygofer, dorsal view **H** pygofer and gonostylus, ventral view. Scale bars: Figs A–C = 0.25 mm; D–E = 0.5 mm; F–H = 0.25 mm.

Head and thorax. Head (Figs 1A, 2A, 2B) projecting before eyes approximately median length of eye, strongly dorsoventrally depressed. Vertex (Figs 1A, 2A) slightly longer in middle than the widest breadth (1.1: 1), distinctly longer than pronotum at midline (1.6: 1); anterior margin projected at an obtuse angle in dorsal view, lateral margins ridged and converged anteriorly; median carina thin and percurrent, with a pair of short sublateral carinae basally between median carina and lateral margins; posterior margin straight. Frons (Fig. 2C) longer in middle than the widest breadth (1.4: 1), disc flat and smooth, covered with sparsely microsetae (Fig. 2B); lateral margins sinuous, diverging from apex, slightly concave at level of eyes, then diverging further to reach their widest point before converging to the clypeus; median carina slender, gradually thinning and obsolete posteriorly, almost reaching to frontoclypeal suture. Clypeus (Fig. 2C) triangular, with broad median carina. Pronotum (Figs 1A, 2A) distinctly shorter than mesonotum in midline (0.4: 1), carinae strongly ridged, lateral carinae diverging posteriorly, median carina distinct, reaching posterior margin. Pronotum and mesonotum together medially 2.2 times as long as median length of vertex. Hind tibiae each with 2 distinct lateral spines; spinal formula of hind leg 5–5–2. Forewings (Figs 1A, 2D) relatively elongate and narrow, 2.7 times as long as maximum breadth, with corium smooth, not granulate, Sc+R forking at 2/5 apical, Cu_1 forking after level of junction of claval veins, cell Sc with a short cross vein at its apical angle, with 13 apical cells and 6 subapical cells, claval veins uniting basad of middle of clavus.

Male genitalia. Pygofer (Figs 2F–H) narrow and relatively high, wider ventrally than dorsally, anterior margin moderately concave, posterior margin nearly straight on ventral half in lateral view. Anal tube (Figs 2F, 2G) distinctly elongate, surpassing to apex of gonostylus, ventral margin slightly bent ventrad in lateral view; lateral margins narrowing distad, apical margin distinctly forked in dorsal view; anal styles relatively short and stout, not surpassing apex of anal tube in dorsal view. Gonostylus (Figs 2F, 2H) very narrow, apical part dorsoposteriorly directed in lateral view; median conical process distinctly elongate and strong, sclerotized, nearly reaching to middle part of gonostylus in ventral view. Periandrium (Fig. 2F) distinctly short, ring-shape, with a long process directed caudad at ventral side, surround aedeagusat medially. Aedeagus (Fig. 2F) with shaft sinuate and apical half dorsoposteriorly directed in lateral view, apical part forking at endosoma, forming two process, which dorsal one distinctly longer than the ventral one; endosoma membranous, slightly expanded.

Material examined. Holotype ♂, PAPUA NEW GUINEA: Madang Province, Finisterre Range, Teptep, stream NE of town, 2100-2560 m, 23 Mar 1989, Stop #89-40A, D. H. Kavanaugh and G. E. Ball collectors, PAPUA NEW GUINEA EXPEDITION-1989 (CAS).

Etymology. This new species is named for the presence of a strong median conical process at apically inner margin of gonostylus (Figs 2F, 2H).

Distribution. Papua New Guinea.

Remarks. This species is similar to *T. languida* Stål, 1859 collected from Sri Lanka, but can be distinguished from the latter in the vertex with two short reddish stripes, pronotum with a pair of orange spots outside lateral carinae, carinae of vertex and pronotum orange, mesonotum with a pair of orange spots beside lateral carinae near posterior margin, forewings with many reddish spots marked from basal part to nodal line and the frons with ratio of median length to the widest breadth 1.4:1 (in *T. languida*, vertex and pronotum without pigmentation, mesonotum sometimes suffused with ochraceous, the frons with ratio of median length to the widest breadth 2:1, see Stål, 1859: 317; Melichar, 1914: 85).

***Tambinia macula* sp. n.**
urn:lsid:zoobank.org:act:AD6252E1-EF47-441F-A4CC-8F6D1A721CE8
http://species-id.net/wiki/Tambinia_macula
Figs 1B, 3A–H

Description. Body length (from apex of vertex to tip of forewings): ♂ 5.6 mm (N=1).

Colour. General colour ocherous, vertex (Figs 1B, 3A) with median carina suffused reddish, the reddish extending from the sides, forming two reddish long stripes, its outer margins irregular, pronotum (Figs 1B, 3A) with a pair of reddish spots at disc depression between median and lateral carinae, frons (Fig. 3C) suffused with pale reddish, forewings (Figs 1B, 3D) with basal portion ocherous, with two red elongate marks near bases of sutural margins, many orange or red spots marked from basal part to nodal line, nodal line suffused with one transverse orange to red band, tips of spines on hind tibiae and tarsi black.

Head and thorax. Head (Figs 1B, 3A) projecting before eyes approximately median length of eye, strongly dorsoventrally depressed. Vertex (Figs 1B, 3A) about as long as broad, two times as long as median length of pronotum, anterior margin projected at an obtuse angle in dorsal view, lateral margins ridged and converged anteriorly; median carina thin and percurrent; posterior margin straight. Frons (Fig. 3C) longer in middle than the widest breadth (1.3: 1), disc slightly depressed, covered with sparsely microsetae (Figs 3B, 3C); lateral margins sinuous, diverging from apex, slightly concave at level of eyes, then diverging further to reach their widest point before converging to the clypeus; without median carina. Clypeus (Fig. 3C) triangular, without median carina. Pronotum (Figs 1B, 3A) distinctly shorter than mesonotum in midline (0.3: 1), carinae strongly ridged, lateral carinae diverging posteriorly, median carina distinct, reaching posterior margin. Pronotum and mesonotum together medially 2.1 times as long as median length of vertex. Hind tibiae each with 2 distinct lateral spines; spinal formula of hind leg 5–5–2. Forewings (Figs 1B, 3D) relatively broad, with basal portion semihyaline, thicker than apical portion, without granulation, 2.7 times as long as maximum breadth, Sc+R forking about medially, Cu_1 forking after level of junction of claval veins, cell Sc with a short cross vein at its apical angle, with 12 apical cells and 5 subapical cells, claval veins uniting distad of middle of clavus.

Male genitalia. Pygofer (Figs 3E, 3G, 3H) narrow and high, wider ventrally than dorsally, anterior margin concave medially, posterior margin produced caudad in lateral view. Anal tube (Figs 3E, 3F) relatively elongate, ventral margin nearly straight and directed caudad in lateral view; lateral margins slightly diverging distad, apical margin concave in dorsal view; anal styles relatively long, distinctly surpassing apex of anal tube in dorsal view. Gonostylus (Figs 3E, 3G, 3H) elongate, basal half broad and apical half abruptly narrow in lateroventral view; median conical process very thin and slen-

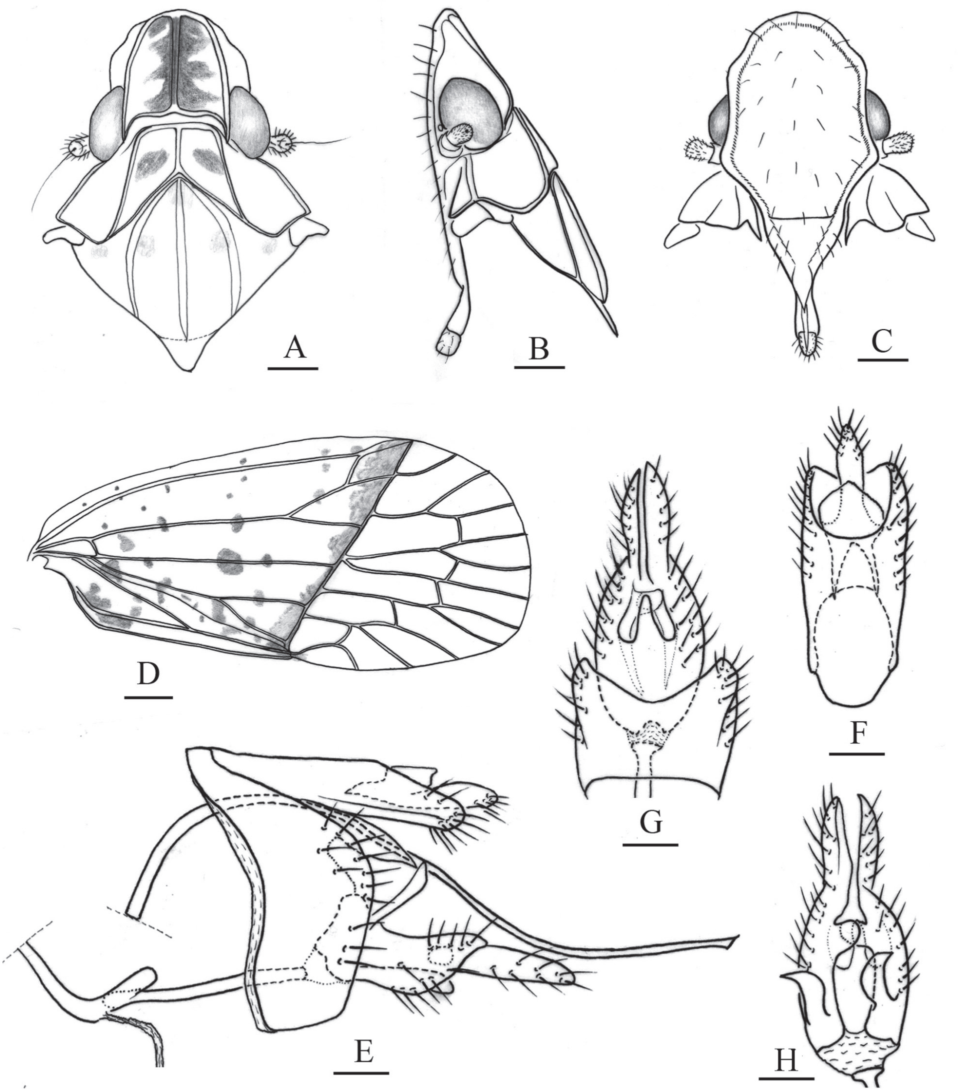

Figure 3. *Tambinia macula* sp. n. **A** head, pronotum and mesonotum, dorsal view **B** head, pronotum and mesonotum, lateral view **C** head, ventral view **D** right fore wing **E** male genitalia, left view **F** anal segment, dorsal view **G** pygofer and gonostylus, ventral view **H** gonostylus, dorsal view. Scale bars: Figs A–D = 0.25 mm; E–H = 0.125 mm.

der, sclerotized in ventral view. Periandrium (Fig. 3E) tube-like, distinctly sclerotized, with a short process directed ventrad at dorsal apex, surrounding aedeagus medially. Aedeagus (Fig. 3E) with shaft very long and thin, simple tubule, sinuate and its apex directed caudad in lateral view, endosoma indistinct.

Material examined. Holotype ♂, MALAYSIA: Banaakan Borneo, 1927.I, Pemberton Coll. (CAS).

Etymology. This new species is named for the presence of many reddish markings on vertex, pronotum and tegmina (Fig. 1B).

Distribution. Malaysia (Borneo).

Remarks. This species is similar to *T. atrosignata* Distant, 1906, but can be distinguished from the latter in vertex with two reddish long stripes, pronotum with a pair of reddish spots, forewings with basal portion ocherous, with two red elongate marks near bases of sutural margins, many orange or red spots marked from basal part to nodal line and nodal line suffused with one transverse orange to red band.

Tambinia robustocarina **sp. n.**

urn:lsid:zoobank.org:act:4583165F-DBE6-4F7A-AA36-FC1FBF6369FF

http://species-id.net/wiki/Tambinia_robustocarina

Figs 1D, 4A–G

Description. Body length (from apex of vertex to tip of forewings): ♂ 6.8 mm (N=1).

Colour. General colour tawny yellow, forewings (Figs 1D, 4D) with two fuscous elongate marks near bases of sutural margins, nodal line suffused with pale brown marks, many fuscous spots marked from nodal line to apex, tips of spines on hind tibiae and tarsi black.

Head and thorax. Head (Figs 1D, 4A) projecting before eyes approximately 3/5 median length of eye, not strongly dorsoventrally depressed. Vertex (Figs 1D, 4A, 4B) distinctly shorter in middle than the widest breadth (0.6: 1), distinctly longer than pronotum at midline (1.7: 1), anterior margin convex, broadly callused, uniting with base of frons to form smooth surface, lateral margins ridged and converged anteriorly, median carina long and percurrent, thickened and broad, posterior margin straight. Frons (Fig. 4C) slightly longer medially than greatest width (1.3: 1), disc flat and smooth, covered with sparsely microsetae (Fig. 4B), lateral margins diverging to below level of eyes, distinctly callused; median carina with basal part strongly broad and thickened, not reaching to frontoclypeal suture, obsolete on level of antennae. Clypeus (Fig. 4C) triangular, with distinctly broad median carina. Pronotum (Figs 1D, 4A) distinctly shorter than mesonotum in midline (0.2: 1), carinae broadly ridged, lateral carinae diverging posteriorly, median carina distinctly thickened and broad, reaching posterior margin. Pronotum and mesonotum together medially 3.0 times as long as median length of vertex. Hind tibiae each with 2 distinct lateral spines; spinal formula of hind leg 5–5–2. Forewings (Figs 1D, 4D) relatively elongate and narrow, 3.0 times as long as maximum breadth, with corium smooth, not granulate, Sc+R forking at apical 2/5, Cu_1 forking after level of junction of claval veins, with 11 apical cells and 6 subapical cells, claval veins uniting at about middle of clavus.

Male genitalia. Pygofer (Figs 4E–G) irregular subquadrate in lateral view, anterior margin concave on dorsal 1/3, posterior margin produced caudad in lateral view. Anal tube (Figs 4E, 4F) relatively elongate, ventral margin slightly bent ventrad in lateral view; lateral margins convex medially then narrowing distad, apical margin slightly

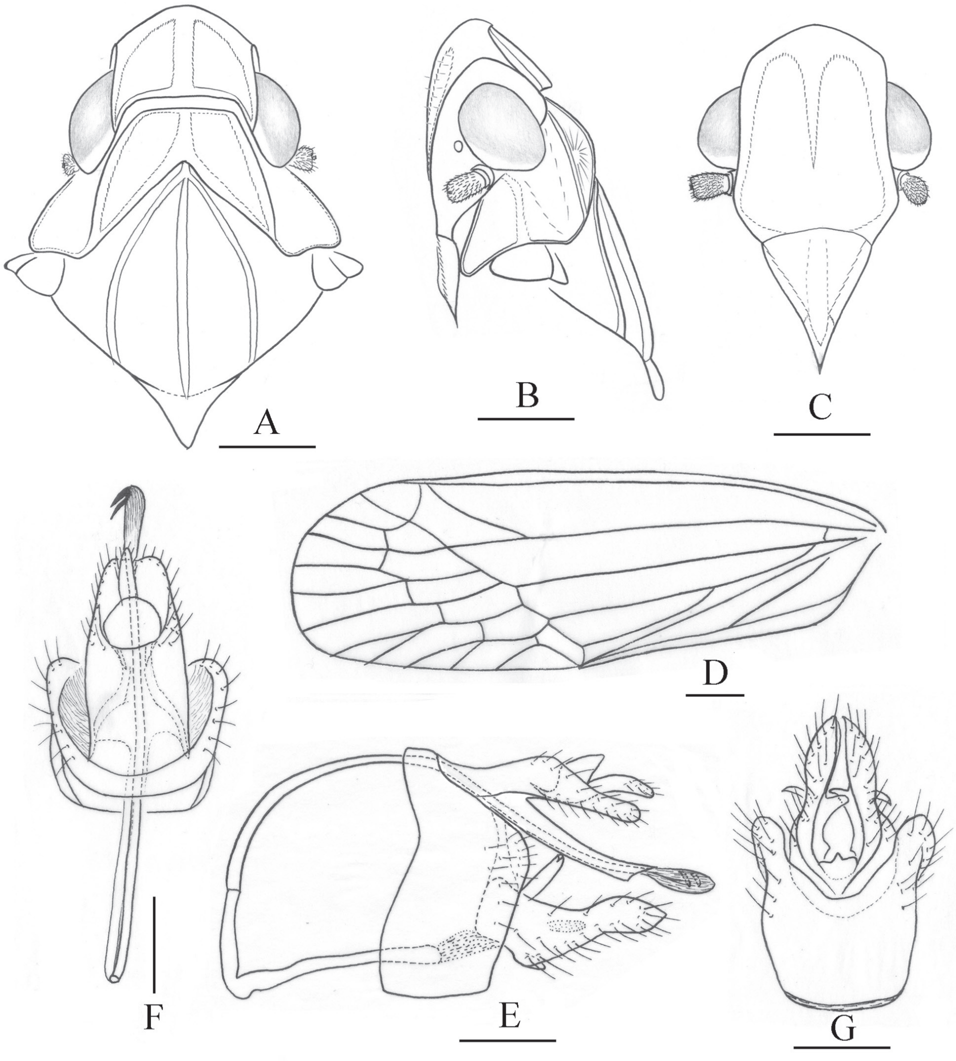

Figure 4. *Tambinia robustocarina* sp. n. **A** head, pronotum and mesonotum, dorsal view **B** head, pronotum and mesonotum, lateral view **C** head, ventral view **D** left fore wing **E** male genitalia, left view **F** male genitalia, dorsal view **G** pygofer and gonostylus, ventral view. Scale bars: Figs A–C = 0.25 mm; D = 0.5 mm; E–G = 0.25 mm.

concave in dorsal view; anal styles relatively long and narrow, surpassing apex of anal tube in dorsal view. Gonostylus (Figs 4E, 4G) elongate, but not surpassing to apex of gonostylus, apical half narrow and basal half broad in lateral view; median conical process very small, sclerotized in ventral view. Periandrium (Fig. 4E) distinctly elongate and slender, tube-like, distinctly sclerotized, with a short process directed caudad at dorsal apex, surrounding aedeagus subapically. Aedeagus (Figs 4E, 4F) with shaft thin and tubular, arched and its apex directed ventrad in lateral view, endosoma membranous, moderately expanded, with two, anteroventrally directed, spinous processes on right side in lateral view.

Material examined. Holotype ♂, MALAYSIA: Malaysia: Sabah: 25 km N Tambunan, 1500 m, 1983.IX.3, at black light, G. F. Hevel & W. E. Steiner (USNM).

Etymology. This new species is named for the presence of a robust median carina on the vertex (Figs 1D, 4A).

Distribution. Malaysia (Sabah).

Remarks. Based on the following combination of characters: head relatively short, not strongly dorsoventrally depressed, broadly produced anteriorly; vertex with median carina strongly thickened and broad; pronotum with median carina relatively broad and frons with basal part of median carina strongly broad and thickened, this species and the four previously described species, *T. menglunensis*, *T. rubrolineata*, *T. similis* and *T. theivora* form a very distinct group within *Tambinia*.

In external appearance, this species is similar to *T. similis* (Fig. 1C) and but differs from the latter in the median carina on vertex long and percurrent, thickened and broad, but not spatula-like, forewings relatively broad, nodal line relatively near middle and cell Sc without a short cross vein at its apical angle. This species is also similar to *T. menglunensis* (see Men and Qin, 2009: 263, Figs 1, 2), but differs from the latter in the obsolete spots and markings on the vertex, pronotum, mesomotum and forewings, median carinae on vertex, pronotum and frons strongly thickened and broad, and gonostylus with median conical process very small.

Tambinia sexmaculata sp. n.

urn:lsid:zoobank.org:act:56274E10-6B5F-41CC-9DB7-563446EC4CD2
http://species-id.net/wiki/Tambinia_sexmaculata
Figs 1E, 5A–H

Description. Body length (from apex of vertex to tip of forewings): ♂ 6.2 mm (N=1), ♀, 6.6–6.8 mm (N=2).

Colour. General colour tawny yellow, vertex (Figs 1E, 5A) with six red spots, genae (Fig. 5B) with orange patch between eye and lateral margin of frons, forewings (Figs 1E, 5D) with two pairs of red spots near bases of sutural margins and distad of level of union of claval veins, relatively, tips of spines on hind tibiae and tarsi black.

Head and thorax. Head (Figs 1E, 5A) projecting before eyes 1.2 times as long as median length of eye, strongly dorsoventrally depressed. Vertex (Figs 1E, 5A) distinctly longer in middle than the widest breadth (1.1: 1), distinctly longer than pronotum at midline (2.3: 1); anterior margin projected at an obtuse angle in dorsal view, lateral margins ridged and converged anteriorly; median carina thin and percurrent, with a pair of short sublateral carinae basally between median carina and lateral margins; posterior margin nearly straight. Frons (Fig. 5C) longer in middle than the widest breadth (1.6: 1), disc flat and smooth, covered with very sparsely microsetae (Figs 5B, 5C); lateral margins sinuous, diverging from apex, slightly concave at level of eyes, then slightly diverging to

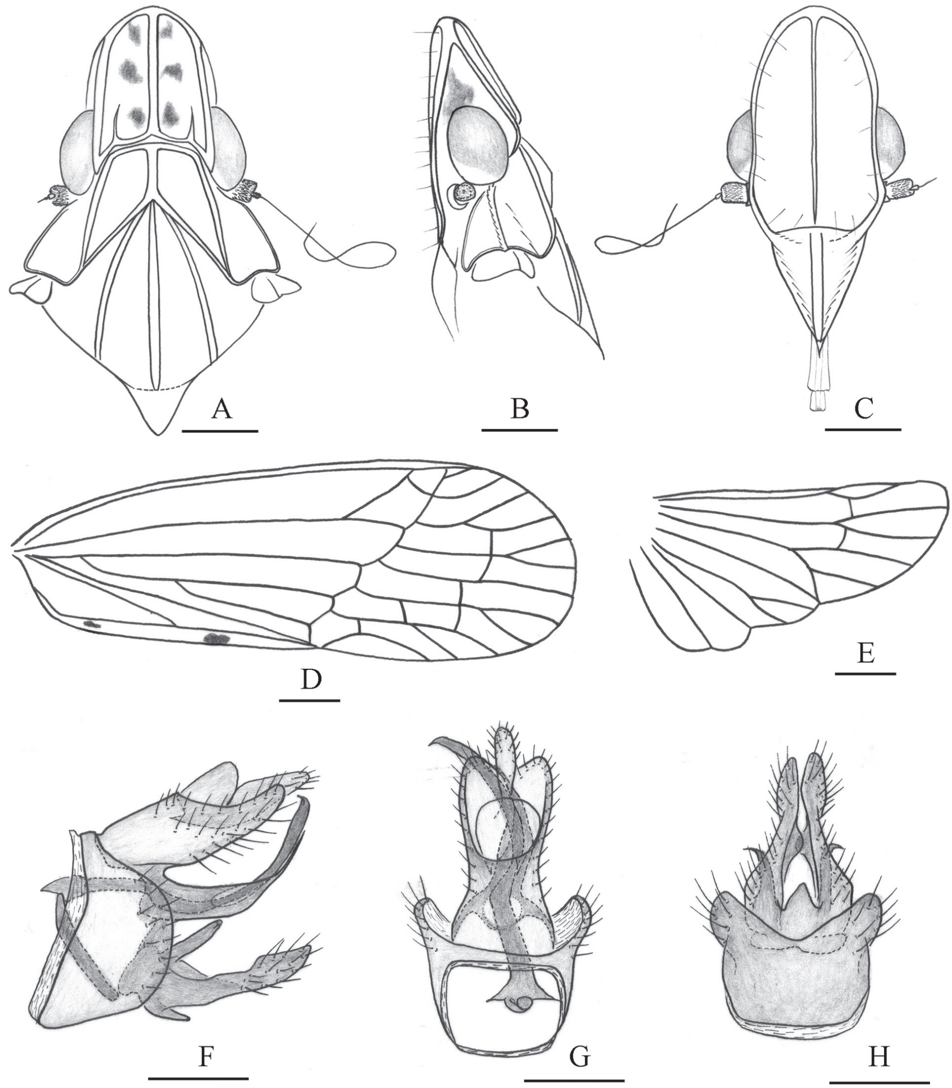

Figure 5. *Tambinia sexmaculata* sp. n. **A** head, pronotum and mesonotum, dorsal view **B** head, pronotum and mesonotum, lateral view **C** head, ventral view **D** right fore wing **E** right hind wing **F** male genitalia, left view **G** male genitalia, dorsal view **H** pygofer and gonostylus, ventral view. Scale bars: Figs A–C = 0.25 mm; D–E = 0.5 mm; F–H = 0.25 mm.

reach their widest point before converging to the clypeus; median carina long and slender, nearly reaching to frontoclypeal suture. Clypeus (Fig. 5C) triangular, with distinct median carina. Pronotum (Figs 1E, 5A) distinctly shorter than mesonotum in midline (0.3: 1), carinae strongly ridged, lateral carinae moderately diverging posteriorly, median carina distinct, reaching posterior margin. Pronotum and mesonotum together medially 2.0 times as long as median length of vertex. Hind titiae each with 2 distinct lateral spines; spinal formula of hind leg 4–5–2. Forewings (Figs 1E, 5D) relatively elongate and narrow, 2.8 times as long as maximum breadth, with corium smooth, not granulate, Sc+R forking at 2/5 apical, Cu_1 forking at level of junction of claval veins, with 12–13 apical cells and 5 subapical cells, claval veins uniting distad of middle of clavus.

Male genitalia. Pygofer (Figs 5F–H) moderately broad, anterior margin concave on dorsal 1/3, posterior margin convex caudad in lateral view. Anal tube (Figs 5F, 5G) distinctly elongate, almost surpassing to apex of gonostylus, ventral margin slightly curve dorsad in lateral view; lateral margins concave medially then diverging from apex, apical margin distinctly concaved in dorsal view; anal styles long and strong, surpassing apex of anal tube in dorsal view. Gonostylus (Figs 5F, 5H) very narrow, expanded subapically then narrowing to apex, directed caudad in lateral view; median conical process distinct, relatively short. Periandrium (Figs 5F, 5G) distinctly elongate and sclerotized, tube-like, surrounding aedeagus medially, with a long, sinuate process at left side, dorsoposteriorly directed. Aedeagus (Figs 5F, 5G) with shaft tubular, apical part abruptly curved through approximately 30°, directed to right; endosoma indistinct.

Material examined. Holotype ♂, AUSTRALIA: Kuranda N. Q. Australia, 1904. VIII.10. Koebele, W. M. Giffard Collection (CAS). Paratypes. 2♀♀, the same data with Holotype (CAS).

Etymology. This new species is named for the presence of six reddish markings on vertex (Figs 1E, 5A).

Distribution. Australia (Kuranda).

Remarks. This species is similar to *T. conus* but can be distinguished from the latter in the vertex with six red spots, forewings with two pairs of red spots and by the male genitalia structure (Figs 5F–H), especially the shape of anal tube, median conical process of gonostylus relatively small, periandrium relatively long, with a long, sinuate process at left side, dorsoposteriorly directed, and the shaft of aedeagus apical part abruptly curved through approximately 30°, directed to right.

Acknowledgments

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Taxonomic remarks about *Semiclivina* (Kult, 1947) new status, with description of *Uroclivina* subgen. n., and of two new species from South America (Coleoptera, Carabidae, Scaritinae, Clivinini)

Alexander Dostal

Duchekgasse 39, Vienna, Austria

urn:lsid:zoobank.org:author:2718D947-D22B-46F1-809C-94EB72EB4FD3

Corresponding author: *Alexander Dostal* (adostal@clifact.com)

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Abstract

The subgenus *Semiclivina* Kult, 1947 of *Clivina* Latreille, 1802 (*sensu lato*) has been re-ranked as a genus, with the most readily observed feature being the stridulation organ of the proepisterna and front femora. A group of species within *Semiclivina* is characterized by a peculiar acute tubercle at the posterior margin of the eye, which corresponds to an equally noticeable incision of the anterior margin of the pronotum. This group is considered as monophyletic and placed as such in the **subgen. n.** *Uroclivina*. The species *Semiclivina* (*Uroclivina*) *bergeri* **sp. n.** from Argentina and southern Brazil and *Semiclivina* (*Uroclivina*) *schmidi* **sp. n.** from French Guyana are described. The following additional species are included in *Uroclivina*: *Clivina urophthalmoides* (Kult, 1947) new combination, *Clivina urophthalma* (Putzeys, 1863) new combination, and *Clivina oxyomma* (Putzeys, 1868) new combination. The two subgenera of *Semiclivina* Kult, and the current five species of *Uroclivina* are differentiated in a key.

Zusammenfassung

Die Untergattung *Semiclivina* Kult, 1947 der Großgattung *Clivina* Latreille, 1802 ist durch das Stridulationsorgan an den Proepisternen besonders auffällig und wird als eigenständige Gattung etabliert. Innerhalb dieser Gattung ist eine Artengruppe durch ein Tuberkel am hinteren Augenrand und der korrespondierenden Einkerbung am Vorderrand des Pronotums besonders auffällig. Diese Artengruppe wird als monophyletische Gruppe angesehen und als solche in der Untergattung *Uroclivina* nov. zusammengefasst. Die Arten *Semiclivina* (*Uroclivina*) *bergeri* **sp. n.** aus Argentinien und S-Brasilien sowie *Semiclivina* (*Uroclivina*) *schmidi* **sp. n.** aus französisch Guyana werden beschrieben. Folgende weitere Arten werden in die neue Untergattung gestellt: *Clivina urophthalmoides* (Kult, 1947) **comb. n.**, *Clivina urophthalma* (Putzeys, 1863) **comb. n.** und *Clivina oxyomma* (Putzeys, 1868) **comb. n.** In einer Bestimmungstabelle werden die beiden Untergattungen von *Semiclivina* Kult, 1947, sowie die fünf Arten der Untergattung *Uroclivina* nov. aufgeschlüsselt.

Keywords

Coleoptera, Carabidae, Scaritinae, Clivinini, *Semiclivina*, *Uroclivina*, South America, Argentina, French Guyana, identification key

Introduction

Currently, the genus *Clivina* Latreille, 1802 includes 456 taxa (species and subspecies) which are arranged worldwide in 12 subgenera: *Antroforceps* (Barr, 1967); *Clivina* s. str.; *Cliviniana* Kult, 1959; *Cliviniella* Kult, 1959; *Dacca* (Putzeys, 1861), *Eoclivina* Kult, 1959; *Isoclivina* Kult, 1959; *Leucocara* Bousquet, 2009; *Paraclivina* Kult, 1947; *Physoclivina* Kult, 1959; *Reichardtula* Whitehead, 1977; *Semiclivina* Kult, 1947). Some of these subgenera are well defined by certain characters and probably to be considered as proper genera in future. One of these is *Semiclivina* Kult, 1947, which is ranked as a genus below. The availability of numerous specimens of this genus led to the investigation of a well characterized species group, which is treated here as an independent subgenus.

Material and methods

Preserved specimens from different collections are used which are mounted on commercially available paper cards. I strongly recommend cutting away the right upper corner of the mounting card, for more convenient investigation of the lower surface of the pronotum, and to remove the abdomen and to mount this, ventral side up, beside the specimen, because the abdomen carries important distinguishing characters. Male and female genital organs were dissected and also glued to the cards beneath the specimens from which they were removed.

The species descriptions were based on the most distinguishing external characters as defined by Baehr (2008: 9). Label data for examined material are given in full, with exact labeling, except for the date format, which is transcribed to the format "dd.mm.jjjj".

Abbreviations of collections mentioned in text:

CBP Collection Petr Bulirsch, Praha

CBM Collection Martin Baehr, München

CDW Collection Alexander Dostal Wien, including the collection Karel Kult
IRSNB Institut Royal des Sciences Naturelles, Bruxelles
MNHP Museum National d'Histoire Naturelle, Paris
ZMHB Museum für Naturkunde der Humboldt Universität Berlin
NMW Naturhistorisches Museum Wien

Measurements

Measurements were taken with a calibrated Leica ocular scale at absolute magnifications 19,4× (for all measurements except pronotum) and 39,1× (for pronotal length and width). L = total length in mm, from Apex of Mandible to apex of elytra. W = maximum width in mm, situated in the apical third of elytra. PL = pronotum length, maximum length of pronotum measured along median line from the base of the anterior bristle fringe to the base of the posterior one. PW = maximum width of pronotum, measured normal to the midline, situated in most cases near the posterior angles P-LW = length-width -index of pronotum (length:width), if the value is smaller than 1, it means that the pronotum is wider than long, for values above 1: the pronotum is longer than wide. F-LW = length-width - index of both elytra, same as previous. Dl, Dr = number of dorsal setiferous punctures (D) in the third interval of the left side (Dl) and of the right side (Dr) respectively. The preapical puncture in the third interval is counted together with the other discal punctures.

Statistics

Following parameter are calculated: M = arithmetical mean, Max = maximum value, Min = minimum value, N = number of individuals measured, SD = standard deviation.

Genus *Semiclivina* Kult, 1947, stat. n.

http://species-id.net/wiki/Semiclivina

Clivina Subgenus *Semiclivina* Kult 1947: 31–32; Reichardt 1977: 391; Nichols 1988a: 154; 1988b: 91; Ball 2001: 136; Lorenz 2005: 145; Baehr 2008: 23; Bousquet 2009: 41.

Type Species. *Clivina dentipes* Dejaen, 1825, by original designation: Kult 1947: 31.

The genus *Semiclivina* (Kult, 1947) is readily recognized by the sculptured band of the proepisternum, extended more or less parallel to the proepisternal margin in the basal part of the proepisternum, curved inward in the anterior part, ended at the anterior end of the proepisternal-prosternal suture (Fig. 1). This structure was differently interpreted by diverse authors (Bousquet 2009: 38) as furrow, ridge or carina or elongate striole (Baehr 2008: 23). In fact it is a slightly elevated band like structure consisting of

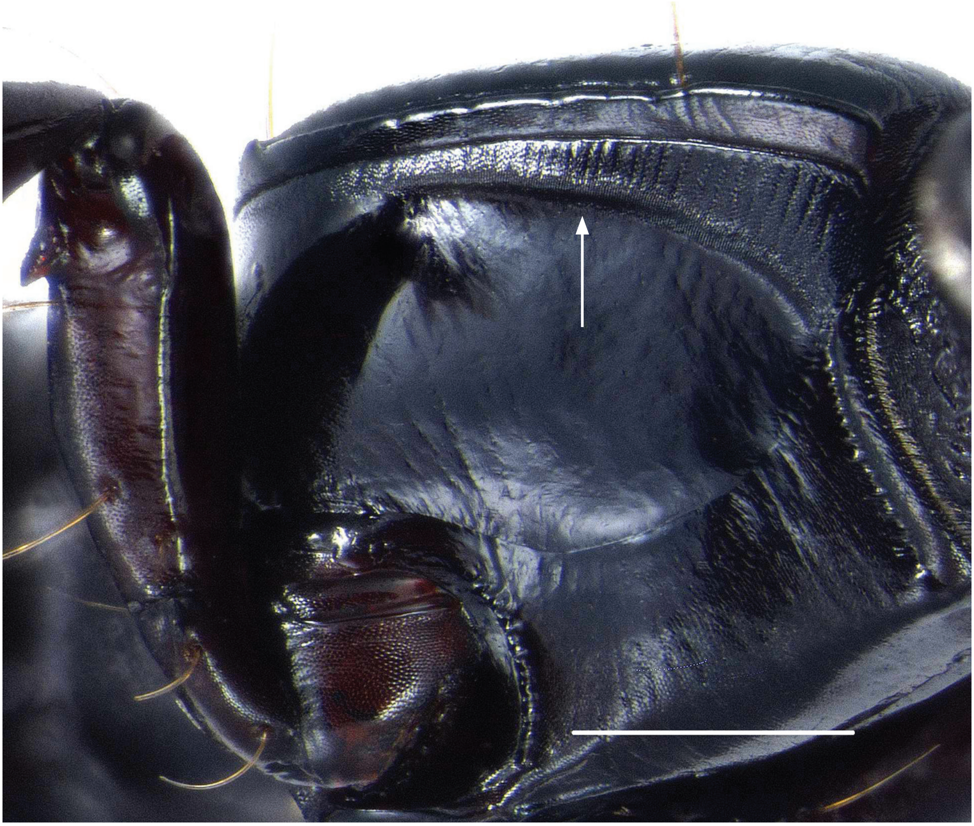

Figure 1. Photograph of prothorax and base of metathorax of *Semiclivina* species; right lateral view, showing the stridulation ridge (arrow); Scale bar: 0,5 mm.

very fine, regular transverse ridges. This sculptured band (Bousquet 2009: 38) is part of a stridulation organ in the sense of a pars stridens, whereas the corresponding plectrum is a fine, sharp longitudinal ridge, just above the distal part of the lower inner edge of the profemur (Fig. 2). In some species the outer edge of the profemur is produced to a remarkable denticle, but this structure does not interact with the stridulation organ in any way. The function of this stridulation organ has not been observed so far.

This organ is not unique within the Tribe Clivinini: exactly the same structures (the stridulation ridge on proepisterna and the ridge on the distal part of the inner edge of the profemur) together with other features separates the ardistomine genus *Ardistomis* Putzeys, 1846 from *Semiardistomis* Kult, 1950, but it is unique within *Clivina* (sensu lato), forming a very isolated, distinct group, restricted to the western hemisphere and to a single species from Australia (New South Wales) described by Baehr 2008: 23–25. Within the tribe Clivinini no other genera than *Ardistomis* Putzeys, 1846 and *Semiclivina* (Kult, 1947) carry a stridulation organ on the proepisternum. Beside this, *Semiclivina* is characterized by a distal spine-like projection at the outer end of the mesotibia, which is small in some taxa, but clearly identifiable by the apical seta

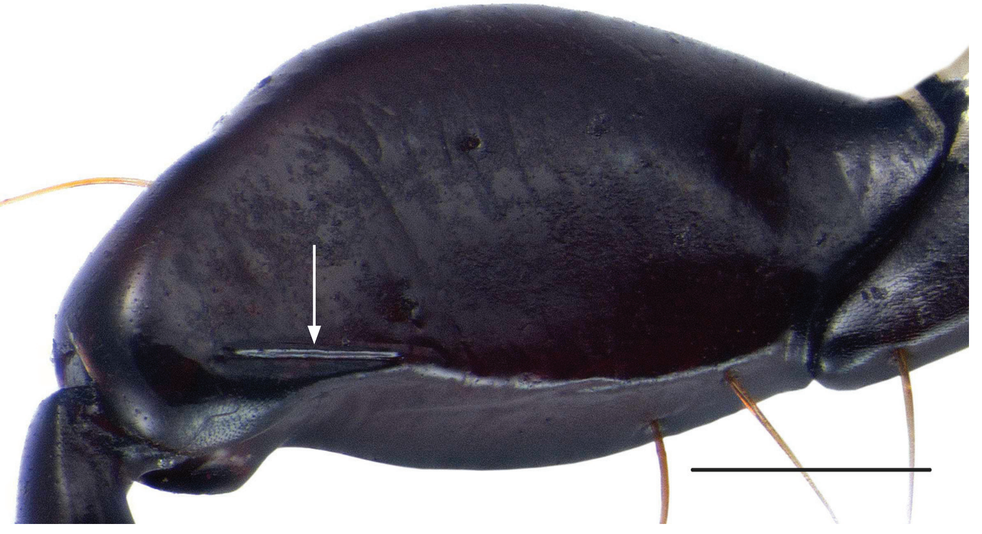

Figure 2. Photograph of right leg, posterior view, of base of trochanter, femur, and base of tibia of *Semiclivina* species, showing stridulation ridge on inner side of profemur (arrow); Scale bar: 0,5 mm.

excentrically inserted, in contradiction to a tubercle, which carries the seta at the top of the tubercle (see also Ball 2001: 136, 140; Bousquet 2009: 41, 43); usually five setae in elytral interval 3 (including preapical puncture); elytral striae 1 to 5 free at base (between humeral channel and suture, the basal keel of some species and the flat tubercles at the end of intervals 2 to 5 do not limit this definition); profemur with a sometimes small dentiform projection at the outer edge toward apex; anal ventrite (abdominal sternum VII) with two marginal punctures at each side relatively close together. The species included in *Semiclivina* are listed in Bousquet (2009: 39–41), where the assignment of some species remains uncertain. It is most likely, that species not included in the subgen. n. *Uroclivina* comprise a more or less heterogeneous group which form a probably paraphyletic group, defined as *Semiclivina* (s. str.). This subgenus will be the objective of further investigations in the future.

Subgenus *Uroclivina* subgen. n.
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http://species-id.net/wiki/Uroclivina

Type species. *Semiclivina bergeri* sp. n., herewith by original designation; it is the most abundant species of this subgenus.

Etymology. combination from the genus-name "*Clivina*" and the specific epithet "*urophthalma*".

Recognition. the species of this subgenus are characterized by the denticle of the posterior margin of the eye, the corresponding incision in the anterior margin of the pronotum at anterior angle and the sculptured band (stridulation organ) on the proepisterna, the latter is the most obvious character of the genus *Semiclivina*.

Description. *Head*: clypeus middle part slightly produced, separated from wings, anterior margin slightly concave, clypeus posteriorly separated from frons by a transverse furrow; posterior margin of eye with an acute dentiform tubercle (Fig. 3a); antennal scape distally with a seta, antennomeres 1 and 2 without pubescence, antennomeres 3 to 11 densely pubescent and longer than wide; labrum 7-setose; penultimate palpomere of labial palpus bisetose. *Pronotum*: with a marginal seta at the end of the anterior fifth and a second one at hind angle; basal border fine, just above the peduncle, finely bordered between basis and hind angle, and from hind angle to markedly produced anterior angles, border in the anterior third broader, anterior margin with a

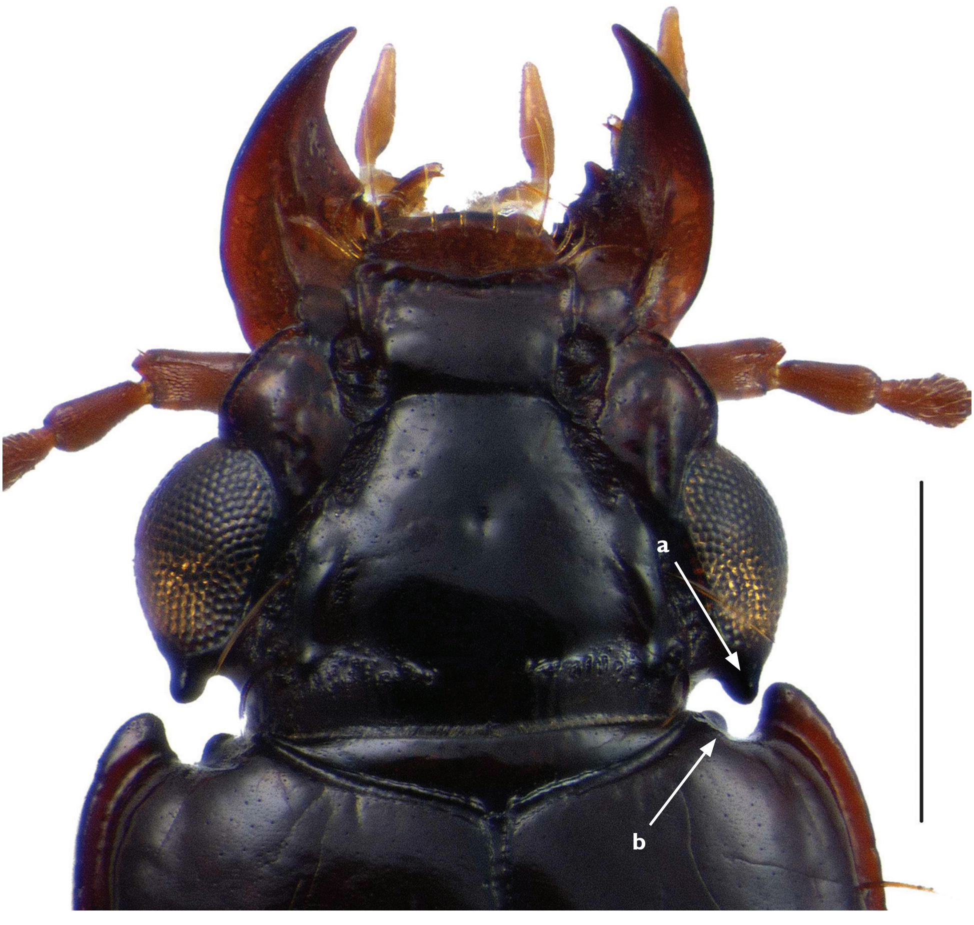

Figure 3. Photograph of head and anterior portion of pronotum, dorsal view, of *Semiclivina bergeri* new species, Holotype, showing **a** tubercle at posterior margin of eye **b** incision of anterior margin of pronotum; Scale bar: 0,5 mm.

sharp, narrow incision just beneath the front angles, corresponding with the tubercle at hind margin of eye (Fig. 3b); middle furrow and front transverse furrow clearly impressed; proepisterna with a stridulation band. *Elytra*: scutellar puncture present, scutellar striole indistinct, marked as short furrow just beneath the suture, or not evident; elytral striae 1 to 5 free at base, means within the humeral denticle and suture; basis at the end of interval 1 to 5 sometimes with flat tubercles, which may join with transverse basal keel; elytral intervals distinctly punctured; interval 3 with 5 setiferous punctures. *Legs*: front femur with a sharp longitudinal stridulation ridge, just above the distal part of the lower inner edge of the profemur; mesotibia with a small distal spur. *Abdomen*: abdominal sterna IV to VI with a paramedian seta on each side, sterna V to VII with a basal transversal ridge; abdominal sternum VII with a pair of marginal setae on each side relatively close together, all abdominal sterna microsculptured.

Geographical distribution. The species are restricted to South America, ranging from French Guyana, southward through the Amazon Basin to southern Brazil, Paraguay, North and Central Argentina and most likely also Uruguay (no evidence from this country so far).

Way of life. most specimens of *Clivina* (*sensu lato*) usually live near wet places or in swamps. Some species, like *Clivina fossor* (Linnaeus, 1758) are not bound to humid habitats. Most of the species are macropterous, capable of flight mostly during night, especially at temperatures above 25°C. Specimens of *Uroclivina* obviously live also close to humid habitats: they were collected at light and sometimes in extraordinary large series near rivers, lakes or other wet places.

Key to subgenera of *Semiclivina* and species of the Subgenus *Uroclivina*

1 Posterior part of eye rounded, without denticle; pronotum without incision of the anterior margin .... **Subgenus *Semiclivina* (s. str.) Kult, 1947**

– Posterior part of eye extended to a sharp denticle; pronotum (Fig. 3) with a sharp incision of the anterior margin *Uroclivina*, subgen. n......................... **2**

2 Elytral base unbordered and without tubercles, except one beside the scutellar puncture **3**

– Elytral base bordered or with tubercles at the basal end of intervals 2, 3, 4 and 5 .... **4**

3 Abdominal sterna, especially sternum VII (anal ventrite) with gross isodiametric microsculpture, all without punctures; median lobe of aedeagus slender, rounded at apex, not markedly flattened laterally (Fig. 7 a,b); distal spur at the outer edge of mesotibia short, about 1.5× as long as wide; punctuation of neck fine, punctures larger in the middle, nearly uninterrupted at middle; on average smaller species, length 4.2 mm; Brazil: Mato Grosso, Corumba .. .. ***Semiclivina* (*Uroclivina*) *urophthalmoides* (Kult, 1947)**

– Abdominal sterna with fine isodiametric microsculpture, without punctures (Fig. 4a); median lobe of aedeagus flattened at apex to a sharp edge (Fig. 6 a, b); distal spur at the outer edge of mesotibia longer, more than 2× as long as wide; punctuation of neck very fine, interrupted at middle; on average larger species, length 5.2–5.7 mm; Argentina, Brazil: Mato Grosso; one of the most abundant species in this area. .... ***Semiclivina* (*Uroclivina*) *bergeri* spec. nov.**

(= *marquardti* Van Emden, (museum label name), Argentina: Santa Fe)

4 Base of elytra not continuously bordered, but with flat tubercles at the basal end of intervals 3, 4, and 5, and a tubercle beside the scutellar puncture; anal ventrite with fine, slightly transverse mashes, without punctures (Fig. 4d); pronotum slightly longer than wide (1.04×); smaller and slender species, body cylindriform, inner elytral intervals slightly convex; length 5.6 mm; ... . ***Semiclivina* (*Uroclivina*) *urophthalma* (Putzeys, 1863)**

– Base of elytra bordered at least at the basal end of interval 4 and 5 and with a more or less confluent tubercle at the end of interval 3, and a tubercle beside the scutellar puncture; anal ventrite at least with fine punctures; body flattened, inner elytral intervals flat; species longer than 6 mm **5**

5 Larger species, length 7.6 mm; pronotum as wide as long (1.05×); anal ventrite with slightly transverse mashes and an area with about 40–50 more gross punctures at each side (Fig. 4c); Brazil: Bahia.. .... ***Semiclivina* (*Uroclivina*) *oxyomma* (Putzeys, 1868)**

– Smaller species, length 6.17–6.43 mm; anal ventrite with extremely fine, slightly transverse mashes and an area with about 10 to 15 fine and shallow punctures at each side(Fig. 4b); French Guyana... .... ***Semiclivina* (*Uroclivina*) *schmidi* sp. n.**

***Semiclivina* (*Uroclivina*) *bergeri* sp. n.**

urn:lsid:zoobank.org:act:C60E1149-8355-456A-BDB5-62634D6B028D

http://species-id.net/wiki/Semiclivina_(Uroclivina)_bergeri

Fig. 3, 4a, 5, 6

Clivina (*Semiclivina*) *marquardti* Van Emden 1949: 861–863, museum label name

Specific epithet. Latinized noun, genitive case, an eponym based on the surname of my friend and partner, Helmut Berger jun., who organizes and joins me in my entomological excursions all over the world.

Recognition. A typical *Uroclivina* – species with basal border of elytra without a keel, elytral stria 1 in the basal part closely joining suture; abdominal sterna without punctuation, but with distinct microsculpture, median lobe of aedeagus flattened, blade-like.

Description. *Color*: mature individuals are unicolorous dark brown to piceous, with annexes lighter, reddish-brown, immature ones are all variations lighter up to light yellow-brown, usually all stages are met within a population. *Microsculpture*: glossy, pronotum and elytra with a fine, sometimes barely visible, more or less isodiametric

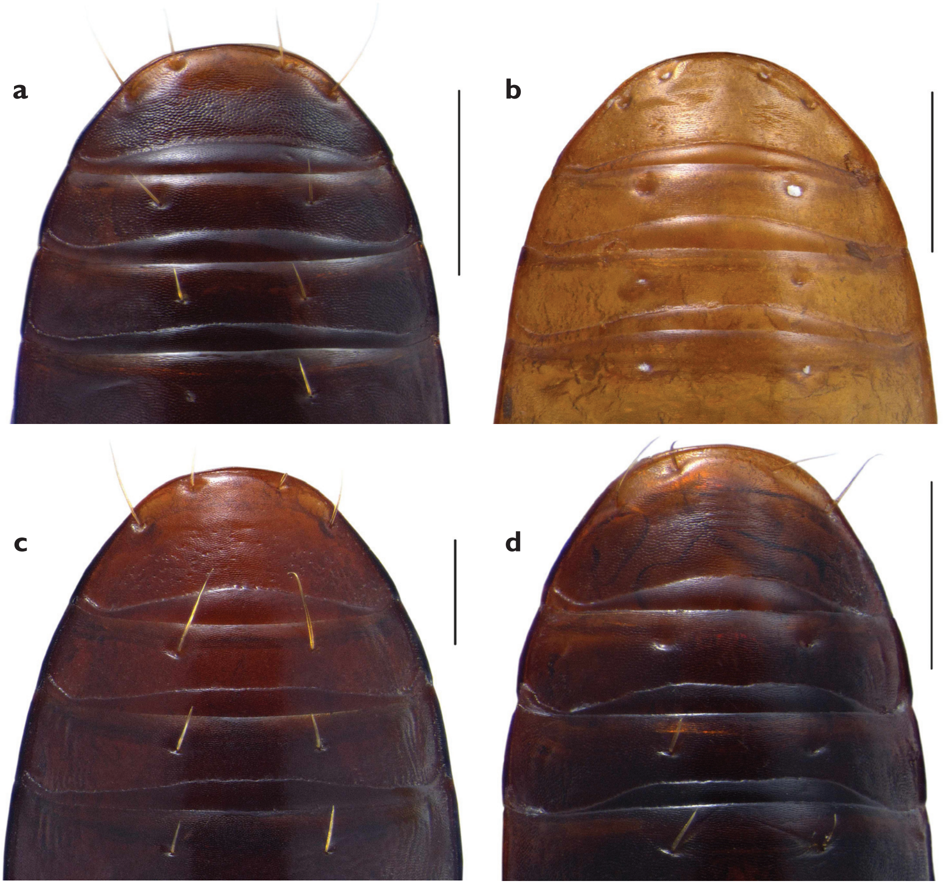

Figure 4. Photograph of abdominal sterna IV-VII, ventral view, of **a** *Semiclivina bergeri*, sp. n., Holotype **b** *S. schmidi* sp. n., Holotype **c** *S. oxyomma* (Putzeys) **d** *S. urophthalma*(Putzeys); Scale bars: 0,5 mm.

microsculpture, but still glossy *Head* (Fig. 3): middle part of clypeus more produced than lateral wings, anterior margin slightly concave, bordered, wings unbordered; preocular area finely bordered; upper surface of clypeus glossy without microsculpture, except microscopic fine punctures; clypeus divided from frons by a transverse furrow; longitudinal sulci broad, ground microreticulate, bearing a seta at basal level of clypeus on each side; frons glossy, with a very shallow central foveola; above supraorbital setae with a broad ridge, medially bordering a small longitudinal reticulate groove; neck finely punctuate, interrupted at middle; posterior margin of eye with the characteristic tubercle. *Pronotum*: convex, disc somewhat flattened, about as wide as long (range 0,88x to 1,04x, see Table 1); surface glossy, but with fine microreticulation, fine transverse wrinkles in the basal two thirds, declivity at base with transverse wrinkles more dense and distinctly shagreened; anterior angles strongly produced forward, mediad with a sharp and narrow incision, which corresponds to the postorbital tubercle. *Elytra*: about twice long as wide (range: 1.93× – 2.11×, see Table 1); subparallel, convex at

Figure 5. Photograph of habitus of holotype of *Semiclivina bergeri* sp. n., dorsal view; Scale bar: 2 mm.

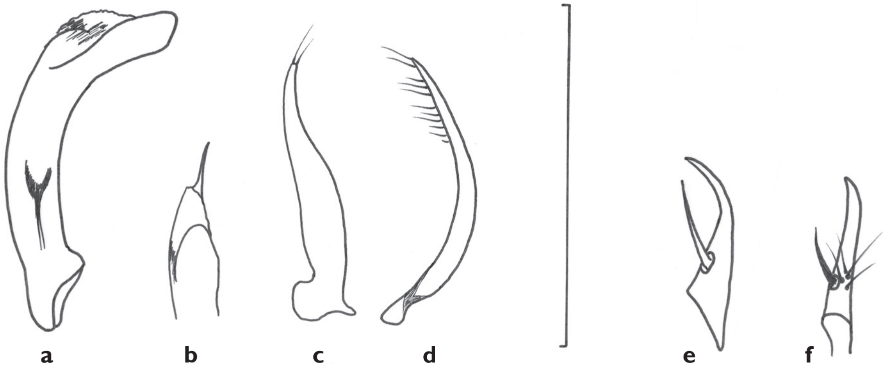

Figure 6. Line drawings of genitalia of *Semiclivina bergeri* sp. n. **a-d** holotype- **a** median lobe, left lateral view **b** median lobe, apical portion, dorsal aspect **c** and **d** left and right paramere, respectively, ventral view **e-f** paratype, ovipositor left stylomere **e** lateral aspect **f** medial aspect. Scale bar = 1 mm.

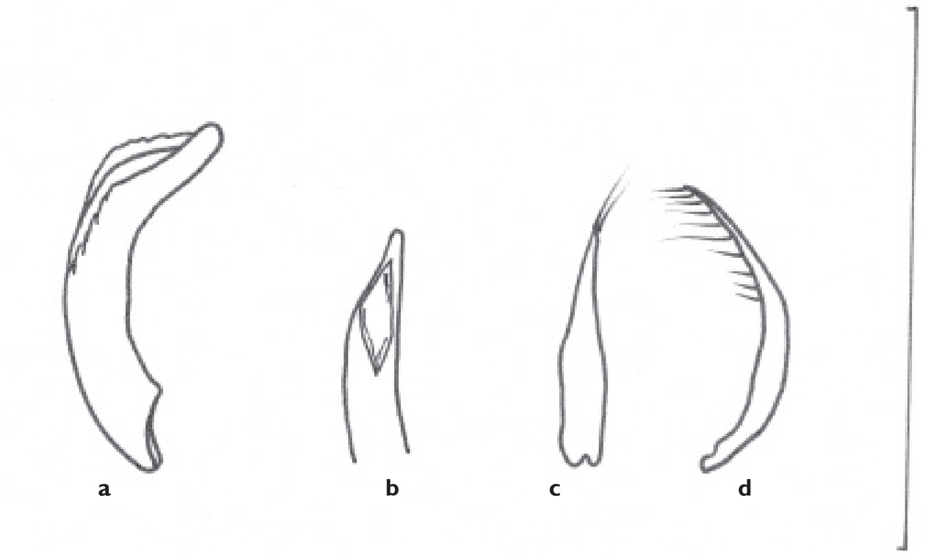

Figure 7. Line drawings of aedeagus of *S Semiclivina urophthalmoides* (Kult, 1947), holotype **a** median lobe, left lateral view **b** median lobe, apical portion, dorsal aspect **c** and **d** left and right paramere, respectively, ventral view; Scale bar = 1 mm.

sides, disc somewhat flattened, glossy, with very fine microreticulation; elytral striae distinctly engraved from base to apex, with gross punctures at base which become finer towards apex; 7th and 8th interval narrowed at base and sometimes elevated to a keel; first elytral stria bending inwards towards suture at base, from the second sixth

Table 1. Descriptive statistics for *Semiclivina* (*Uroclivina*) bergeri spec. nov. from the population sample south of Corrientes, Argentina (N = 114).

	P-LW	E-LW	L (mm)	W (mm)	PL (mm)	PW (mm)	Dl	Dr
Min	0.88	1.93	4.49	1.22	1.07	1.11	5.00	5.00
Max	1.04	2.11	6.32	1.68	1.53	1.59	5.00	5.00
Mean	0.97	2.01	5.41	1.44	1.28	1.33	5.00	5.00
SD	0.03	0.04	0.35	0.09	0.09	0.09	0.00	0.00
Holotype	0.95	2.04	5.25	1.38	1.22	1.29	5	5

onwards it continues parallel to suture up to the apex. *Legs*: fore-tibia 4 dentate, the proximal one very small, triangular, upper surface distinctly sulcate; mesotibia with a small distal spur on the upper edge, which is about two times longer than wide. *Abdominal sterna* (Fig. 4a): IV to VI finely transversally microreticulate, isodiametric at sides, VII completely isodiametrically microsculptured, with 2 pairs of marginal setae in both sexes, relatively close together. *Male genitalia* (Fig. 6a-d): median lobe blade-like flattened, apex spatulate; parameres long and slender, left one about twice as broad as the right one, with 2 setae at apex, right one with an apical fringe of about 10 setae. *Female genitalia*: stylus tall, slender, bent inwards, apex acute, lateral with one big seta, ventral with 4 smaller setae (Fig. 6e-f).

Measurements. see Table 1; length 4.49–6.32 mm, width 1.22–1.68 mm

Geographical distribution. The range of this species extends from the Mato Grosso of Brazil southward to Paraguay and Argentina.

Material examined. *Holotype*: ♂, Argentina NE, S of Corrientes, River Parana, 16. 01. 2009, leg. M.

Snizek, (CDW). 4247 *Paratypes*: **Argentina:** 2 Ex., Argentine Republic, Villa Ana, F.C.S. Fe, December 1924, K.J. Hayward, Paratype Clivina marquardti Van Emden, (CDW); 1 Ex., dtto, January 1926, (CDW); 1 ♀, dtto, December 1925, at light, (CDW); 1 ♂, Argentine, Prov. Corrientes, zw. Lago Ibera & Santo Tome, 26. 09. 1997, (CDW); 84 ♂, 69 ♀, 4046 Ex, Argentina NE, S of Corrientes, River Parana, 16. 01. 2009, leg. M. Snizek, (CBP, CDW, CBM, NMW); 1 ♂, 1 ♀, Argentina, NC, Gran Chaco, Salada riv., S of Macapilo (SE Salta), 20.01.2009, leg. M. Snizek, (CDW); 3 ♂, 3 ♀, Argentina NW, Salta prov., Chicoana riv., El Carril, 28.01.2009, leg. M. Snizek, (CDW); 6 ♂, 8 ♀, Argentina NW, Salta prov., Andes mts., N of Cachi, 2600 m, 25. 01. 2009, leg. M. Snizek, (CDW); 8 ♂, 5 ♀, Argentina N, S of Salta (50 km), E of Coronel Moldes, 23. 01. 2009, leg. M. Snizek, (CDW); 1 Ex., S-Amerika: Argentinia, Prov. Entre Rios/Dept Colon, 5.-10.II.1989, leg. Liebig, (CBM); **Brazil:** 2 ♂, 1 ♀, Corumba, Matt. Grosso, Cl. urophthalmoides Kult, Paratypes (CDW); 3 ♂, Corumba, Matt. Grosso, Cl. urophthalmoides Kult, (CDW); **Paraguay:** 2 Ex. Paraguay, S. Antonio, (CDW); 1 ♂ Paraguay, Prov. Pres Hayes, Buffalo Bill, 23.16S 58.54W 108 m, 01.12.2010 Sv. Bily leg., (CDW); 2 Ex., Paraguay Asuncion, 2.X.1991, (CBM).

***Semiclivina* (*Uroclivina*) *schmidi* sp. n.**
urn:lsid:zoobank.org:act:2BB78AC8-BC09-4F3C-885F-1894BF971101
http://species-id.net/wiki/Semiclivina_(Uroclivina)_schmidi
Fig. 4b, 8, 9

Specific epithet. Latinized noun, genitive case, an eponym based on the surname of the collector of this species, my colleague and friend Herbert Schmid.

Recognition. a typical *Uroclivina* – species with base of elytra with a keel at the end of intervals 3 to 5; elytral stria 1 extended parallel to suture, not joined to suture near base; abdominal sterna with very fine, transverse microreticulation and a group of shallow punctures at sides; median lobe of aedeagus flattened, blade-like.

Description. *Color*: both individuals are immature and lighter reddish-brown; it is most likely that mature individuals are unicolorous dark brown to piceous, with annexes lighter, reddish-brown. *Microsculpture*: frons, pronotum and elytra with a fine, sometimes barely visible, more or less isodiametric microsculpture, but surface glossy. *Head*: middle part of clypeus more produced than lateral wings, anterior margin slightly concave, bordered, wings unbordered, preocular area finely bordered; upper surface of clypeus glossy without microsculpture, except microscopic fine punctures; divided from frons by a transverse furrow; longitudinal sulci broad, surface microreticulate, bearing a seta at basal level of clypeus on each side; frons glossy, but with fine, sometimes indistinct microreticulation, with a very shallow central foveola; above supraorbital setae with a broad ridge, medially bordering a small longitudinal groove, in this area the microreticulation more distinct; neck finely punctate, interrupted at middle in the holotype, not interrupted in the paratype; posterior margin of eye with the characteristic tubercle. *Prothorax*: convex, disc somewhat flattened, about as wide as long (0.97x, see Table 2); surface glossy, but with fine microreticulation, fine transverse wrinkles in the basal two thirds, declivity at base with transverse wrinkles more dense and more distinctly shagreened; anterior angles markedly produced forward, mediad with a sharp and narrow incision, which corresponds to the postorbital tubercle. *Elytra*: about twice long as wide (range: 1.94× – 1.98×, see Table 2); subparallel, convex, broadest in the apical third, glossy, with very fine, barely visible microreticulation; elytral striae distinctly engraved from base to apex, with gross punctures at base which become finer towards apex; 6^{th} to 8^{th} interval narrowed at base and elevated as a keel; first stria elytral extended more or less parallel to suture, not bent inward toward suture at base; a fine, scutellar keel extended from the basal tubercle at the end of the second interval obliquely posteriorly to suture. *Legs*: fore-tibia 4 dentate, the proximal dentiform projection very small, triangular, upper surface indistinctly sulcate; profemur with a sharp denticle at the proximal end of the outer edge; mesotibia with a small distal spur on the upper edge, which is about two times longer than wide.

Abdominal sterna: abdominal sterna IV to VII very finely transversally microreticulate, mesh pattern isodiametric at sides, abdominal sternum VII with a group of about

Figure 8. Photograph of habitus of the holotype of *Semiclivina schmidi* sp. n., dorsal view; Scale bar: 2 mm.

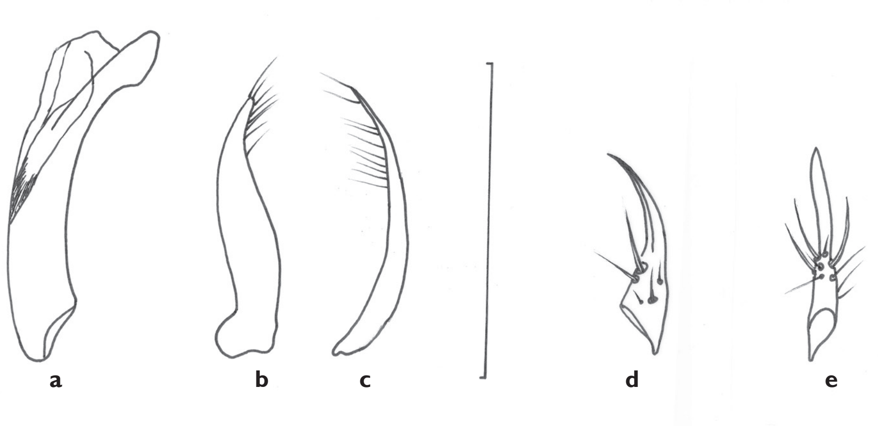

Figure 9. Line drawings of genitalia of *Semiclivina schmidi* sp. n. **a-c** holotype, aedeagus **a** median lobe, left lateral view **b** and **c** left and right paramere, respectively, ventral view **d-e** paratype, ovipositor **d** left stylomere, lateral aspect **e** medial aspect. Scale bar = 1 mm.

10 fine and shallow punctures on each side, and with 2 pairs of marginal setae in both sexes, relatively close together. *Male genitalia* (Fig. 9 a-c): median lobe blade-like flattened, apex spatulate; parameres long and slender, left one about twice as broad as the right one, with 7 setae at apical margin, right one with a apical fringe of about 10 setae. *Female genitalia, ovipositor*: stylus long, slender, bent inwards, apex acute (Fig. 9d-e).

Measurements. see Table 2; length 6.17–6.43 mm, width 1.58–1.68 mm.

Geographical distribution. known only from French Guyana

Material examined. *Holotype*: ♂, Fr. Guyana, Mt. Singes, 01.08.2007, leg. Herbert Schmid, (CDW); Paratype: 1 ♀, same dates as Holotype, (CWD).

***Semiclivina* (*Uroclivina*) *urophthalmoides* (Kult, 1947)**
http://species-id.net/wiki/Semiclivina_(Uroclivina)_urophthalmoides

Clivina (*Semiclivina*) *urophthalmoides* Kult 1947: 34 -35; Van Emden 1949: 861–863; Lorenz 2005: 145; Bousquet 2009: 41

Type locality. Brazil, Mato Grosso, Corumba

Holotype. original series from the same locality, about 30 specimens, holotype in the author's collection (collection Kult in CDW), paratypes in the collections of ETHZ, IRSNB, MNHN, ZMHB: Kult 1947: 35

Geographical distribution. known from type locality only: Brazil, Matto Grosso, Corumba

Table 2. Measurements of *Semiclivina* (*Uroclivina*) *schmidi* sp. n.

	P-LW	E-LW	L (mm)	W (mm)	PL (mm)	PW (mm)	Dl	Dr
Holotype male	0.97	1.94	6.17	1.58	1.48	1.53	5.00	5.00
Paratype female	0.97	1.98	6.43	1.68	1.56	1.61	5.00	5.00

Material examined. 1 ♂, Holotype with red label "TYPE" and a handwritten determination label "*S. urophthalmoides* KT." det. K. Kult 1946, Corumba, Matt. Grosso, (CDW)

Annotation. in the collection of Karel Kult this species is represented by the Holotype (see above for details) and 2 males, 1 female, Corumba, Matt. Grosso, with the labels in red "COTYPE", without determination labels; 3 males, Corumba, Matt. Grosso, one with the handwritten determination label "*Clivina urophthalmoides* m." det. K. Kult [without year], most likely also Paratypes of *Semiclivina urophthalmoides* (Kult, 1947), but not indicated as such; 2 Ex., Argentine Republic, Villa Ana, F.C.S. Fe, December 1924, K.J. Hayward, Paratype *Clivina marquardti* Van Emden; 1 female, ditto, January 1926; 1 female, ditto, December 1925, at light; 2 Ex. Paraguay, S. Antonio, with a red printed label "Compared with Type, K. Kult, 1950". It is noticeable, that the individual labeled as Type is much smaller (4.3 mm) than the other ones. This led to the investigation of the other *Semiclivina urophthalmoides* (Kult, 1947) specimens with dissection of genitalia and abdomen. The result of this investigation was that all other specimens mentioned above except the Holotype, are markedly different (see Figs. 6a-d, 7a-d) and belong to another species, which is described above as *Semiclivina* (*Uroclivina*) *bergeri*. The differentiation of these two species is given in the key.

***Semiclivina* (*Uroclivina*) *urophthalma* (Putzeys, 1863)**

http://species-id.net/wiki/Semiclivina_(Uroclivina)_urophthalma
Fig. 4d

Clivina urophthalma Putzeys 1863: 37 -38; 1866: 145; Csiki 1927: 512; Van Emden 1949: 862–863 *Clivina* (*Semiclivina*) *urophthalma* Putzeys, 1863: Kult 1947: 35; Bousquet 2009: 41

Type locality. Amazonia

Holotype. 3 Ex., "Amazone": Putzeys 1863: 38; Coll. Putzeys (IRSNB).

Geographical distribution. Amazonia

Material examined. 1 Ex Brazil: Para, (CDW).

Annotation. Kult 1947: 35 examined the type of *Clivina urophthalma* Putzeys, 1863 and compared it with his *Clivina urophthalmoides* Kult, 1947; Van Emden 1947: 862–863 did this as well, both authors agreed in the interpretation of *Clivina urophthalma* Putzeys, 1863 in comparison to *Clivina urophthalmoides* Kult, 1947.

The specimen of *Clivina urophthalma* Putzeys, 1863 in Kult's collection fits very well Putzeys' description (Putzeys 1863: 37–38) and the interpretation of above mentioned authors.

***Semiclivina* (*Uroclivina*) *oxyomma* (Putzeys, 1868)**
http://species-id.net/wiki/Semiclivina_(Uroclivina)_oxyomma
Fig. 4c

Clivina oxyomma Putzeys 1868: 10; Csiki 1927: 509; Van Emden 1949: 862–863
Clivina (*Semiclivina*) *oxyomma* Putzeys, 1868: Kult 1947: 35, Bousquet 2009: 41

Type locality. Brazil: Bahia

Holotype. 1 Ex. Coll de Castelnau (MNHN): Putzeys 1868: 10

Geographical distribution. Brazil: Bahia

Material examined. 1 ♀, Brazil: Tapajos, (CDW).

Annotation: Van Emden 1947: 862–863 examined type material of *Clivina oxyomma* Putzeys, 1868, the specimen represented in Kult's collection fits well Van Emden's interpretation of this species and the short description of Putzeys (1868: 10).

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RESEARCH ARTICLE

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Two new Neotropical species of *Ceracis* Mellié (Coleoptera, Ciidae) and redefinition of the *cucullatus* group

Caio Antunes-Carvalho[1,†], Cristiano Lopes-Andrade[2,‡]

1 *Programa de Pós-Graduação em Entomologia, Departamento de Entomologia, Universidade Federal de Viçosa, 36570-000, Viçosa, Minas Gerais, Brazil* **2** *Departamento de Biologia Animal, Universidade Federal de Viçosa, 36570-000, Viçosa, Minas Gerais, Brazil*

† *urn:lsid:zoobank.org:author:257E8142-E3F7-4D8B-A099-1A1A5CE9B3BD*
‡ *urn:lsid:zoobank.org:author:6A3F4101-8599-44D9-9210-BCD5DD8564E9*

Corresponding author: *Caio Antunes-Carvalho* (cantunescarvalho@gmail.com)

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Abstract

Two new Neotropical species of *Ceracis* Mellié are described: *Ceracis cassumbensis* Antunes-Carvalho & Lopes-Andrade, **sp. n.** from a single locality in northeastern Brazil and *Ceracis navarretei* Antunes-Carvalho & Lopes-Andrade, **sp. n.** from a single locality in southern Mexico. Scanning Electron Microscope images of adults and photographs of holotypes and male terminalia are provided for both species, their similarities and differences with other *Ceracis* are briefly discussed, and the *cucullatus* species-group is redefined for including the new species described herein.

Keywords

Ciid, minute tree-fungus beetle, Ciinae, Brazil, Mexico

Introduction

Ceracis Mellié (Coleoptera: Ciidae: Ciinae) encompasses 47 described species, being the second most speciose genus of the family. The genus was redefined by Lawrence (1967), who dealt mostly with Nearctic *Ceracis* but briefly discussed their affinities to

Neotropical and Indo-Pacific species. He has also proposed two species-groups, the *furcifer* and the *cucullatus*, each including morphologically related species.

Ceracis cucullatus (Mellié), which names the *cucullatus* group, has drawn the attention of ciidologists due to its broad and disjunct geographic distribution. It is widespread in the Neotropical region, also occurring in several localities of the Afrotropical and Afrotemperate regions (sensu Morrone 2002), including several islands (Mellié 1849, Scott 1926, Blackwelder 1945, Lawrence 1967, Lopes-Andrade 2008, Lopes-Andrade et al. 2009, Lawrence and Lopes-Andrade 2010). There is a single record of the species from France (Abeille de Perrin 1874), but it is possibly not established there.

While conducting a survey on the morphology, life cycle and geographic distribution of *C. cucullatus*, mainly to evaluate the conspecificity of disjunct populations under this name, we found two morphologically related new species. Here we describe *Ceracis cassumbensis* sp. n., a rare record of Ciidae in a Brazilian estuarine system, and *Ceracis navarretei* sp. n. from southern Mexico. We include them in the *cucullatus* species-group, which is redefined.

Material and methods

Holotypes were neither dissected nor examined under Scanning Electron Microscope (SEM). SEM images of whole specimens (Figs 4-6, 14-16) and photographs of dissected sclerites of male terminalia (Figs 7-10, 17-20) are from topotypes (specimens collected in the type locality but not labeled as paratypes; sensu Evenhuis 2008). These figures are cited in the descriptions for the purpose of illustration.

Examination of specimens, measurements and descriptions were made under a Zeiss Stemi 2000 stereomicroscope with a scale ocular. Holotypes were photographed with a Canon EOS 1000D digital camera attached to the same stereomicroscope. Digital photographs taken from different focus were processed and enhanced in the image stacking freeware CombineZP (Hadley 2010). Permanent slide preparations of male terminalia followed the methodology detailed by Lopes-Andrade (2011) and were photographed with a Canon A640 digital camera adapted to a Zeiss Axioskop 40 compound microscope. SEM images were taken with a LEO 1430 VP. A few topotypes were dehydrated in a series of alcohol solutions, dried in a Critical Point Dryer (Balzers CPD 020), mounted on stubs and sputter-coated with gold (Balzers Sputter Module SCA 010).

The following abbreviations are used for measurements and ratios: CL, length of the antennal club; EL, elytral length (taken from the base of scutellum to the elytral apex); EW, greatest elytral width; FL, length of the antennal funicle; GD, greatest depth of the body (taken from the elytra to the metaventrite); PL, pronotal length along midline; PW, greatest pronotal width; TL, total length (EL+PL; head not included). Range, mean and standard deviation are given for the abovementioned measurements and the following ratios: EL/EW; EL/PL; GD/EW; PL/PW; TL/EW. The ratio GD/EW was adopted as an indication of degree of convexity, and TL/EW indicates degree of body elongation. These measurements and ratios were taken from the whole type series. Measurements of antennomeres, eyes, scutellum and abdominal ventrites were taken only from holotypes. Morphological variations between specimens of the type series (males and females) are given in the section on "Variation", together with measurements and ratios (accompanied by mean ± standard deviation). Specimens selected as holotypes are fully pigmented males.

We compared specimens of *C. cassumbensis* sp. n. and *C. navarretei* sp. n. with named specimens of *C.cucullatus* from Brazil, Galapagos and several localities from Africa. Dissected terminalia of males from these localities were also carefully compared. The terminology adopted for external morphology and male terminalia's sclerites are explained by Lopes-Andrade and Lawrence (2005) and Lopes-Andrade (2008). The term sensillifer is used here to designate the compound sensory structure on the ciid antennal club (see Lawrence 1971, Lopes-Andrade and Lawrence 2005, Lawrence and Lopes-Andrade 2010). For a brief explanation on the use of the terms mesoventrite and metaventrite, see Lopes-Andrade (2007).

The following acronyms are used in this paper:

ANIC Australian National Insect Collection, CSIRO Ecosystem Sciences (Canberra, Australia)

CZUG Colección Entomológica del Centro de Estudios en Zoología, Universidad de Guadalajara (Zapopan, Jalisco, Mexico)

LAPC Cristiano Lopes-Andrade Private Collection (Viçosa, MG, Brazil)

Descriptions

Ceracis cassumbensis Antunes-Carvalho & Lopes-Andrade, sp. n.

urn:lsid:zoobank.org:act:26A7C976-D6E8-44C2-AC4A-A795421CAE24
http://species-id.net/wiki/Ceracis_cassumbensis
Figs 1–10

Type-locality. "Ilha da Cassumba" (Cassumba island) in Caravelas, southern portion of the state of Bahia, northeastern Brazil (17°46'S, 39°17'W).

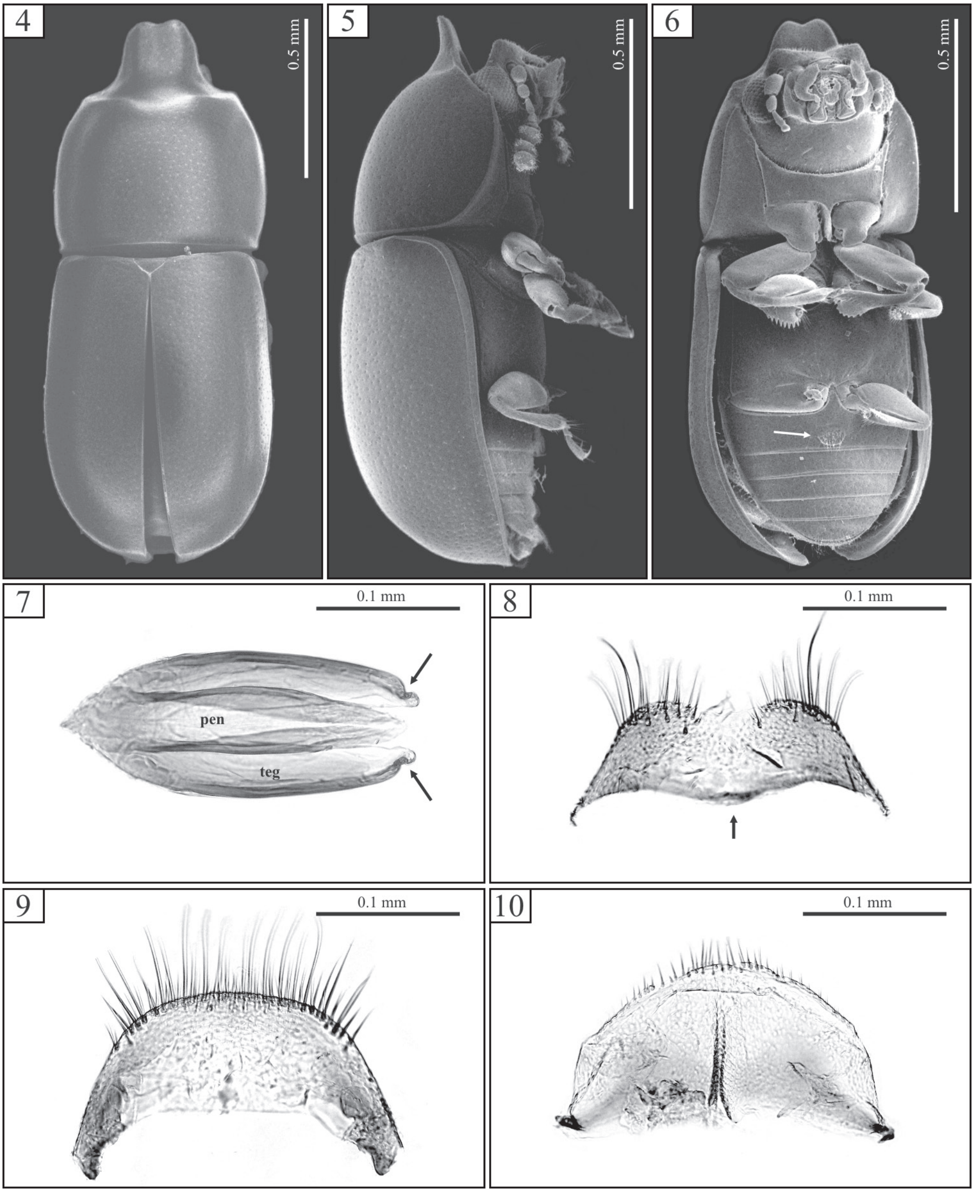
Etymology. The specific epithet refers to the *terra typica* of the species.

Diagnosis. Each antenna with eight antennomeres. Pronotum with relatively fine punctation; its anterior edge projected for- and upward forming a raised plate, slightly concave, with a short emargination at apex. Elytral punctation relatively dense. First abdominal ventrite with a broad transversely oval, setose sex patch (Fig. 6, arrow). Tegmen with lateral edges bearing a small excavation near apex (Fig. 7, arrows).

Description. Male holotype (Figs 1-3), measurements in mm: TL 1.56; PL 0.60; PW 0.64; EL 0.96; EW 0.64; GD 0.56. Ratios: PL/PW 0.94; EL/EW 1.50; EL/PL

Figures 1–3. Habitus of *Ceracis cassumbensis* Antunes-Carvalho & Lopes-Andrade, sp. n., holotype. **1** Dorsal view **2** Lateral view **3** Ventral view.

1.60; GD/EW 0.88; TL/EW 2.44. Body elongate, robust; dorsal and ventral surfaces dark brown, almost black; basal antennomeres and funicle, mouthparts and legs mostly yellowish brown; antennal club blackish and terminal palpomere of the maxillary palp yellowish black. Head barely visible from above; dorsal surface subglabrous, sparsely punctate, bearing a transverse impression at disc, preceded by a weak protuberance (seen in the dissected topotype); frontoclypeal ridge produced forward, transversely concave, with anterior margin emarginate at middle forming two subtriangular plates visible from below (Fig. 6), the anterior edge with a row of setae along it. Each eye with a widest diameter of 0.14 mm; some short slender yellowish setae emerging from the intersection between ommatidia. Each antenna with eight antennomeres (FL 0.09, CL 0.17, CL/FL 1.89); length of antennomeres (in mm) as follows (from base to apex): 0.07, 0.05, 0.05, 0.03, 0.02, 0.05, 0.05, 0.07; each antennomere of the club bearing several sparse slender setae, and four conspicuous sensillifers symmetrically positioned at its upper portion. Pronotum with sides reasonably rounded, widest at middle; lateral margins narrow, not visible from above, except for the most posterior corners; anterior edge projected for- and upward, forming a curved raised plate, slightly concave, with a short emargination at apex (Figs 1, 4); disc impressed in the area surrounding pronotal projection; anterolateral angles inconspicuously produced, relatively obtuse; punctation relatively fine, single, uniformly distributed, the posterior half of the median longitudinal surface devoid of punctures; distance between punctures from 1.75



Figures 4–10. *Ceracis cassumbensis* Antunes-Carvalho & Lopes-Andrade, sp. n., SEM of male topotypes (4–6) and slide preparations of male terminalia of a topotype (7–10). **4** Dorsal view **5** Lateral view **6** Ventral view, showing the transversely oval sex patch at the first abdominal ventrite (arrow) **7** Aedeagus showing penis (pen) and tegmen (teg). Note the conspicuous excavation in either side of tegmen (arrows) **8** Eighth sternite with anterior margin rounded at middle (arrow) **9** Eighth tergite **10** Fused ninth and tenth tergites.

to 2.25 puncture-widths, being greater at the anterior half of pronotum (including pronotal projection); each puncture bearing a fine yellowish decumbent minute seta; in between punctures shiny, microreticulate. Scutellum small, triangular, with few punctures, each one bearing a short, fine, decumbent bristle; basal width 0.11mm and length along the longitudinal midline 0.05 mm. Hind wings developed. Elytra with sides subparallel at the basal two-thirds, then abruptly converging toward apex; punctation single, confused, denser than pronotal punctation; punctures irregular, but ever finer than those on pronotum; vestiture similar to that of pronotum, but in between punctures smooth and shiny. Ventral sclerites microreticulate. Prosternum in front of coxae shallowly concave longitudinally, and a bit transversely convex; surface beside coxae weakly concave; prosternal process laminate, reasonably elevated, almost as long as coxae. Metaventrite moderately convex, bearing sparse slender setae; punctation shallow, consisting mostly of few punctures close to the lateral edges; median suture (discrimen) obscurely indicated posteriorly (see section on "variation"). Abdominal ventrites bearing sparse slender decumbent yellowish setae, longer than those on the dorsal surface; punctation shallow and sparse; lengths of abdominal ventrites (from base to apex, at the longitudinal midline) as follows (in mm): 0.19; 0.08; 0.08; 0.06; 0.06; length of abdominal ventrites together 0.46 mm; abdominal width (basal width of the first abdominal ventrite) 0.63 mm; first abdominal ventrite bearing a broadly transverse margined setose sex patch (Fig. 6, arrow), located postered of center, with a transverse diameter of 0.06 mm. Apex of each protibia expanded; outer apical angle rounded and bearing a row of spines.

Male terminalia. (Figs 7–10) Ninth segment (=genital ring) V-shaped. Fused ninth and tenth tergites (Fig. 10) with posterior margin rounded and bearing small suberect bristles at middle; sides slightly diverging, almost subparallel. Eighth sternite (Fig. 8) with posterior margin shallowly emarginate at middle; posterior angles rounded and bearing some bristles; lateral margins diverging; anterior margin biconcave, rounded and slightly sclerotized at middle but not forming a strut (Fig. 8, arrow). Eighth tergite (Fig. 9) with posterior margin almost straight, bearing long and short bristles along it; lateral margins diverging; anterior margin concave. Aedeagus (Fig. 7) around twice as long as wide; basal piece not observed, possibly membranous. Tegmen slightly longer than and twice as wide as penis; posterior portion subtriangular, then subparallel sided at most of its length, lateral edges slightly curved inward to apex; both sides bearing a small excavation near apex (Fig. 7, arrows). Penis elongate, subcylindrical; sides subparallel at the basal three-fourths, with apical one-fourth subtriangular and weakly sclerotized.

Females. Differing from males in the following features: frontoclypeal ridge rounded, not produced. Lateral margins of pronotum rounded; anterior margin rounded, not produced, bearing small yellowish setae along it; pronotal and elytral punctation slightly finer than in males. Abdominal sex patch absent.

Variation. Males, measurements in mm (n=21, including holotype): TL 1.12–1.80 (1.46 $\pm$ 0.18); PL 0.44–0.84 (0.66 $\pm$ 0.11); PW 0.48–0.76 (0.63 $\pm$ 0.07); EL 0.68–0.96 (0.80 $\pm$ 0.07); EW 0.52–0.76 (0.64 $\pm$ 0.07); GD 0.44–0.68 (0.55 $\pm$ 0.06).

Ratios: PL/PW 0.92–1.19 (1.04 ± 0.07); EL/EW 1.12–1.33 (1.25 ± 0.06); EL/PL 1–1.55 (1.23 ± 0.14); GD/EW 0.76–0.92 (0.86 ± 0.04); TL/EW 2.15–2.50 (2.28 ± 0.09). Body varying from dark reddish brown to dark brown (almost black). Frontoclypeal ridge and apex of pronotum weakly developed in the smallest males and strongly projected in the largest ones. Discrimen indiscernible to barely discernible in most individuals.

Females, measurements in mm (n=10): TL 1.32–1.56 (1.45 ± 0.09); PL 0.56–0.68 (0.62 ± 0.05); PW 0.56–0.68 (0.61 ± 0.05); EL 0.76–0.92 (0.84 ± 0.05); EW 0.6–0.72 (0.66 ± 0.04); GD 0.52–0.6 (0.56 ± 0.04). Ratios: PL/PW 1–1.07 (1.01 ± 0.02); EL/EW 1.17–1.44 (1.28 ± 0.09); EL/PL 1.24–1.44 (1.36 ± 0.08); GD/EW 0.81–0.94 (0.85 ± 0.05); TL/EW 2.06–2.44 (2.22 ± 0.12).

Type series. Male holotype (LAPC) "BRASIL: BA Caravelas; Ilha da Cassumba 30.ii.2006 *leg.* K.S. Furieri, F.C.C. Barreto, E.S. Rediguieri" "*Ceracis cassumbensis* Antunes-Carvalho & Lopes-Andrade HOLOTYPUS" [printed on red paper]. Paratypes: 20 males, 10 females (LAPC), same data as holotype. All paratypes distinguished labeled "*Ceracis cassumbensis* Antunes-Carvalho & Lopes-Andrade PARATYPUS" [printed on yellow paper].

Natural history. Cassumba is a continental island at the Caravelas-Peruípe estuarine system, with around 120Km². It is located at the northern portion of the Atlantic Forest and encompasses forest remnants and large mangrove areas mixed in a landscape apparently well preserved. It is the first record of Ciidae from the island and a rare record of the family from a Brazilian estuarine system. However, we do not know either the host-fungus of this single collection of *C. cassumbensis* sp. n. or whether it was caught close to a mangrove or a forest remnant at the island.

Ceracis navarretei Antunes-Carvalho & Lopes-Andrade, sp. n.

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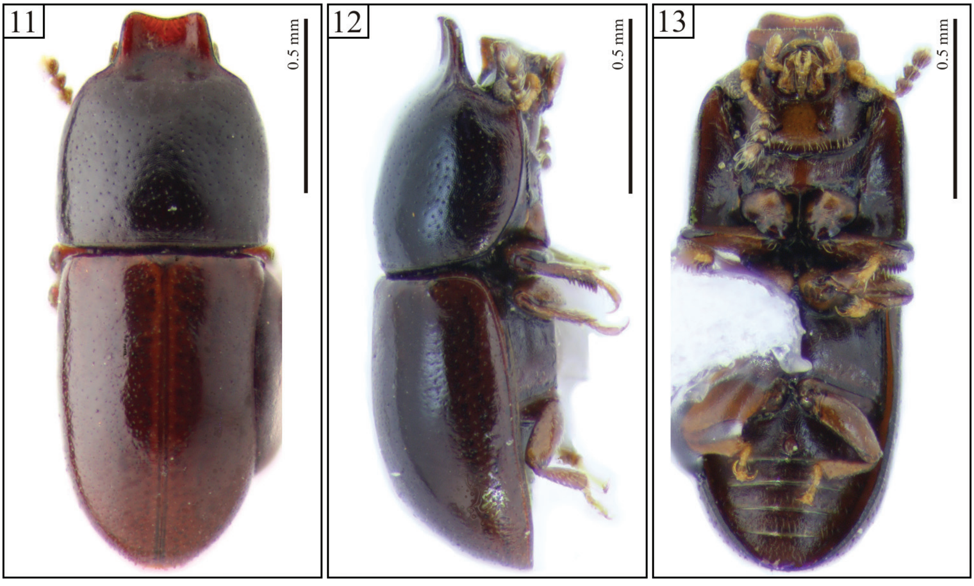
http://species-id.net/wiki/Ceracis_navarretei
Figs 11–20

Type-locality. Dos Amates, southern portion of the state of Veracruz, southern Mexico (17°24'N, 94°35'W).

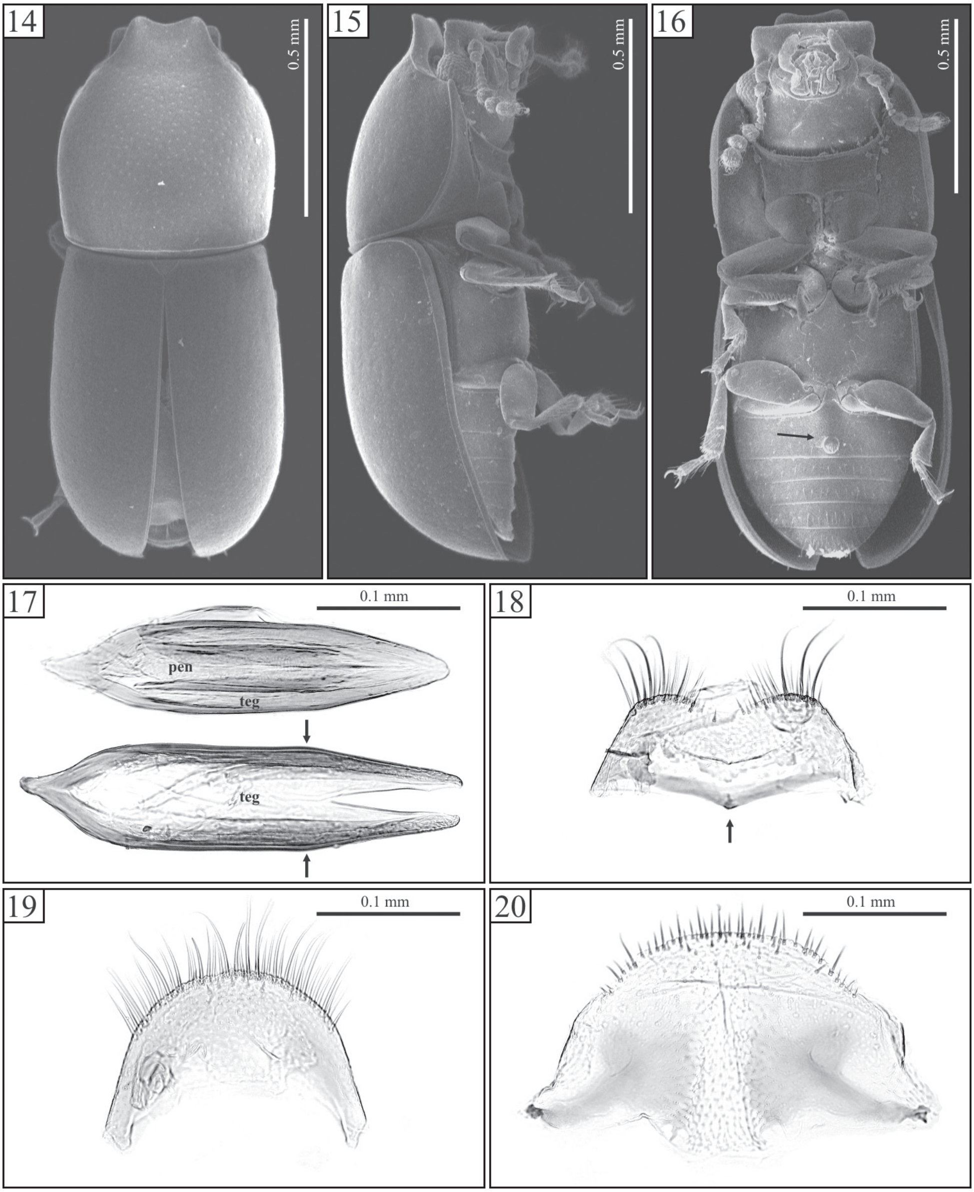
Etymology. The specific epithet is in honor of José Luis Navarrete Heredia, who made available to us the majority of the specimens included in the type series.

Diagnosis. Body with very fine, sparse punctation. Each antenna with nine antennomeres. Pronotum mostly black; elytra and apex of pronotum reddish brown. Pronotal apex projected for- and upward, forming a curve, raised foursquare plate, weakly emarginated at the anterior edge. Elytra with lateral margins subparallel at the basal half, then gradually converging toward the apex. Aedeagus 4× longer than wide (Fig. 17); tegmen with parallel sides at most of their lengths, lateral edges angulate at the beginning of the apical third (Fig. 17, arrows) and then converging in straight line toward the apex.



Figures 11–13. Habitus of *Ceracis navarretei* Antunes-Carvalho & Lopes-Andrade, sp. n., holotype. **11** Dorsal view **12** Lateral view **13** Ventral view.

Description. Male holotype (Figs 11-13), measurements in mm: TL 1.60; PL 0.72; PW 0.64; EL 0.88; EW 0.62; GD 0.56; TL/EW 2.58; PL/PW 1.13; EL/EW 1.42; EL/PL 1.22; GD/EW 0.90. Body subcylindrical, moderately convex; elytra and apex of pronotum reddish brown, remainder of pronotum black; ventral surface reddish brown; legs, mouthparts, basal antennomeres and funicle yellowish brown; antennal club dark brown. Head barely visible from above; dorsal surface flattened, subglabrous, bearing minute, sparsely decumbent fine setae, almost indiscernible; punctation sparse, consisting of shallow coarse punctures; frontoclypeal ridge produced forward, transversely concave, with its anterior margin slightly emarginate at middle, the anterior edge with a row of setae along it. Each eye with a widest diameter of 0.13 mm; some short slender yellowish setae emerging from the intersection between ommatidia. Each antenna with nine antennomeres (FL 0.09, CL 0.15, CL/FL 1.67); length of the antennomeres (in mm) as follows (from base to apex): 0.06, 0.04, 0.04, 0.02, 0.02, 0.02, 0.04, 0.04, 0.06; each antennomere of the club bearing several sparse slender setae, and four conspicuous sensillifers symmetrically positioned at its upper portion. Pronotum with subparallel sides, widest at middle; lateral margins narrow, being a bit thicker at the anterior portion; only the anterior and posterior corners can be seen from above, but the latter is weakly visible; anterior edge projected for- and upward, forming a curve, raised foursquare plate, slightly emarginated at apex (Figs 11, 14); raised plate transversely concave; anterolateral angles slightly produced, moderately obtuse;



Figures 14–20. *Ceracis navarretei* Antunes-Carvalho & Lopes-Andrade, sp. n., SEM of male topotypes (14–16) and slide preparations of male terminalia of topotypes (17–20). **14** Dorsal view **15** Lateral view **16** Ventral view, showing the circular margined sex patch at the first abdominal ventrite (arrow) **17** Above, aedeagus showing penis (pen) and tegmen (teg). Below, a tegmen alone. Arrows indicate the angulation point from which the sides of tegmen converge in straight line toward the apex **18** Eighth sternite, showing the anterior margin weakly produced at middle (arrow) **19** Eighth tergite **20** Fused ninth and tenth tergites.

punctation fine, single, relatively uniform; distance between punctures from 2.5 to 3 puncture-widths; vestiture of yellowish decumbent seta; in between punctures shiny, microreticulate. Scutellum small, triangular, glabrous, with few fine punctures; basal width 0.11mm; length along the longitudinal midline 0.05 mm. Hind wings developed. Elytra with sides subparallel at basal half, then gradually converging to apex; only the most anterior corners visible from above; punctation single, confused, finer and denser than that of pronotum; vestiture consisting of minute, fine, decumbent yellowish setae; in between punctures smooth and shiny. Ventral sclerites microreticulate. Prosternum in front of coxae shallowly concave longitudinally and transversely convex; surface beside coxae weakly concave; prosternal process laminate, almost as long as coxae. Metaventrite moderately convex, bearing sparse slender setae; punctation shallow and sparse, almost indiscernible; discrimen indiscernible. Abdominal ventrites bearing sparse slender decumbent yellowish setae, longer than those on the dorsal surface; punctation shallow and sparse; lengths of abdominal ventrites (from base to apex, at the longitudinal midline) as follows (in mm): 0.19; 0.07; 0.07; 0.07; 0.08; abdominal length 0.50 mm, abdominal width (basal width of the first abdominal ventrite) 0.55 mm; first abdominal ventrite bearing a circular margined sex patch (Fig. 16, arrow), located postered of center, with a transverse diameter of 0.04 mm. Apex of each protibia expanded; outer apical angle rounded and bearing a row of spines.

Male terminalia. (Figs 17–20) Ninth segment (=genital ring) V-shaped. Fused ninth and tenth tergites (Fig. 20) with posterior margin reasonably straight, with small suberect bristles along it; sides diverging, each bearing a small protuberance at middle. Eighth sternite (Fig. 18) with posterior margin weakly emarginate at middle; posterior angles rounded and bearing some bristles; lateral margins diverging; anterior margin biconcave, sclerotized and forming a short median strut (Fig. 18, arrow). Eighth tergite (Fig. 19) with posterior margin rounded, bearing long and medium size bristles along it; lateral margins diverging; anterior margin concave. Aedeagus (Fig. 17) 4× longer than wide; basal piece not observed, possibly membranous. Tegmen slightly longer than and twice as wide as penis; posterior portion subtriangular and then parallel sided at most of its length, either side angulate at the beginning of the apical third (Fig. 17, arrows) and converging in straight line toward apex. Penis elongate, subcylindrical; sides subparallel at the basal three-fourths, with apical one-fourth subtriangular and weakly sclerotized.

Females. Differing from males in the following features: frontoclypeal ridge rounded, not produced. Head with dorsal surface usually convex. Lateral margins of pronotum rounded; anterior margin rounded, not produced; pronotal and elytral punctation slightly finer than in males. Abdominal sex patch absent.

Variation. Males, measurements in mm (n=22, including holotype): TL 1.22–1.74 (1.53 ± 0.13); PL 0.46–0.78 (0.67 ± 0.08); PW 0.50–0.68 (0.61 ± 0.05); EL 0.76–0.96 (0.86 ± 0.05); EW 0.50–0.68 (0.60 ± 0.05); GD 0.40–0.60 (0.53 ± 0.04). Ratios: PL/PW 0.92–1.27 (1.09 ± 0.08); EL/EW 1.38–1.57 (1.44 ± 0.05); EL/PL 1.14–1.65 (1.31 ± 0.12); GD/EW 0.80–0.94 (0.88 ± 0.04); TL/EW 2.43–2.73 (2.56 ± 0.09). Color of pronotum varying from black to reddish brown, usually reddish;

elytra dark reddish to reddish brown. Anterior edge of pronotum weakly developed in the smallest males and strongly projected in the largest ones. In some cases the anterior and posterior corners of the lateral margins of pronotum are not visible from above. Surface of pronotum weakly to distinctly microreticulate. Eighth sternite with anterior margin completely rounded to weakly produced at middle.

Females, measurements in mm (n=18): TL 1.16–1.50 (1.35 ± 0.09); PL 0.44–0.58 (0.51 ± 0.04); PW 0.44–0.60 (0.54 ± 0.04); EL 0.72–0.92 (0.84 ± 0.05); EW 0.46–0.62 (0.55 ± 0.04); GD 0.42 ± 0.54 (0.49 ± 0.04). Ratios: PL/PW 0.88–1.00 (0.95 ± 0.04); EL/EW 1.43–1.59 (1.51 ± 0.05); EL/PL 1.54–1.79 (1.64 ± 0.07); GD/EW 0.81–0.96 (0.89 ± 0.05); TL/EW 2.31–2.57 (2.43 ± 0.08).

Type series. Male holotype (CZUG) "MEXICO: Veracruz Dos Amates 03.vi.1988 S.L. Álavez *leg*." "*Ceracis navarretei* Antunes-Carvalho & Lopes-Andrade HOLOTYPUS" [printed on red paper]. Paratypes: 19 males, 16 females (11 males and 12 females at CZUG, 8 males and 4 females at LAPC), same data as holotype; 2 females and 2 males (2 females and 1 male at ANIC, 1 male at LAPC) "MEXICO: Veracruz Dos Amates 28/2/1987 polypore 0114 J. Navarrete". All paratypes distinguished labeled "*Ceracis navarretei* Antunes-Carvalho & Lopes-Andrade PARATYPUS" [printed on yellow paper].

Natural history. Dos Amates is surrounded by small villages, being a mosaic of forest remnants and deforested areas apparently far from major urban areas. We have no information on the host-fungus of this new species. We only know that a few specimens were collected in a polypore (see "Type series" above).

Discussion

Organizing morphologically similar species of Ciidae into species-groups has been an useful taxonomic tool, especially in speciose genera as *Ceracis*, *Cis* Latreille and *Scolytocis* Blair (Lopes-Andrade 2008, Lopes-Andrade et al. 2002), as it facilitates the task of recognizing new species or synonyms. Currently, there are four defined species-groups (*cucullatus*, *furcatus*, *furcifer* and *singularis*) for 17 species of *Ceracis*. The *furcatus* group includes *C. furcatus* (Bosc), *C. militaris* Mellié, *C. minutus* Dury and *C. variabilis* (Mellié). These species were discussed together in the work of Lawrence (1967) and called a species-group by Lopes-Andrade (2002), who erroneously included *C. furcifer* Mellié (lapsus calami with *C. minutus*; Lopes-Andrade pers. obs.). *Ceracis furcifer* names another group including *C. cornifer* (Mellié), *C. cylindricus* (Brèthes), *C. furcifer*, *C. hastifer* (Mellié), *C. monocerus* Lawrence, *C. ruficornis* Pic, *C. simplicicornis* (Pic) and *C. unicornis* Gorham (sensu Lawrence 1967). The *singularis* group (sensu Lopes-Andrade et al. 2002) includes *C. furcicollis* (Blair), *C. limai* Lopes-Andrade et al. and *C. singularis* (Dury).

Lawrence (1967) proposed the *cucullatus* group for *C. bicornis* (Mellié) and *C. cucullatus*. He also synonymized *C. bilamellatus* (Pic), *C. lamellatus* (Pic) and *C. tabellifer* (Mellié) with *C. cucullatus* because they were described based on size and development of pronotal characters in the male, features considered variable within the populations examined by the author. *Ceracis cucullatus* and *C. bicornis* can be distinguished by the pronotal apex that is weakly emarginate in *C. cucullatus*, and deeply emarginate in *C. bicornis* forming two distinct horns in males with developed secondary sexual characteristics. Lawrence (1967) suggested that the nearctic *C. thoracornis* (Ziegler) and the palearctic *C. shikokuensis* (Miyatake) and *C. japonus* (Reitter) could be part of the *cucullatus* group, although not formally including them. We have examined named specimens of these three species and concluded that they are not similar enough to either *C. cucullatus* or *C. bicornis* to be included in the group. Here we redefine the *cucullatus* group so to include *C. cassumbensis* sp. n. and *C. navarretei* sp. n., as follows: (i) each antenna with eight or nine antennomeres, (ii) pronotum with fine and sparse punctation, (iii) body moderately long, and (iv) relatively long lamina on the apex of pronotum in males with fully developed secondary sexual characteristics. In the original proposal (see Lawrence 1967), only species with nine antennomeres were included in the *cucullatus* group. However, the number of antennomeres can vary even among morphologically similar species of *Ceracis*, as within the *furcifer* group: *C. furcifer* and *C. ruficornis* have eight antennomeres, while the other species have nine antennomeres (Lawrence 1967).

Among the species in the *cucullatus* group, as proposed here, *C. navarretei* sp. n. is possibly the most similar to *C. cucullatus*, mainly to its African populations. Differences are notable especially on male terminalia: The tegmen of *C. navarretei* sp. n. has the lateral edges parallel at most of their lengths, the apical third converging in straight line toward the apex. In named specimens of *C. cucullatus* examined by us, the sides of tegmen are either subparallel or weakly curved. Moreover, the aedeagus in *C. navarretei* sp. n. is 4× longer than wide, while in *C. cucullatus* it is around 3×. *Ceracis cassumbensis* sp. n. may be distinguished from *C. cucullatus* by its greater depth of the body (most evident when comparing females), antennae with eight antennomeres, elytral punctation denser and abdominal sex patch larger and transversely oval (Fig. 6, arrow). Moreover, either lateral edge of the tegmen in *C. cassumbensis* sp. n. has a peculiar excavation near apex (Fig. 7, arrows). This characteristic is also observed in *C. similis* Horn, although this species is distinguishable from *C. cassumbensis* sp. n. by its reddish body, punctation comparatively coarser and denser and relatively wider pronotal lamina.

The morphological limits of both *C. cucullatus* and *C. bicornis* were not satisfactorily established. The former is one of the most widely distributed ciid species in the tropics and the latter is widespread in the Neotropical region, having been reported in Mexico, Guatemala, Costa Rica, Peru (Lawrence 1967), northeastern, southeastern and southern Brazil (C. Lopes-Andrade pers. obs.). Morphological variation among allopatric populations of these species has been frequently observed and possibly interpreted as polymorphism, which may be overshadowing the recognition of new species. The description of *C. cassumbensis* sp. n. and *C. navarretei* sp. n. is a reflex of this scenario. *Ceracis cucullatus* and *C. bicornis* may be cryptic species complexes and shall be more carefully studied. Other *Ceracis* species, as those in the *furcatus* group, also have strong morphological interpopulational variation and possibly involve undescribed forms.

Acknowledgements

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RESEARCH ARTICLE

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Michanthidium almeidai, a new species from northeastern Brazil (Hymenoptera, Megachilinae)

Danúncia Urban†, Daniele Regina Parizotto‡

Laboratório de Biologia Comparada de Hymenoptera, Departamento de Zoologia, Universidade Federal do Paraná, Caixa Postal 19020, 81531-980, Curitiba, Paraná, Brazil

† *urn:lsid:zoobank.org:author:1EA41402-C917-4909-826D-F8FC8BF91B96*
‡ *urn:lsid:zoobank.org:author:80EE1E6F-455E-444E-AD3D-54DA752A6157*

Corresponding author: *Daniele Regina Parizotto* (dparizotto@gmail.com)

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Abstract

A new species of *Michanthidium* Urban (Hymenoptera, Megachilinae) is described and figured from Sergipe and Bahia States, northeastern Brazil. An identification key, illustrations, and a distribution map for the three species of the genus are presented. The male genitalia of *M. almeidai* **sp. n.** and *M. albitarse* are illustrated and compared for the first time.

Keywords

Anthidiini, Apidae, Neotropical, taxonomy

Introduction

Michanthidium Urban, 1995 is an exclusively Neotropical anthidiine genus, according to the classification proposed by Urban and Moure (2007), although it is considered by Michener (2007) as a subgenus of *Hypanthidioides* Moure, 1947, along with nine other subgenera. Two species of *Michanthidium*, *M. sakagamii* (Urban) and *M. ferrugineum* (Urban) were originally described in *Gnathanthidium* Urban, 1993 and subsequently renamed by Urban (1995), because it was a junior homonym of *Gnathanthidium* Pasteels, 1969. In a recent paper, Gonzalez and Griswold (2011) proposed a new combination, *Hypanthidioides* (*Michanthidium*) *albitarsis* (Friese, 1916) (here considered *Michanthidium albitarse*) as the oldest name, resulting in *Michanthidium sakagamii* as a junior synonym.

The species of the genus can be recognized by the following combination of characters present in both sexes: presence of a juxtantennal carina; strong hooked hairs on the underside of the labial palpus and throughout the length of the galeal blade; omaulus with short carina dorsally; pronotal lobe with curved lamellae in profile view; and base of propodeum with row of lateral pits. Additionally, males are characterized by the basal tooth of mandibles separated from the middle tooth by a broad concave margin; fifth sternum with lateral spine-like projections and the presence of arolia. The females are distinguished by the mandibles with smooth apical margin between two small apical teeth and the basal angle, and the external surface with slender carinae not reaching basal half of mandible.

The species of this genus were known from southern Brazil and Argentina, with *Michanthidium ferrugineum* (Urban, 1993) from Argentina (Tucuman) and *M. albitarse* (Friese, 1916) from Brazil (Paraná, Santa Catarina and Rio Grande do Sul) and Argentina (Misiones). The new species, described here is the first record of the genus from northeastern Brazil (Fig. 1). The key presented here is based on the material we had on hands of the three species, except for the male of *M. ferrugineum*, included here based on the description provided by Gonzalez and Griswold (2011). The map here included was based only on the material examined by us and by Gonzalez and Griswold (2011), except by the type of *M. albitarse* that has a label from Costa Rica and it is probably an error as suggested by those authors.

Material and methods

The measurements are given in millimeters. T and S are used here for metasomal terga and metasomal sterna, respectively. Total length was measured in lateral view, from head to apex of metasoma; length of forewing was measured at anterior margin, from the costal sclerite to the wing apex. The type material is deposited in the following institutions: Coleção Entomológica Pe. Jesus Santiago Moure, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Brazil (DZUP) and Coleção Entomológica do Departamento de Zoologia, Universidade Federal de Minas Gerais, Belo Horizonte (DZMG).

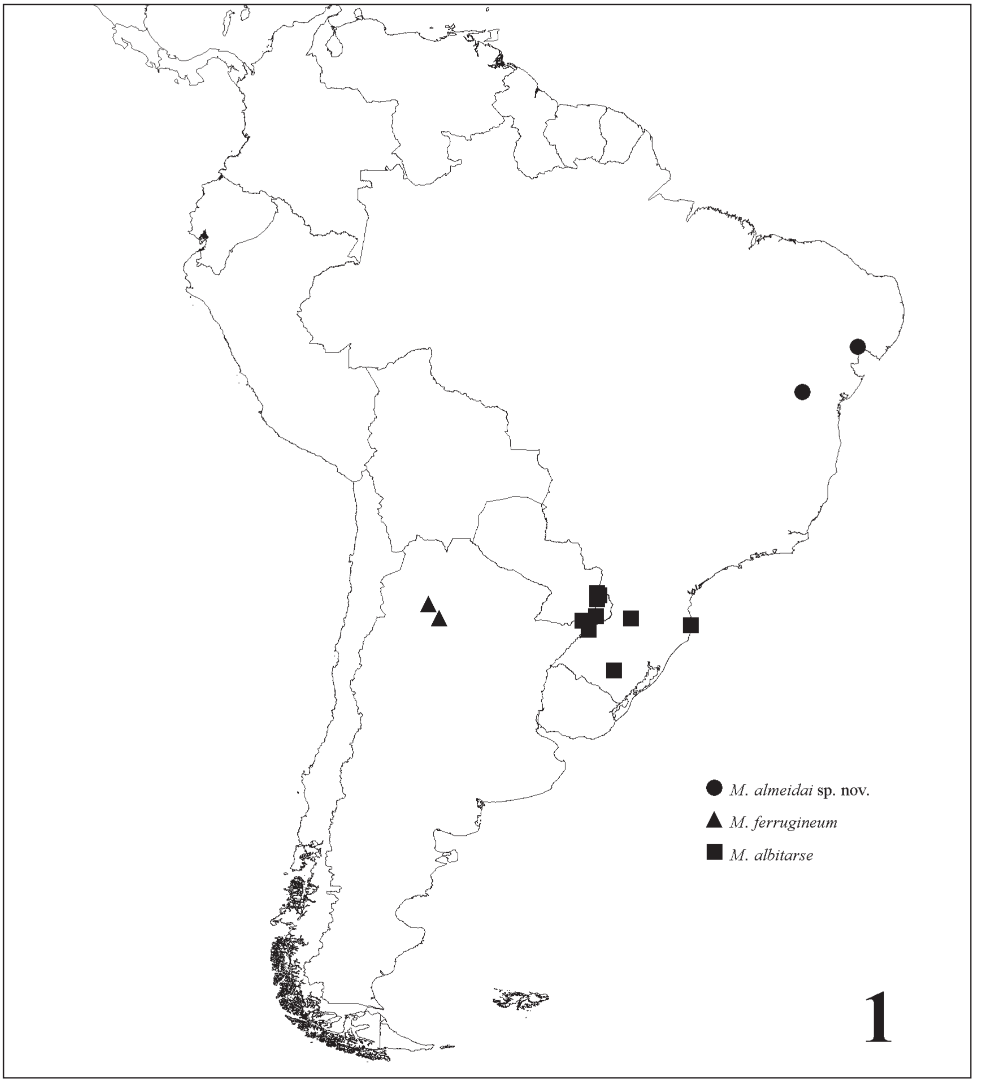


Figure 1. Collecting record map of species of *Michanthidium*.

Taxonomy

Michanthidium almeidai **Urban & Parizotto, sp. n.**
urn:lsid:zoobank.org:act:39581B7E-DF5E-4987-876D-A2C6B6D24B57
http://species-id.net/wiki/Michanthidium_almeidai
Figs 4–7, 8, 11, 13, 17–18, 20, 22–23

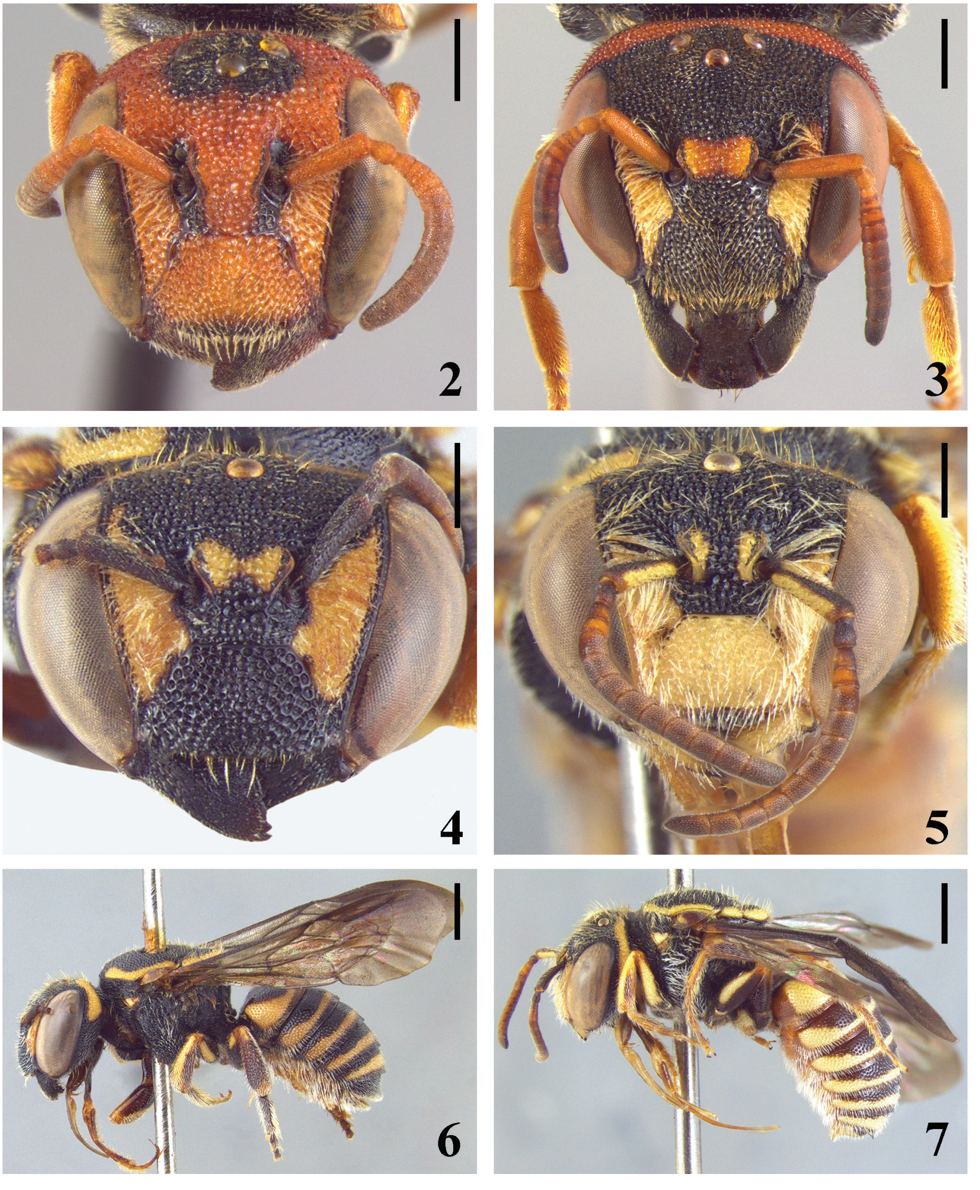
Diagnosis. Tegula sparsely punctate; lateral margin of axilla subangulate; posterior margin of scutellum weakly emarginated at middle (Fig. 11); integument black with yellow maculae. Male with light yellow bands in all terga, laterally wider; distal tergum bilobed with a rounded median emargination (Fig. 20). First to fifth terga of female with yellow bands, slightly light brown colored; bands wider laterally on T1–T3 (Fig. 13).

Description. Holotype female. Length 6.22; length of forewing 4.90; width of head 2.50; length of eye 1.67; upper interorbital distance 1.55; lower interorbital distance 1.12. Integument black with the following yellow areas: paraocular maculae almost reaching upper angle of compound eyes, irregularly narrowing above antennal sockets; interalveolar maculae narrow at middle, butterfly-shaped (Fig. 4); postocellar band extending across vertex to dorsal third of gena (Fig. 6). Pronotal lobe with spot; mesoscutum with band along anterior and lateral margins; axilla and posterior margin of scutellum. Tegula amber with small spot near base. Wings dark brown, darker at base and at costal margin (Figs 6 and 8). Fore and middle legs with coxae and trochanters black; femora with light brown area and a light yellow maculae on external surface; tibiae light brown with yellow band elongated; tarsomeres light brown. Hind legs with coxae black and with a light yellow spot; trochanter black; femora light brown with yellow band narrower than in anterior femora; tibiae light brown with a narrow yellow basal band; tarsomeres darkened. T1-T5 with yellow bands, distinctly wider laterally on first basal three terga; distal tergum black.

Pilosity: color predominantly light yellow, hairs sparse, longer than ocellar diameter, on paraocular area denser and longer; posterior tibiae with dense and plumose hairs; scopa white.

Structure: mandible punctate, punctures smaller and denser on distal half, external surface with slender carinae not extending to basal half. Head and mesosoma densely punctate; posterior margin of scutellum weakly emarginated at middle; terga with punctures sparser than those of head and mesosoma, sparser and shallower on disc than on sides.

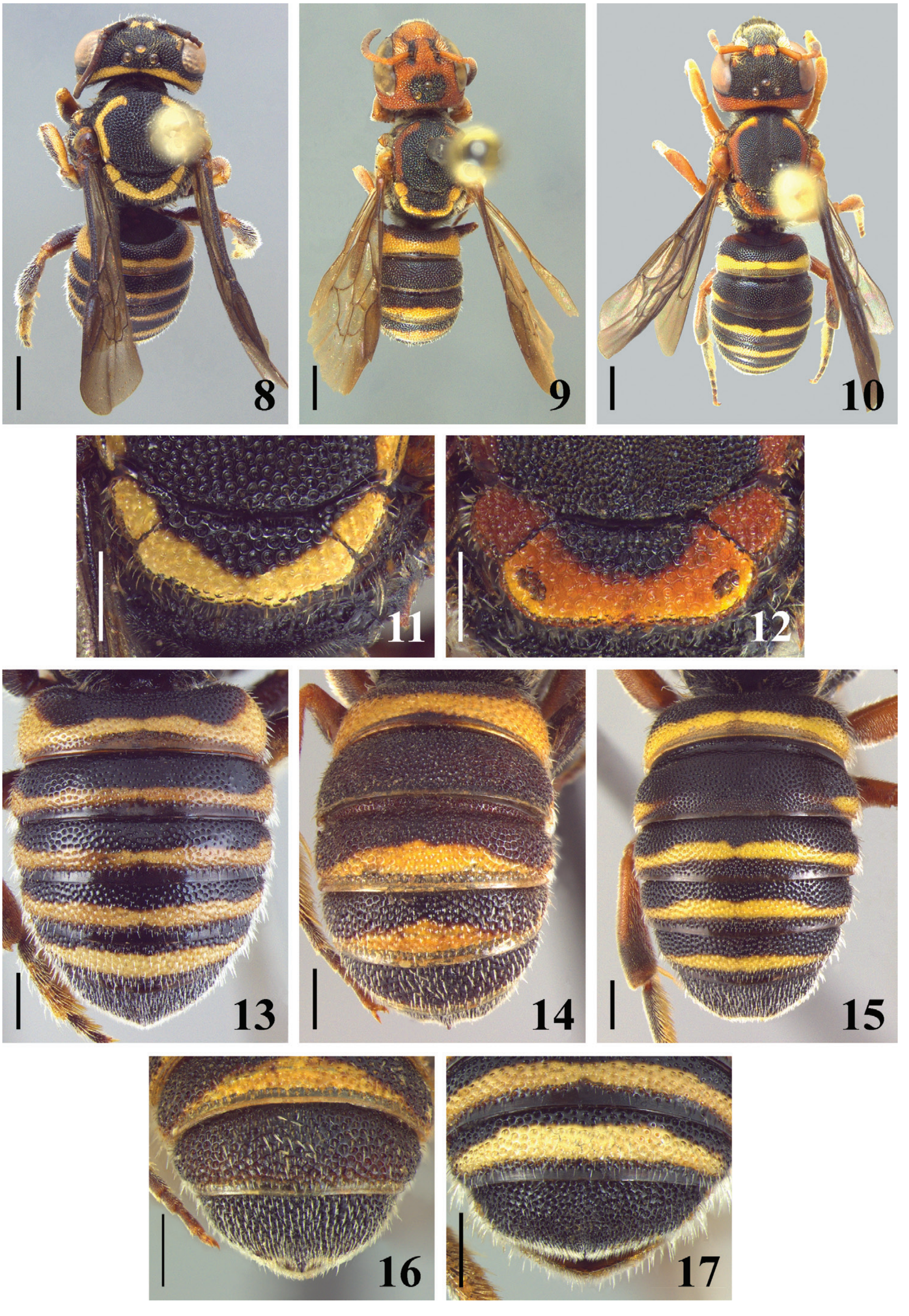
Paratype male. As in female except for denser pilosity and the following: Length 6.24; length of forewing 5.09; width of head 2.48; length of eye 1.52; upper interorbital distance 1.55; lower interorbital distance 1.01. Integument predominantly black, with the following yellow areas: mandibles, except teeth and borders; clypeus; inferior paraocular area; translucent interalveolar carinae with yellow narrow spot. Ventral surface of scape almost entirely yellow; pedicel and ventral surface of flagellomeres darkened; dorsal surface brown (Fig. 5). Fore and middle legs with coxae and trochanters black; femora and tibiae dark brown with large light brown area; femora with yellow elongated internal band; tibiae with light yellow elongated external band; basitarsus amber on external surface. Hind legs with coxae with large yellow maculae on ventral surface; femora almost entirely black, with apical half of ventral surface ferruginous, external surface with small yellow macula; tibiae almost entirely ferruginous with two yellow maculae, one basal and one apical; basitarsus and tarsomeres light brown. Basal tergum light brown; first and second terga with marginal area ferruginous; all terga with light yellow subapical bands, wider laterally on T1–T5, distinctly wider on T1; T6 band wider at middle; distal tergum almost entirely light yellow, black only at base and with translucent ferruginous margin (Figs 7, 18, 20 and 22). Sterna brown with light yellow irregular and narrow median bands.



Figures 2–7. 2–4 head in frontal view of female **2** *M. ferrugineum* **3** *M. albitarse* **4** *M. almeidai* sp. n. **5** head in frontal view of male of *M. almeidai* sp. n. **6–7** lateral view **6** female of *M. almeidai* sp. n. **7** male of *M. almeidai* sp. n. Scale line = 0.5 mm (Figures 2–5). Scale line = 1.0 mm (Figures 6–7).

Structure. Distal tergum medially emarginated on distal margin, thus forming two lobes with lateral margins medially convergent (Fig. 20).

Genitalia. Gonostylus as long as penis valves, about the same width across length; gonocoxites joined by narrow area with base projected. Penis valves with apodemes



Figures 8–17. 8–10 dorsal view of female **8** *M. almeidai* sp. n. **9** *M. ferrugineum* **10** *M. albitarse* **11–12** dorsal view of scutellum and axilla **11** *M. almeidai* sp. n. **12** *M. albitarse* **13–15** dorsal view of metasoma of female **13** *M. almeidai* sp. n. **14** *M. ferrugineum* **15** *M. albitarse* **16–17** apex of metasoma of female **16** *M. ferrugineum* **17** *M. almeidai* sp. n.

shorter than in *M. albitarse* (Fig. 23). The gonostylus are narrow on the apical third in *M. albitarse*, and distinctly incurved (Fig. 24).

Type material. Holotype female. BRAZIL, Sergipe. "Canindé do **[sic]** São Fran- / cisco – SE, Sta Maria / Brasil 23.09.2005 / Debora Moura leg.", "L 172 P 140 / *Scoparia dulcis*" (DZUP). One male paratype: same data as holotype, except by "25.10.2005, "L 172 P1190 / *Schultesia guianensis"* (DZUP). One male paratype: BRAZIL, Bahia. "Lençois, BA / BRASIL 08/01/1997 / E. A. B. Almeida" (DZMG).

Etymology. The specific epithet is homage to our friend and bee specialist, Dr. Eduardo Andrade Botelho de Almeida, professor at the Universidade de São Paulo, Ribeirão Preto (FFCLRP).

Comments. The paratype male from Bahia State is probably a teneral specimen judging the pale coloration of legs and sterna. The paratype from Sergipe State has the sterna black with light yellow bands and tibiae and femora with black areas. The wings and antennae are partially damaged.

Key to *Michanthidium* species

1 Male **2**

– Female **4**

2(1) Head and mesosoma without ferruginous areas; sixth tergum with a large translucent apical margin, angulated at middle (Fig. 22); seventh tergum with wide rounded lateral lobes, without median spine and with a rounded median depression (Fig. 20) .... ***M. almeidai* sp. n.**

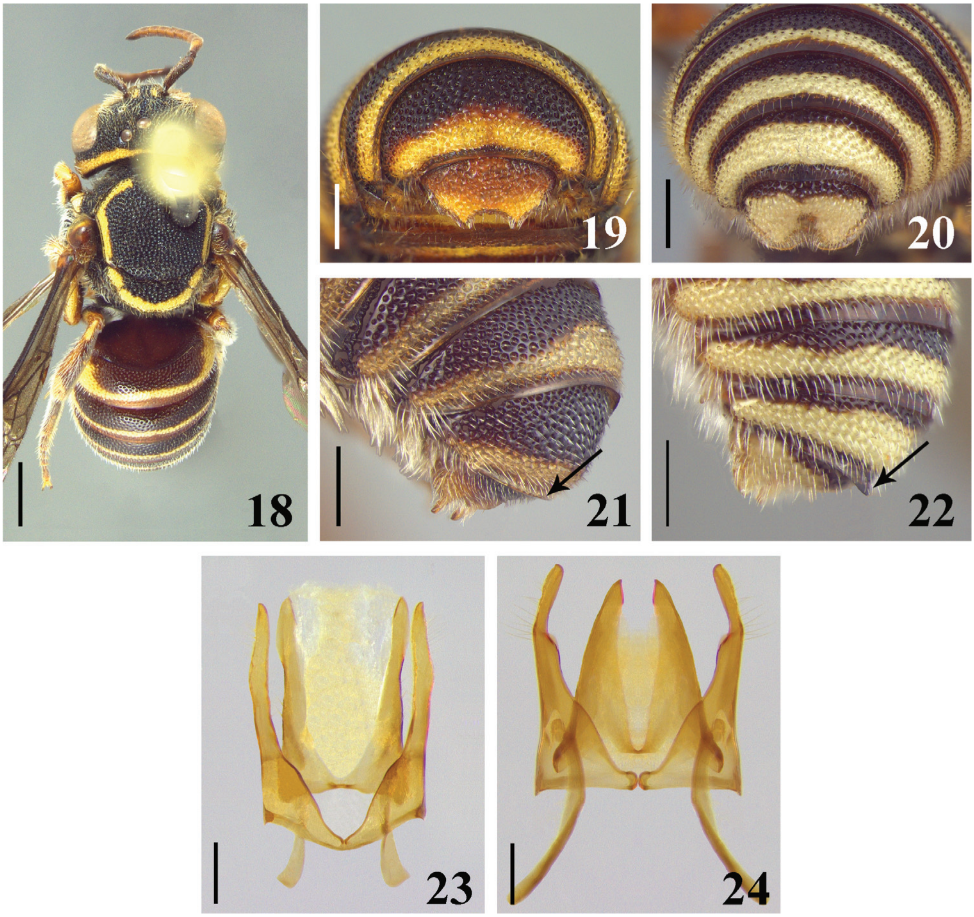
– Head and mesosoma with ferruginous areas; sixth tergum with straight apical margin (Fig. 21); seventh tergum with lateral lobes acute, with or without median spine and without a median depression (Fig. 19) **3**

3(2) Hind coxa with midapical spine; sixth tergum with small sublateral tooth; seventh tergum without median spine (Fig. 19) .... ***M. albitarse***

– Hind coxa without midapical spine, with a short row of black, thick short hairs on median margin; sixth tergum without sublateral tooth; seventh tergum with median spine .... ***M. ferrugineum***

4(1) Lateral margin of axilla broadly rounded; posterior margin of scutellum subtruncate and laterally expanded in a large translucent area (Fig. 12); external surface of tibiae and basitarsi with small, fine punctures, and pilosity decumbent; shorter than ocellar diameter; tegula densely punctate, punctures separated by one or less puncture diameter **5**

– Lateral margin of axilla subangulate; posterior margin of scutellum weakly emarginated at middle, laterally expanded in a small translucent area near axillae (Fig. 11); external surface of tibiae and basitarsi with coarser punctures, pilosity longer than ocellar diameter; tegula sparsely punctate, punctures separated by much more than one puncture diameter .... ***M. almeidai* sp. n.**



Figures 18–24. 18 dorsal view of male of *M. almeidai* sp. n. **19–20** dorsal view of apex of metasoma of male **19** *M. albitarse* **20** *M. almeidai* sp. n. **21–22** apex of T6 of male **21** *M. albitarse* **22** *M. almeidai* sp. n. **23–24** male genitalia in dorsal view **23** *M. almeidai* sp. n. **24** *M. albitarse*. Scale line= 1.0 mm (Figure 18). Scale line = 0.25 mm (Figures 19–20; 23–24). Scale line = 0.5 mm (Figures 21–22).

5(4) Head mostly black with limited ferruginous areas (Fig. 3); mesoscutum laterally with coarse, large punctures (about one-third median ocellar diameter); distal tergum not medially projecting into spine .... ***M. albitarse***

– Head almost totally ferruginous (Fig. 2); mesoscutum uniformly punctate; punctures small (about one-fourth to one-fifth median ocellar diameter); distal tergum medially projecting into spine (Fig. 16).............. ***M. ferrugineum***

Discussion

The curved hairs on the underside of the labial palpi are shared with *Larocanthidium* Urban, 1997, although in *Michanthidium* those hairs are also present throughout the length of the galeal blade in both sexes. This morphology suggests a special floral relationship (Michener 2007) although there is scarce information about the plants visited by *Michanthidium* species. Gonzalez and Griswold (2011) reported that the examined females and males of *M. ferrugineum* were collected on flowers of *Cuphea* sp. (Lythraceae). The holotype female of *Michanthidium almeidai* sp. n. was collected on *Scoparia dulcis* Linnaeus (Scrophulariaceae) and the paratype male from Canindé de São Francisco on *Schultesia guianensis* (Aublet) Malme (Gentianaceae). Although these are only isolated records, they could be a first step to understanding specialization in these bees.

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RESEARCH ARTICLE

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Biometry based ageing of nestling Indian Spotted Owlets (*Athene brama brama*)

Satish Pande[1], Amit Pawashe[1], Mahadeo N. Mahajan[1], Anil Mahabal[2], Reuven Yosef[3], Neelesh Dahanukar[1]

1 *Ela Foundation, C-9, Bhosale Park, Sahakarnagar-2, Pune 411009, Maharashtra, India* **2** *Zoological Survey of India, W. R. S. Akurdi, Pune, Maharashtra, India* **3** *Ben Gurion University at Eilat, P. O. Box 272, Eilat 88000, Israel. Present address: Women's College for Higher Education, Nagpur, Maharashtra, India*

Corresponding author: *Reuven Yosef* (ryosef@eilatcity.co.il)

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Abstract

Biometric analysis helps in sex differentiation, understanding development and for studies of avian biology such as foraging ecology, evolutionary ecology, and survivorship. We suggest that biometry can also be a reliable, practical and inexpensive tool to determine the age of nestlings in the field by non-invasive methods. As an example we studied the biometry of wing, culmen, talon, tarsus and body mass of nestling southern Indian Spotted Owlets (*Athene brama brama*). Based on the growth pattern analysis using logistic growth model, discriminant analysis and CHAID (Chi-squared Automatic Interaction Detection) based decision tree, we show that biometry of nestling Spotted Owlets is an easy, reliable and inexpensive method to determine nestling age and to assess growth rate and relative nutritional status. These biometric parameters also allow us to predict their ability to initiate first flight from the nest site. This method is described here for the first time and we postulate that such charts can be devised for other avian species as well, so as to assist conservation biologists and bird rescuers.

Keywords

Spotted Owlet, Age, Biometry, Nestling, Flight-Predictor

Introduction

Adult and juvenile birds of the same species are of similar size but are differentiated on the basis of plumage, fault bars, tail shape, castellated feathers, bill shape, cere color, and other parameters (eg., Svensson 1992; Sutherland 2000). Such differences and others like the appearance of down are less marked and much more subjective in the nestling period, especially if the nestling period is of short duration. Hence, the necessity of some other criteria for determination of the exact age of nestlings is essential. Because body size change is rapid during nestling growth period, biometry can be a useful parameter to determine age since hatching.

Our ability to monitor and understand biometric parameters is important from ecological and conservation perspectives. During the nestling period, these parameters allow one to evaluate parental feeding ability, and to monitor relative nutritional condition between siblings and between neighboring nests of different habitats. Parameters can also help in the rehabilitation of orphaned nestlings in determining whether they are fed appropriately so that growth rates are comparable to nestlings in the wild.

Retrograde calculation of hatching and egg-laying dates can be accurately determined from the age of the nestling or from time of fledging (Blotzheim and Bauer 1980; Cramp and Simmons 1985; Penteriani 2002). However, hatching dates are not always available for nestlings found during field surveys. Biometry has been previously used in the determination of sex of adult owls (Ali and Ripley 1969; Delgadiao and Penteriani 2004), development in owls (Kristan et al. 1996; Nagarajan et al. 2002; Penteriani et al. 2004) and for studies of avian biology such as foraging ecology, evolutionary ecology, and survivorship (Anderson and Norberg 1981; Newton et al. 1983; Clutton-Brock 1986). Biometry is also used to distinguish between subspecies of raptors and other avian species (Ali and Ripley 1969; White and Boyce 1988).

In this paper we show how the use of biometry can be a reliable, practical and inexpensive tool to determine the age of nestlings in the field by non-invasive methods, and by taking the minimum required measurements through the use of a flow chart as described. A method to estimate the time of acquiring flight ability using biometric parameters is also investigated and described. We have taken southern Indian Spotted Owlets (*Athene brama brama*) as an example. Southern Indian Spotted Owlet *A. brama brama* is a valid subspecies of spotted owlet *A. brama* and is endemic to this zoogeographical region (Ali and Ripley 1969; Kumar 1985). Feeding and nesting behavior of this species is known (Kumar 1985; Jadhav and Parasharya 2003; Pande et al. 2006), however, detailed biometric analysis of developing nestlings is done for the first time in this study. In this study we present the biometry of the nestling from the day of hatching through fledging.

Methodology

Data collection

A total of 53 active nests of southern Indian Spotted Owlet *Athene brama brama* were included in our study. The study was conducted for two consecutive years (2003 and 2004) in and around Saswad (18°19'N to 18°20' N and 73°57' E to 74°01' E) in Pune district, Maharashtra, India. The nests were identified by: a) direct information about known nest sites from local residents, b) passive auditory surveys by authors at dawn and dusk during the breeding season, December to April, when owlets are most vocal, c) searching for probable nest sites, when at least three visits to each site were made, d) by requesting local people to inform about new sites found, after making them familiar about the ongoing study through a public-outreach program.

Out of the 53 active nests found, seven nests were intensively studied during the 2003 breeding season for the documentation of breeding biology and biometry. Biometry of eight nestlings from hatching till fledging, from 0 to 32 days, was done at weekly intervals, and the data was entered serially for each chick. A total of 136 measurements were taken, averaging 17 measurements per nestling. We included only those nests that were easily accessible where the exact dates of egg laying and hatching were recorded. Nestlings that died in the middle of the study were excluded. We ringed each nestling with a numbered aluminum ring placed on the tarsus to facilitate individual identification of each nestling. Sexes are alike in external appearance and thus we could not separate between the nestlings in this study based on their sexes (Hipkis et al. 2002).

We used a Vernier calipers ($\pm$0.001mm), wing-stop and tail rulers (0.1mm) for measurement, and Pesola spring scales (60 gm, 100 gm) to weigh body mass. In order to be consistent, only two trained researchers (AP & SP) took all measurements. We measured the biometry of five parameters: (a) wing chord: carpal joint to the tip of the longest primary with the wing flattened, (b) tarsus: ankle joint to the attachment of toes where measurements were taken using flexion at proximal and distal joints, (c) talon: length of claw of the middle toe was measured with Vernier caliper from the point of insertion to the tip, (d) culmen: the exposed part of the culmen from the cere to the tip, (e) body mass: all body mass was taken at sunset. Allowing for the fact that Spotted Owlets forage at dusk or at night, this assured an empty stomach, which minimized the effect of meals. This also caused minimal disturbance to the owlets, which resumed their crepuscular and nocturnal activities immediately after our visits to the nests.

Statistical analysis

To each of the biometric character we fitted the logistic model to understand its growth pattern and growth rate (Ricklefs 1979). The logistic equation is,

$$\text{Character value} = a/[1+b*\exp(-c*Age)] \qquad (1)$$

Where a, b and c are positive constants. Constant *a* signifies maximum possible value of the character, constant *b* signifies the delay in growth associated with the lag phase and constant *c* is the growth rate. The goodness of fit was determined by regression coefficient.

We also studied the growth patterns by nullifying the effect of size using Principle Component Analysis (PCA) as described by Badyaev and Martin (2000). PCA was performed on ln-transformed data of four biometric parameters namely wing chord, talon, tarsus and culmen lengths. The PCA was performed on the covariance matrix. The isometric vector defined as $(1/p)^{1/2}$, where p is the number of characters, was 0.5. We calculated the angle theta between the eigenvector for each age class and isometric vector to understand the developmental pattern.

We performed Discriminant Factor Analysis (DFA) to understand whether different age groups form significantly different clusters and which factors can best discriminate between the clusters (Legendre and Legendre 1984). We performed Pillay's trace statistic to find the significant difference between the clusters (Harris 2001).

To predict the nestling age using biometric characters we constructed decision tree (regression tree) using exhaustive CHAID (Chi-squared Automatic Interaction Detection) algorithm. At each step, CHAID chooses the independent (predictor) variable that has the strongest interaction with the dependent variable. Categories of each predictor are merged if they are not significantly different with respect to the dependent variable (Kass 1980).

Results

Growth pattern

Observations on the biometric parameters of nestling Spotted Owlets of different age groups are given in Table 1. All biometric characters showed a good fit to logistic model of growth ($p < 0.01$; Fig. 1). Among the five biometric characters talon length had the highest growth rate (2.39 mm/week) followed by body mass (2.2 g/week), while wing chord length showed the least growth rate (1.56 mm/week). Even though the rate at which both culmen and wing chord increased were similar, wing chord showed initial lag and thus attained a mature chord length at 5 weeks (Fig. 2) while culmen attained maximum length in only two weeks.

After a small lag body mass displayed linear growth with a steep rise through 2.5 weeks. Eighty percent of adult growth was attained at the end of 2 weeks (Fig. 1a). At 0–1 week the average mean mass was 26.8 gm (11.1 SD, range 13–42, n = 6) and at 4–5 weeks was 125 gm (7.9, 115–135, n = 5). Coefficient of variation (CoV, 41.46) was highest at one week. The nestlings attained 91.9% of adult body mass at 4.5 weeks, and no significant change was found up to 6.5 weeks. We observed a drop in mass at 3.5 weeks, one week prior to fledging (Table 1).

Out of five biometric parameters, wing chord length showed the longest lag phase. It started growing rapidly only after two weeks and attained maximum length after five

Table 1. Mean, standard deviation and coefficient of variation of biometric parameters for age in weeks of nestling Spotted Owlets (*Athene brama brama*).

Character	1st Week (n =11)		2nd Week (n =11)		3rd Week (n = 6)		4th Week (n = 6)		5th Week (n = 6)	
	$\bar{x}$ (sd)	CV	$\bar{x}$ (sd)	CV	$\bar{x}$ (sd)	CV	$\bar{x}$ (sd)	CV	$\bar{x}$ (sd)	CV
Body Mass (g)	23.36 (9.96)	42.64	82.73 (10.08)	12.19	117.17 (6.62)	5.65	113.83 (12.50)	10.98	126.83 (8.38)	6.60
Wing Chord (mm)	13.06 (3.49)	26.69	33.45 (10.20)	30.48	87.42 (5.14)	5.88	103.17 (6.68)	6.47	121.67 (6.53)	5.37
Talon (mm)	2.46 (0.81)	32.89	6.43 (0.28)	4.29	7.42 (0.25)	3.35	7.48 (0.26)	3.53	7.85 (0.10)	1.34
Tarsus (mm)	14.93 (3.16)	21.18	30.17 (2.91)	9.66	36.22 (1.22)	3.36	38.40 (2.02)	5.26	39.27 (1.76)	4.49
Culmen (mm)	6.74 (0.90)	13.43	10.5 (0.40)	3.86	11.33 (0.23)	2.06	11.57 (3.36)	3.36	12.40 (0.41)	3.35

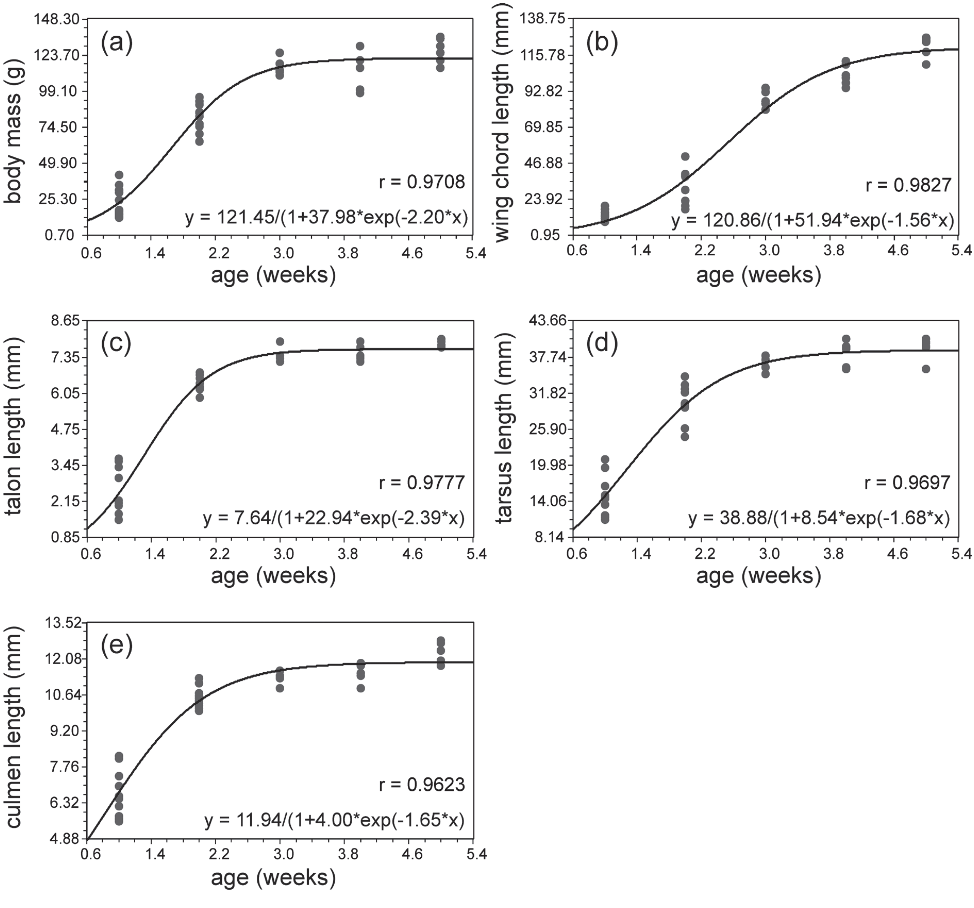

Figure 1. Biometry of body mass, wing chord length, talon length, tarsus length and culmen length plotted against the age of nestling Spotted Owlets (*Athene brama brama*). The smoothed curve is the logistic growth model fitted to the data.

weeks (Fig. 1b, 2). The average mean value for wing growth at 0–1 week was 13.98mm (3.67, 10.0–20.0, n = 8) and at 4–4.5 weeks 120 mm (7.7, 110–127, n = 4). CoV (35.3) was highest in the second week. This might be due to sex differences in the nestlings, but because of our inability to sex the birds this remains untested. Similar difference during the first week is seen in growth of other parameters also, which accounts for the higher CoV values in this period. However, this aspect needs to be evaluated separately in a future study. Wing chord length is 33 % of adult size at two weeks, 80 % of adult size at 4.5 weeks and 85.4 % adult size at 6.5 weeks.

The claw of the middle toe, talon, had the maximum growth rate among the five characters. It showed linear growth up to first two weeks and then it slowed down and attained mature size in the third week (Fig 1c). At 0–1 weeks the average mean value was 2.5 mm (0.84, 2–4, n = 5) and at 4–4.5 weeks was 7.9 mm. Adult size was attained at 4.5 weeks. CoV (33.96) was greatest at 0–1 week (Table 1).

Tarsus showed a steep linear growth up to 2.5 weeks, and adult size was attained at 4.5 weeks (Fig. 1d). At 0–1 week the average mean size was 156 mm (3.5, 110–210, n = 7) and at 4–4.5 weeks was changed to average 389 mm (2.1, 360–410, n = 4). CoV (42.88) was greatest at 1–2 weeks (Table 1).

Culmen had a growth rate equal to the wing chord length however it did not show any lag period and grew rapidly from hatching to the second week (Fig. 1e). Culmen

Wing Chord (mm)	9.6 - 16.6	
Talon (mm)	1.7 - 3.3	= 1st WEEK (N = 11)
Tarsus (mm)	11.8 - 18.1	
Culmen (mm)	5.8 - 7.6	
Wing Chord (mm)	23.3 - 43.7	
Talon (mm)	6.2 - 6.7	= 2nd WEEK (N = 11)
Tarsus (mm)	27.3 - 33.1	
Culmen (mm)	10.1 - 10.9	
Wing Chord (mm)	82.3 - 92.6	
Talon (mm)	7.2 - 7.7	= 3rd WEEK (N = 6)
Tarsus (mm)	35.0 - 37.4	
Culmen (mm)	11.1 - 11.6	
Wing Chord (mm)	96.5 - 109.9	
Talon (mm)	7.2 - 7.7	= 4th WEEK (N = 6)
Tarsus (mm)	36.4 - 40.4	
Culmen (mm)	8.1 - 14.9	
Wing Chord (mm)	115.1 - 128.2	
Talon (mm)	7.8 - 7.9	= 5th WEEK (N = 6)
Tarsus (mm)	37.5 - 41.0	
Culmen (mm)	12.0 - 12.8	

Figure 2. Identification key for ageing nestling Spotted Owlets (*Athene brama brama*) based on biometrics. Highlighted in grey are those parameters that are most reliable for field use.

attained adult size in the third week. At 0–1 weeks the average mean size was 6.94 mm (0.96, 6–8, n = 7) and at 4–5 weeks was 12.33 mm (0.5, 12–13, n = 4). CoV (13.8) was highest at 0–1 weeks (Table 1).

In the post-fledging and adult Spotted Owlets showed following biometric characters (n = 8): wing chord 150 mm (145–154), body mass 240 gm (235–245), talon 7.85 mm (7.8–7.9), tarsus 37 mm (33–40), culmen 14.5 mm (14–15)(Ali and Ripley 1969; SP, unpubl. data). One ringed fledgling was recaptured at 6.5 weeks following hatching, 2 weeks after fledging. Its biometrics were: wing chord 126 mm (84% of adult), body mass 125 gm (52.1%), talon 7.9 mm (100%), tarsus 40 mm (108%), and culmen 17 mm (117%). A sibling fledgling of this cohort was also recaptured but only body mass was measured.

We also studied the developmental patterns in the size adjusted characters and compared it with the isometric developmental pattern (Table 2). In the first week of development all other characters showed negative allometric relationship (i.e. relationship less than 1) to talon length (eg. Wing chord length / talon length = 0.5873/0.7197 = 0.82 based on Table 2). For second and third weeks all characters had negative allometric relationship with wing chord length followed by tarsus. For the fourth week all characters had negative allometric relationship with wing chord length followed by talon. While, for fifth week all characters had negative allometric relationship with wing chord length followed by culmen. The angle theta between the eigenvectors and isometric vector increased till fourth week.

Predicting age from biometric characters

Growth rate of different parameters varied significantly with respect to age. This allowed us to derive useful biometric parameters to predict age during the nestling period (Fig. 2). The Discriminant Factor Analysis (DFA) of the data extracted four factors but only first two factors had eigenvalues more than one. The first factor explained 84.86% of the total variation in the data while the second factor explained 14.46% of the total variation and together they explained 99.32% of the variation. All five age

Table 2. Eigenvalues of the first principle component for four ln-transformed biometric characters for each age class along with percent variability explained by each principle axis and angle theta between eigenvector and isometric vector.

Age	Characters				Variability (%)	theta
	wing	culmen	talon	tarsus		
Week 1	0.5873	0.2099	0.7197	0.3051	76.14423	0.4252
Week 2	0.9869	0.0124	0.0549	0.1515	91.54507	0.9242
Week 3	0.8562	0.0239	-0.4256	0.292	73.92306	1.1886
Week 4	0.6962	0.2667	0.338	-0.5744	87.19698	1.1987
Week 5	0.9299	0.3455	-0.0074	-0.1261	53.56812	0.963

groups formed significantly different clusters in DFA (Pillay's trace = 2.211, F = 8.408, p < 0.0001). Clusters of the first two weeks showed significantly separate clusters while clusters of remaining weeks had partial overlaps (Fig. 3). All factors had high factor loading on the first factor but the maximum was for wing chord length and tarsus length (Fig. 3). Fig. 3 also depicts that first week nestlings can be differentiated from second week nestlings with the biometric characters talon length, culmen length and tarsus length while the nestlings of the second, third, forth and fifth weeks can be primarily separated from each other only using the wing chord length. These observations were consistent with the PCA analysis (Table 2).

To predict the age of a nestling from the minimum biometric characters, we constructed a regression tree using CHAID algorithm. The regression tree could separate the nestling of different ages using three characters - wing chord length, culmen length and tarsus length (Fig. 4). The decision rules which separate the nestling of different ages according to Fig. 4 are as follows.

If wing chord length (mm) is in the range [9.5, 66.15] then Age = 1 week in 50% of cases.

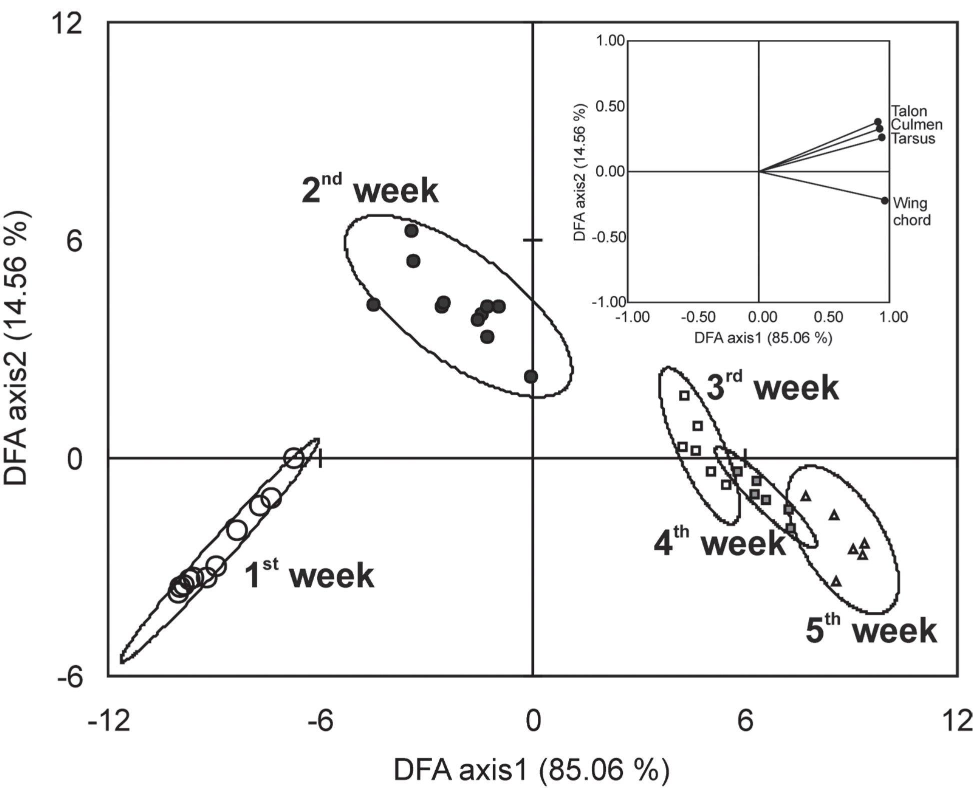

Figure 3. Discriminant Factor Analysis of the age classes based on five biometric characters of nestling Spotted Owlets (*Athene brama brama*). The figure shows the factor scores of observations. Factor loading of variables is given in the inset. Percentages in parenthesis are percent variation explained by each factor.

If wing chord length (mm) is in the range [66.15, 127] then Age = 3 weeks in 33.3% of cases.

If culmen length (mm) is in the range [5.6, 9.1] and wing chord length (mm) is in the range [9.5, 66.15] then Age = 1 week in 100% of cases.

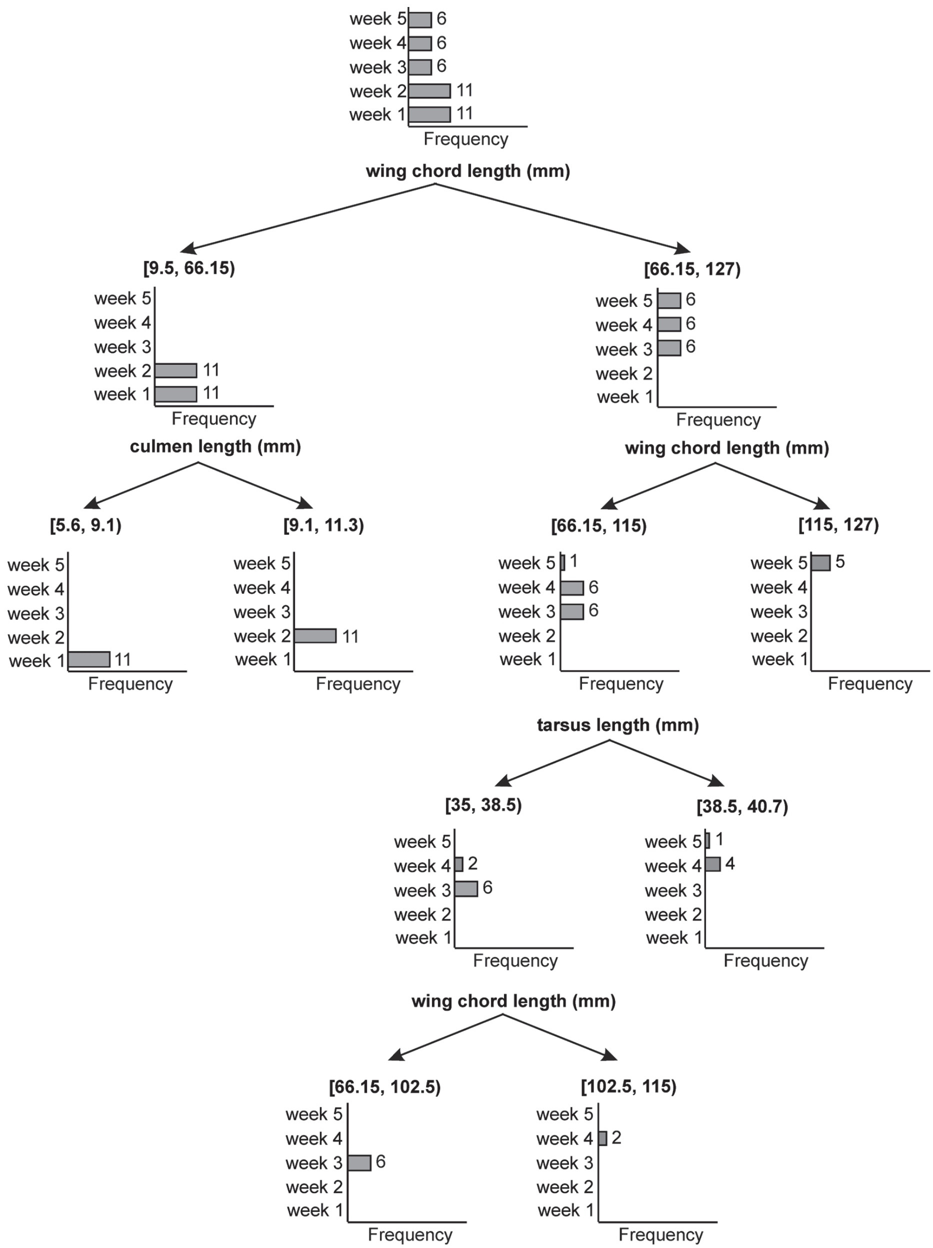

Figure 4. Decision tree based on exhaustive CHAID algorithm. Bar diagrams show the number of individuals in each age class 1 to 5 weeks of nestling Spotted Owlets (*Athene brama brama*). Numbers on the bars indicate individuals in the given age class.

If culmen length (mm) is in the range [9.1, 11.3] and wing chord length (mm) is in the range [9.5, 66.15] then Age = 2 weeks in 100% of cases.

If wing chord length (mm) is in the range [66.15, 115] then Age = 3 weeks in 46.2% of cases.

If wing chord length (mm) is in the range [115, 127] then Age = 5 weeks in 100% of cases.

If tarsus length (mm) is in the range [35, 38.5] and wing chord length (mm) is in the range [66.15, 115] then Age = 3 in 75% of cases.

If tarsus length (mm) is in the range in [38.5, 40.7] and wing chord length (mm) is in the range [66.15, 115] then Age = 4 weeks in 80% of cases.

If wing chord length (mm) is in the range [66.15, 102.5] and tarsus length (mm) is in the range [35, 38.5] then Age = 3 weeks in 100% of cases.

If wing chord length (mm) is in the range [102.5, 115] and tarsus is in the range [35, 38.5] then Age = 4 weeks in 100% of cases.

However, we also present a simple flow-chart style of the biometrics with the minimum-maximum measurements (Fig. 2). In this case all five parameters were important to identify the age of the nestling during the first three weeks post-hatching. But only wing chord length was a reliable parameter for the whole study period, especially during the fourth and fifth weeks. Talon growth in the 3rd and 4th week was similar but greater in the 5th week. Tarsus and culmen were reliable only for the first three weeks of post-hatching growth.

Predicting capacity of flight

Correlation between wing chord size and body mass was examined in order to understand when the fledglings are capable of flight. Examination of biometric data of mass gain and wing chord growth revealed that in the early nestling period the growth rate of wing size was less than that of mass, but was equal at 4.5 weeks.

Based on the above, we devised a formula to examine this correlation and determine the optimal wing chord length to body mass ratio to predict when the nestling would be capable of initiating its first attempt at flight.

$$\text{Flight formula} = \frac{\text{Wing chord length (mm)}}{\text{Body mass (g)}} \tag{2}$$

The average value of flight formula of fifth week nestling was 0.96 while nestlings of younger age showed lesser values (Fig. 5). Nestlings of age 1^{st} to 4^{th} week showed average flight formula values 0.59, 0.41, 0.75 and 0.91 respectively. Adults had a test value of 0.97 for males (n = 7) and 0.97 for females (n = 6). However, two fledglings that were flying well at 6.5 weeks showed a test value of 0.99.

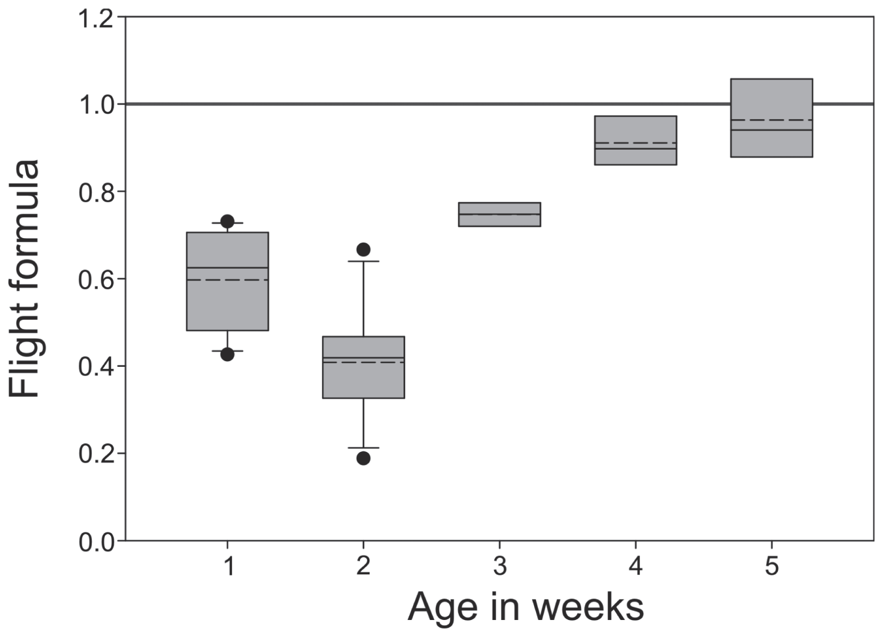

Figure 5. Flight formula for different age groups of nestling Spotted Owlets (*Athene brama brama*). Box plot of flight formula index are plotted for different age groups. When the flight formula approaches unity birds are ready to fly.

Discussion

In this study we have used only externally measured biometric parameters in order to understand nestling growth rate and to present an idea of how we can use these data to help future studies that may need to evaluate age of hatchlings in Spotted Owlets. However, we consider our limited sources to also be a limiting factor in the depth to which this study could be done at present. Our inability to sex individuals at the nest prevents us from knowing the differential growth rates of males compared to females. Ali and Ripley (1981) mention that females are larger than males but do not explain how to separate the sexes. It is a well known phenomenon that in owls the sex ratio of offspring is adjusted to food availability (cf. Appleby et al. 1997; Sasvari and Nishiumi 2005). Future studies should avail of techniques such that we can not only present a general picture for the subspecies but also of the sex-specific differences in biometrics and their growth rates.

In our study, all five biometric parameters studied in Spotted Owlets showed logistic growth during the nestling period from hatching till 4.5 weeks when they fledged. The growth rate of all the parameters examined in this study is differential, this heterochrony is used to estimate the age of the nestlings. Three parameters - talon, tarsus and culmen - achieve 100 % growth at 4.5 weeks, while body mass gain is 89% and wing chord growth is 80% of adults at 4.5 weeks.

We attribute this differential growth to the required capabilities that enable fledging. Upon fledging each of the individuals has to fend for itself – from predators and for food. This requires fully developed talons, culmen and tarsus, and a significant increase in body mass. In many cases we have observed Spotted Owlets nestlings - similar to many other owl species - walk out of the nest hole and perch on branches of the nest tree prior to gaining the ability of flight. We assume that the reason for this is to escape increased risk of predation at the nest, where the stench and odor from accumulated pellets, fecal matter and other debris is likely to attract predators. We base this assumption on our having documented predation of eggs and nestlings from the nest hole by Small Indian Civet (*Viverricula indica*) and House Crows (*Corvus splendens*). We realize that predation avoidance is only one of many reasons, and it is obvious that it's impossible to learn to fly while housed inside a small, crowded nest cavity.

Owing to the fact that the mean values of wing chord, tarsus and body mass differed significantly between the age groups, based on the flow chart, a comparison of the field measurement with our data will allow the researcher to estimate age with a high level of accuracy. We suggest that only three characters (tarsus length, culmen length and wing chord length) are sufficient for determining the age of the nestling.

The estimation of nestling age from this flow chart is useful for conservation and rescue work. The biometric parameters obtained can be compared with the values of various parameters plotted against age in normal wild nestlings given in this paper. From this normal base line trend, one may evaluate the growth and assess the nutritional status of nestlings reared in an orphanage or by foster parents. If a discrepancy is apparent, appropriate corrective measures can be taken by adjustments in feeding.

The nestlings attained 91.9% of adult body mass at 4.5 weeks but experienced a drop in mass at 3.5 weeks, one week prior to fledging. This trend is also recorded in other birds of prey towards the end of nestling stage and can be explained as a response to achieve appropriate wing loading in order to make the first flight easier (Brown 1976).

An analysis of the wing chord length and the body mass using our flight formula (eq. 2) suggests that as the nestling approaches maturity and is capable of first attempt of flight the flight formula value approached unity. In the simplest words our analysis shows that as the wing chord length (mm) approaches body mass (g) the bird becomes capable of flight. This finding is important for rescued fledglings that have suffered injuries or fractures, and for which, appropriate time of release needs to be calculated. The optimal body mass to wing chord ratio helps decide the amount of feeding and time required between rescue and release. We have observed that hand-reared nestlings and rehabilitated adult owls may exhibit good wing flapping, but do not immediately take flight when released. Hence, with the application of our formula one can predict the capability of flight and thus prevent predation after release.

In summary, biometry of wing, body mass, talon, tarsus and culmen of nestling Spotted Owlets is an easy, reliable and inexpensive method to determine nestling age, to assess growth rate and nutritional status, and to predict ability to initiate first flight.

This method is described here for the first time for Spotted Owlets, and we postulate that such charts can be devised for other avian species as well.

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