

***Halocoryza* Alluaud, 1919, sea-side beetles of the Indian, Atlantic (*sensu lato*), and Pacific Oceans: a generic synopsis and description of a remarkable new species from Baja California Sur, México (Coleoptera, Carabidae, Scaritini, Clivinina)**

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Abstract

Information on the three previously described species of *Halocoryza* Alluaud is updated and a new species for the genus from Isla Carmen, Sea of Cortés, Baja California Sur, México is described. *Halocoryza whiteheadiana* sp. n. was found at UV light on a beach of that island. This species does not fit the profile of the other three species, i.e., living on coralline beach sands, or in the Mangrove intertidal zone. Two alternative possibilities as to why this is so are suggested and a study plan for testing these possibilities is proposed.

Resumen

Información de las tres especies de *Halocoryza* Alluaud previamente descritas se actualiza y una especie nueva para el género se describe de la Isla de Carmen, Mar de Cortés, Baja California Sur, México. *Halocoryza whiteheadiana* sp. n. se encontró a luz UV en la playa de esa isla. Esta especie no corresponde con los perfiles de las otras tres especies (por ejemplo, viviendo en arenas coralinas de playa o en la zona intermareal en el manglar. Dos posibles alternativas para la razón de esto son sugeridas y un plan de estudio para probar estas posibilidades se propone.

Keywords

Sea of Cortés, Caribbean Sea, Gulf of México, intertidal zone, sandy beaches, beetles, centipedes, coral reefs, Isla Carmen

Palabras clave

Mar de Cortés, Mar Caribe, Golfo de México, zona intermareal, playas, arenosas, escarabajos, ciempiés, arrecifes de coral, Isla Carmen

Introduction

Halocoryza beetles belong to the subtribe Clivinina and are closely related to the genus *Schizogenius* Putzeys 1846, the so-called Rib-headed Beetles that D.R. Whitehead revised for his doctoral dissertation and treated in subsequent publications (Whitehead 1966, 1969, 1972; Whitehead and Reichardt 1977). During a review of collections for Volume 3 of my series of books on the Western Hemisphere Caraboidea (Erwin 2007; Erwin and Pearson, 2008), I discovered in the National Museum of Natural History collection a remarkable new species of *Halocoryza* from Isla Carmen in the Sea of Cortés, Baja California Sur, México.

It is named here in honor of Donald R. Whitehead[†] who had a great interest in this group of beetles and discovered a lot about their special place on the sea shore. I have personally collected but one specimen of this genus on the shore of the Caribbean side of Panamá, and was amazed that these beetles accept such saline conditions, as they do. Whitehead pondered whether *Halocoryza* should be included within *Schizogenius*, perhaps as a subgenus, as is *Listropus* Putzeys, a group that Whitehead and Reichardt (1977) ranked as such. Unfortunately, Whitehead was not able to continue with this study due to his early death. Here, I am retaining the generic status he left in legacy because I believe ecological shift, in addition to structural and physiological attributes, should be an important element in deciding classification status. A shift to salt from fresh water is one that must be difficult. Living in a very saline habitat requires markedly specialized characteristics, both physically and physiologically (Kavanaugh and Erwin 1991). When additional specimens become available, especially males, classification of this species needs to be revisited.

Methods and specimens

Methods and species concepts follow those previously described (Erwin and Kavanaugh 1981; Kavanaugh and Erwin 1991). The species validation and diagnosis format follows as closely as possible that suggested in Erwin and Johnson (2000). Measurements of length (ABL, SBL) and width (TW) follow those of Ball (1972) and Kavanaugh (1979): ABL (apparent body length), measured from apex of labrum to apex of longer

elytron; SBL (standardized body length), equals the sum of the lengths of the head (measured from apex of clypeus to a point on midline at level of the posterior edge of compound eyes), PL (pronotal length), measured from apical to basal margin along midline, and LE (elytron length), measured from apex of scutellum to apex of the longer elytron; and TW (total width), measured across both elytra at their widest point with suture closed.

Included in this study are a total of 12 specimens from the National Museum of Natural History, Washington, DC (NMNH) in my charge, and a single paratype from the California Academy of Sciences (CASC, David H. Kavanaugh, Curator). The habitus images of the adult beetles portray most of the character states referred to in the key provided. Illustrations of male genitalia (modified from Vinson 1956 and Whitehead 1966) are standard for descriptive taxonomy of carabid beetles. The habitus images of the adults were made with a Visionary Digital™ high resolution imaging system. Figure captions include an ADP number, which is a unique identification number for the specimen that was illustrated or imaged and links the specimen and associated illustrations and/or image to additional information in electronic databases at the NMNH.

Geographical data are presented for species based on all known specimens available at the time of manuscript preparation, including those in the literature. Georeferences have been determined from locality information provided on specimen labels; only those exact georeferences that are provided on the label are placed in quotes, otherwise I have estimated these as closely as possible from places, mileage, etc. listed on the label and searched with Google Earth. Latitude and longitude are reported in decimal degrees. Here, English vernacular names are proposed, as common names are becoming increasingly needed in conservation and/or agricultural and forestry applications, and for the Encyclopedia of Life (www.eol.org).

Accounts of taxa

Halocoryza Alluaud, 1919

Saline Catarrh Beetles

Halocoryza Alluaud, 1919:100

<http://species-id.net/wiki/Halocoryza>

Type species. *Halocoryza maindroni* Alluaud, 1919:101

Number of species. Four

Taxonomy. Stable. Adelphotaxon: *Schizogenius* Putzeys, 1846

Geographic Distribution. Equatorial to Tropic of Cancer; sea coasts and islands of east Africa – Comoros – Mayotte; Djibouti; Madagascar; Mauritius; Saudi Arabia; Somalia; and natural invasive from the Caribbean into west Africa – Cameroon; Ecuador – Galapagos Islands; Barbados; Brazil – Pernambuco; Dominican Republic;

Grenada; Guadeloupe; Jamaica; México – BJ, GO, QR, YC; Panamá; Puerto Rico; USA – FL; Virgin Islands – St. John, St. Thomas

Habitat. Sea beaches and mangrove intertidal zone

References. Bruneau de Miré (1979), Lorenz (2005), Peck (2006), Vinson (1956), Whitehead (1966)

Note. The common name, Saline Catarrh Beetles, proposed here follows my principle of translating the scientific name as strictly as possible. In this case, “coryza” comes from the Greek, *koryza*, meaning cold, catarrh, as in disease. Why Alluaud named the genus so is not known.

Diagnostic Combination. Differing in adult attributes from those of its adelphotaxon, *Schizogenius* Putzeys, 1846, by the following: Pygidium not striate or with very subtly crenulate striae; antennomere 2 pluristose. In addition, mandibles prominent, nearly straight laterally, abruptly angulate near apices; lacinia asetose on outer margin; frontal carinae nearly perfectly regular, parallel, equidistant, and equally raised; frons evenly convex; neck not pitted or punctate dorsally; eyes reduced, bordered laterally by a distinct carina; gula broad; mentum not deeply emarginate at middle, with median tooth obsolete and epilobes short; tarsi short; paramedian carinae of sternum II short, widely spaced and poorly developed; median lobe of male genitalia neither arcuate nor abruptly deflexed in apical third; fused stylus and coxite of the ovipositor with one robust seta (Whitehead 1966, 1972).

Geographic Distribution. Sea beaches, intertidal lagoons on the edges of mangroves, and island shores of the Atlantic, Indian, and Pacific Oceans, the Caribbean Sea, Sea of Cortés, and the Gulf of México.

Included Species. The species list below, as well as arrangement of descriptions that follow is ordered alphabetically.

<i>Halocoryza acapulcana</i> Whitehead, 1966	Ecuador; México
<i>Halocoryza arenaria</i> (Darlington, 1939)	Barbados; Brazil; Dominican Republic; Grenada; Guadeloupe; Jamaica; México; Panamá; Puerto Rico; USA; Virgin Islands; Africa – Cameroon
<i>Halocoryza maindroni</i> Alluaud, 1919	Comoros – Mayotte; Djibouti; Madagascar; Mauritius; Saudi Arabia; Somalia
<i>Halocoryza whiteheadiana</i> sp. n.	México

Key to the Species of *Halocoryza* Alluaud, 1919

- 1 Pronotum without median sulcus, anterior angles acute; Indian Ocean
.....*Halocoryza maindroni* Alluaud, 1919
- 1' Pronotum with median sulcus, anterior angles rounded; Atlantic, Caribbean, or Pacific Oceans2
- 2(1') Form markedly elongate; pronotum without paramedian carinae at margins of sulcus, Sea of Cortés *Halocoryza whiteheadiana* sp. n.

- 2' Form moderately elongate; pronotum with paramedian carinae at margins of sulcus.....**3**
- 3(2') Smaller species (LE: 1.20 – 1.35mm), elytra sparsely setose, interval 3 with 10 or fewer setae; color pale testaceous; Pacific Ocean.....
.....*Halocoryza acapulcana* Whitehead, 1966
- 3' Larger species (LE: 1.35 – 1.45mm), elytra densely setose, interval 3 with 10 or more setae; color dark testaceous; Atlantic Ocean and Caribbean Sea
.....*Halocoryza arenaria* (Darlington, 1939)

Species accounts

Halocoryza acapulcana Whitehead, 1966

Acapulco Saline Catarrh Beetle

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

Figs 1, 4, 7

Halocoryza acapulcana Whitehead, 1966:222

Geographic Distribution. Native, New World. Ecuador – Galapagos Islands: Rábida (Jervis); México – OA.

Way of Life. MACROHABITAT: Lowlands, sea level, in the intertidal zone of beaches. **MICROHABITAT:** Adults are ground-dwelling on saline soils. **DISPERSAL ABILITIES:** Macropterous, capable of flight; slow runners. **SEASONAL OCCURRENCE:** Adults have been found in March and August. **BEHAVIOR:** Nocturnal predators, adults are attracted to lights.

References. Peck (2006), Whitehead (1966). New data from CASC and NMNH collections.

Halocoryza arenaria (Darlington, 1939)

Sand Saline Catarrh Beetle

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

Figs 2, 5, 8

Schizogenius arenaria Darlington, 1939:84

Geographic Distribution. Native, New World. Barbados; Brazil; Dominican Republic; Grenada; Guadeloupe; Jamaica; México – QR, YC; Panamá; Puerto Rico; USA – FL; Virgin Islands – St. John, St. Thomas; natural invasive, Africa – Cameroon.

Way of Life. MACROHABITAT: Lowlands, sea level – 1 meter altitude, on sea beaches and in the intertidal area, at or near the high tide line, and in mangrove swamps.

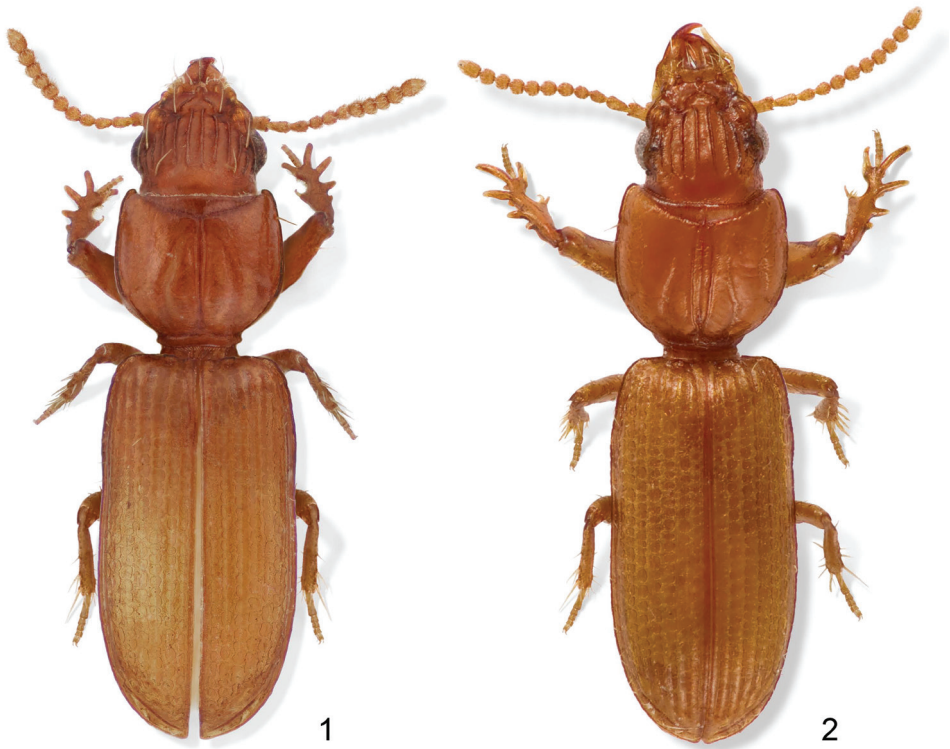


Figure 1–2. **1** Color image, showing habitus of *Halocoryza acapulcana* Whitehead, 1966, dorsal aspect, ABL = 2.4mm, ADP127171; Acapulco, México **2** Color image, showing habitus of *Halocoryza arenaria* (Darlington, 1939), dorsal aspect, ABL = 2.9mm, ADP116798; St. Johns, Virgin Islands.

MICROHABITAT: Adults are ground-dwelling on exposed wet substrate consisting of coquina-coral cemented by very fine silt or sand and covered with seaweed mats. **DISPERSAL ABILITIES:** Wing-polymorphic: macropterous form probably capable of flight; brachypterous form, consequently flightless thus vagility limited to walking or running; both forms slow runners. **SEASONAL OCCURRENCE:** Adults have been found in March – April, July, and October. **BEHAVIOR:** Adults are nocturnal predaceous halobionts and take cover in the sand or under drift and piles of seaweed on the beach. Populations of this species are associated with the centipede *Pectiniunguis halirrhytus* Crabill. In the northern part of their range, adults overwinter in the substrate; in the southern part, they likely aestivate during the dry season in the substrate.

References. Bruneau de Miré (1979), Nichols (1988, Ph.D. dissertation), Peck and Thomas (1998), Whitehead (1966, 1969).

Halocoryza maindroni* Alluaud, 1919*Maindron's Saline Catarrh Beetle**

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

Figs 9, 10

Halocoryza Maindroni Alluaud, 1919:101

Halocoryza atriceps Alluaud, 1899:378 [not Fairmaire, 1901:5]

Halocoryza jeanneli Vinson, 1956:313

Geographic Distribution. Native, Old World. Comoros – Mayotte; Djibouti; Madagascar; Mauritius; Saudi Arabia; Somalia.

Way of Life. MACROHABITAT: Lowlands, sea level, in the intertidal zone of sea beaches. **MICROHABITAT:** Adults are ground-dwelling on coralline sands in the vicinity of coral reefs. **DISPERSAL ABILITIES:** Wing-polymorphic: macropterous form probably capable of flight; brachypterous form, consequently flightless thus vagility limited to walking or running; both forms slow runners. **SEASONAL OCCURRENCE:** Adults have been found in January and October. **BEHAVIOR:** Nocturnal predators, adults take cover during the day under dry seaweed just above the high water mark.

References. Alluaud (1919), Jeannel (1946), Vinson (1956).

Note. Vinson (1956) provided a partial description of the 3rd instar larva.

Halocoryza whiteheadiana* Erwin, sp. n.*Whitehead's Saline Catarrh Beetle**

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

Figs 3a, 3b, 6

Holotype. México. BAJA CALIFORNIA SUR, Isla Carmen, north end, sea level, approximately “26.05°N, 111.1°W,” 18-19 July 1984 (S.E. Miller) (NMNH: ADP127139, female).

Derivation of specific epithet. The epithet “*whiteheadiana*” is an eponym, based on the family name of Donald R. Whitehead[†], who had a profound interest in the species of this genus and its adelphotaxon, *Schizogenius* Putzeys, during his relatively short career.

Proposed English vernacular name. WHITEHEAD'S SALINE CATARRH BEETLE.

Diagnosis. With the attributes of the genus described by Whitehead (1966) and large sized for the genus. Adults rufotestaceous and shiny throughout; shallow microsculpture only in sulci. Occiput five-carinate each side with one medial and two lateral carinae on frons. Clypeus with 3 prominent tubercles; lateral margins prominently lobate. Elytron with 10 setae in interval 3, close to interneur 2.



Figure 3. Color image, showing habitus of *Halocoryza whiteheadiana* sp. n., 3a, left lateral aspect, 3b, dorsal aspect, ABL = 2.9mm; Holotype: Isla Del Carmen, BJ, México.

Description. (Fig. 3). *Size:* Very small, ABL = 2.8 mm, SBL = 2.52 mm, EW = 0.69 mm, LP = 0.647mm, WP = 0.622mm, LE = 1.476mm. *Color:* Rufotestaceous throughout. *Luster:* Shiny throughout. *Head:* Labrum slightly emarginate apically, six-setose. Frons markedly tri-tuberculate apically, laterally markedly lobate, lobes nearly vertical, bicarinate basally, carinae set on an angle, widest basally. Eyes slightly convex; gena short and flat. Occiput five-carinate each side; rim above eye also carinate. *Prothorax:* Markedly convex, moderately longer than broad (W/L: 0.96), narrowed basally antieriad of posterior lateral pore; surface smooth, five-sulcate; lateral sulci 2/3 length of pronotum, extended to posterior lateral pore, paramedian sulci sigmoid shaped, not reaching base, median sulcus deep, extended from near apex to base of pronotum, slightly crossing anterior transverse sulcus; anterior and posterior lateral setae present. *Pterothorax:* Elytra markedly convex (W/L: 0.46), intervals markedly convex, intervals 3, 5, and 7 each with a serial row of setiferous punctures, 10 such in interval 3.

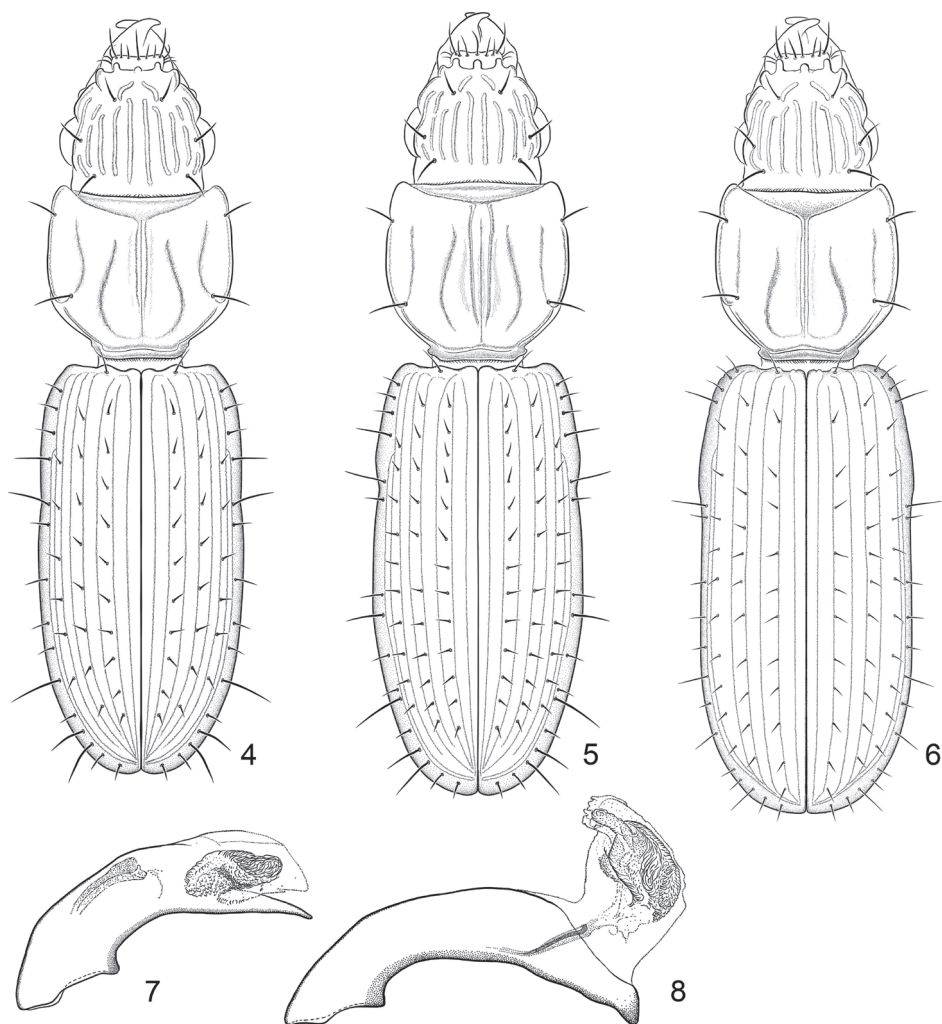
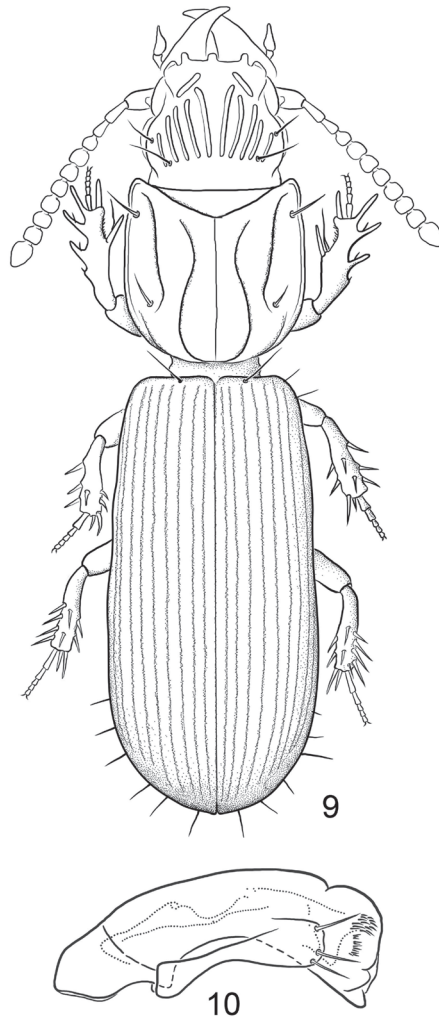


Figure 4–8. **4** Line drawing, showing habitus of *Halocoryza acapulcana* Whitehead, 1966, dorsal aspect, ABL = 2.4mm; Acapulco, México; modified from Whitehead 1966 **5** Line drawing, showing habitus of *Halocoryza arenaria* (Darlington, 1939), dorsal aspect, ABL = 2.9mm; Rio Piedras, Puerto Rico; modified from Whitehead, 1966 **6** Line drawing, showing habitus of *Halocoryza whiteheadiana* sp. n., dorsal aspect, ABL = 2.9mm; ABL = 2.8mm, ADP127139; Isla Del Carmen, México **7** Line drawing, showing male genitalia, median lobe, of *Halocoryza acapulcana* Whitehead, 1966, left lateral aspect, 0.41mm (dorsal margin of basal lobe to apex); Acapulco, México; modified from Whitehead 1966 **8** Line drawing, showing male genitalia, median lobe, *Halocoryza arenaria* (Darlington, 1939), left lateral aspect with internal sac everted, 0.41mm (dorsal margin of basal lobe to apex); Rio Piedras, Puerto Rico; modified from Whitehead, 1966.

Legs: Normal in female. *Abdomen:* Abdominal sterna III to VI of female with normal ambulatory setae, VII with a pair of setae each side. *Male genitalia:* Unknown. *Female genitalia:* Not studied.



Figures 9–10. **9** Line drawing, showing habitus of *Halocoryza maindroni* Alluaud, 1919, dorsal aspect, ABL = 2.4mm; Black River, Mauritius; modified from Vinson (1956). N. B. discal setae of elytra not shown **10** Line drawing, showing male genitalia, median lobe and left paramere, *Halocoryza maindroni* Alluaud 1919, left lateral aspect, ca. 0.40mm; Black River, Mauritius; modified from Vinson (1956).

Dispersal potential. These beetles, as represented by the holotype, are macropterous and are capable of flight; they are slow runners, strong burrowers. However, both the Caribbean and Indian Ocean species are wing-polymorphic and perhaps with additional specimens, *H. whiteheadiana* may prove to be the same.

Way of life. Adults of other *Halocoryza* species are found on coralline sands in the intertidal zone of open beaches and among mangroves; a larva of the Indian Ocean species of this genus was found under dry seaweed just above the high-water mark on

coralline sands. The single known specimen of *H. whiteheadiana* was collected at UV light on a sandy beach on the north shore of Isla Carmen, Baja California Sur. Adults of *H. whiteheadiana* are likely nocturnal halobiont predators, as are members of the other known species of this genus.

Other specimens examined. None.

Evolutionary aspects

According to Whitehead (1966) and Vinson (1956) these beetles are strictly associated with coralline sands on open sea beaches, or in the intertidal zone of mangroves in the Indian, Atlantic, and Pacific Oceans, the Caribbean Sea, and the Gulf of Mexico. The recently discovered exception is *H. whiteheadiana* sp. n., described herein. It was found on the north shore of Isla Carmen in the Sea of Cortés. The nearest living reef to its type (and only known) locality is 350 km to the south at Bahía Pulmo. According to Markes E. Johnson (pers. comm.) the present sandy beaches on the north side of Isla Carmen “are exclusively carbonate sands derived from crushed mollusk shells.” Therefore, the question arises: Has *H. whiteheadiana* undergone an ecological shift from coralline sands to crushed mollusk shell sands by way of evolving its more cylindrical and elongate form. Alternatively, is it a remnant species left over after more extensive corals that prehistorically occupied the more northern part of the Sea of Cortés became extinct? According to Johnson (pers. comm.), “fossil corals are to be found on Isla Carmen, and during the latest Pleistocene, “reefs”, formed by *Porities panamensis* (Verrill) did develop at several localities on that island in Balandra Bay, Marquer Bay, and along the south end of the island. Pliocene corals are common, but I would not say they formed reefs ...” Many south-facing beaches are composed of rhodolith sand (Johnson and Ledesma-Vázquez 2009). While all of these types of beaches are derived from different animals (corals and mollusks), or red algae (rhodoliths), they all are fundamentally calcium carbonate. For *Halocoryza* species, it may be a case not of calcium carbonate, but rather of texture that is important, i.e. grain size and shape. Exploration of beaches on other islands and those near Bahía Pulmo are likely to produce more specimens (perhaps additional species); careful analysis of the sea-side substrate will be important to test the alternate suppositions made above, i.e. remnant species, or adaptive species. In addition, more specimens will test the hypothesis that this new species, like two others in the genus, is wing-polymorphic.

Thanks to information provided by my good friend and colleague, Rick Brusca, and his colleagues Markes E. Johnson and Ramon Andres Lopez Perez, I now know that Isla Carmen has fossil coral deposits on it and that corals in the past were more extensive in the Sea of Cortés. Today, they occur in the waters off Isla Carmen, but do not form reefs there. Thus, species of the genus *Halocoryza* could be indicators of both present and/or past corals in the adjacent seas that are presently contributing, or have in the past, to the sandy mix of the beach on which they are found. Alternatively,

H. whiteheadiana may represent a species that has undergone an ecological shift since the Pleistocene to an existence on another form of calcium carbonate, namely crushed mollusk shells. Determining if they also occur on the rhodolithic sands, (i.e. those of derived from coralline alga which are major contributors of CaCO_3 to beaches in the area) will require an additional sampling.

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New genera of philopotine spider flies (Diptera, Acroceridae) with a key to living and fossil genera

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Abstract

In this paper we describe two new genera of philopotine Acroceridae: *Schlingeriella irwini* **gen. et sp. n.** (New Caledonia) and *Quasi fisheri* **gen. et sp. n.** (Mexico). The Baltic amber species *Eulonchiella eocenica* Meunier, 1912 is rediagnosed and a neotype designated based on a newly discovered specimen. We also provide a dichotomous key to the world genera of Philopotinae, both living and fossil.

Keywords

Spider fly, Acroceridae, cybertaxonomy

Introduction

Spider flies (Diptera, Acroceridae) are a geographically cosmopolitan group although most species are relatively rarely collected. Most species feed at flowers and are likely important specialized pollinators as suggested by their frequently elongate proboscis (often equal to body length) and nectar feeding habits, although some species have reduced or even vestigial mouthparts (Schlinger 1981, 1987). Adults have a distinctive mor-

phology and a wide diversity of form and colour, but usually with a small head, greatly enlarged lower calypter and swollen abdomen. Larvae are parasitoids of spiders, with a hypermetamorphic life cycle consisting of four instars (Schlinger 1981, 1987, 2009).

Acroceridae comprise over 520 described species in about 53 genera (Pape and Thompson 2011). The species are traditionally separated in three extant subfamilies – Acrocerinae, Panopinae and Philopotinae, based on adult morphology and host specificity. Panopinae have been postulated as the most primitive and Acrocerinae the most derived, with Philopotinae supposedly occupying an intermediate position (Schlinger 1987). Phylogenetic analyses by Winterton et al. (2007) based on molecular data, however, do not corroborate this subfamilial arrangement, with Acrocerinae recovered as polyphyletic and Panopinae as a derived clade. The monophyly of Philopotinae has never been questioned based on a series of morphological synapomorphies (Schlinger 1981), a position also strongly supported by analyses of molecular data (Winterton et al. 2007). Adults of Philopotinae are characterized by enlarged postpronotal lobes that are usually contiguous dorsomedially to form a collar around the head, as well as varying degrees of arched body shape (Figs 1–7).

There are approximately 52 species and 14 genera in Philopotinae, both living and fossil, found in all major biogeographical regions. Two morphological groups are easily recognizable in the subfamily based on reduction of wing venation (i.e. number of wing cells and primary veins approximating wing margin). The first group comprises six genera with relatively complete wing venation and includes: *Dimacrocolus* Schlinger, 1961 (Madagascar), *Eulonchiella* Meunier, 1912 (Baltic amber), *Helle* Osten Sacken, 1896 (New Zealand), *Megalybus* Philippi, 1865 (Chile), *Parahelle* Schlinger, 1961 (Madagascar) and *Thyllis* Erichson, 1840 (South Africa and Madagascar). The second group comprises eight genera characterized by reduced wing venation such that cells d, bm and even m₃ are absent through reduction and loss of crossveins. The wings typically have only major veins radiating from cell br (Figs 1B, D). Genera in this group include *Africaterphis* Schlinger, 1968 (Africa), *Archaterphis* Hauser & Winterton, 2007 (Baltic amber), *Oligoneura* Bigot, 1878 (Palearctic), *Philopota* Wiedemann, 1830 (South and Central America), *Prophilopota* Hennig, 1966 (Baltic amber), *Quasi* gen n. (Mexico), *Schlingeriella* gen n. (New Caledonia) and *Terphis* Erichson, 1840 (South America).

Eulonchiella eocenica Meunier, 1912 was briefly described and poorly illustrated by Meunier (1910) and (1912) from Baltic amber (only in the latter publication was the name *Eulochiella eocenica* applied for the first time). The holotype was deposited in the Albertus University Collection in K  nigsberg - Prussian territory at the time and now belonging to Russia - but was lost during the Second World War (Hennig 1966). Fortunately, Frank Hull made relatively more accurate drawings than Meunier and notes about the fossil during a visit to this collection prior to the war. Based on these unpublished data, Hennig (1966) redescribed and figured the species. Recently a specimen in the George Poinar collection, matching the original descriptions by Meunier (1910, 1912) and subsequent redescription and figure in Hennig (1966), has been identified as *E. eocenica*. This individual is also from Baltic amber deposits and is preserved in

excellent condition. Herein we diagnose *Eulonchiella eocenica* and designate a neotype based on this newly discovered specimen. We also describe the new genera *Schlengeriella irwini* gen. et sp. n. from New Caledonia and *Quasi fisheri* gen. et sp. n. from Mexico, and provide a dichotomous key to all living and fossil genera of Philopotinae.

Materials and methods

Terminology follows McAlpine (1981) and Schlinger (1981). In most acrocerids, two crossveins span the area between the radial and medial sectors enclosing the cell r_{4+5} . The proximal crossvein is r-m, while the distal crossvein bisecting cell r_{4+5} (between wing veins M_1 and R_{4+5} , or rarely R_5) is referred to here as 2r-m following Hardy (1946). Collections where specimens are deposited are as follows: Muséum National d'Histoire Naturelle, Paris, France (MNHN), California Academy of Science, San Francisco, USA (CAS), California State Collection of Arthropods, Sacramento, USA (CSCA) and Queensland Museum, Brisbane, Australia (QM). Descriptions were constructed using Lucid Builder 3.5, using a matrix database of character states, which were then exported using the natural language function into XML and a text document. Specimen images were taken at different focal points using a digital camera and subsequently combined into a serial montage image using Helicon Focus software. High-resolution digital images were deposited into Morphbank with embedded URL links within the document between descriptions and Morphbank images. All new nomenclatural acts and literature are registered in Zoobank (Pyle and Michel 2008).

Taxonomy

Eulonchiella Meunier

<http://species-id.net/wiki/Eulonchiella>

Figs 1E–G, 2

Eulonchiella eocenica Meunier 1912: 177 – Meunier 1910: 177, Brunetti 1926: 583, Hennig 1966: 7, Evenhuis 1994: 311. Type species: *Eulonchiella eocenica* Meunier, 1912: 177.

Type material. Neotype male, Baltic amber (#DB 10-12) (CAS).

Diagnosis. Body shape arched; colouration non-metallic brown-black; head spherical, size slightly smaller than thorax width; eye bare; male frons narrowed; eyes contiguous above and below antennal base; posterior margin of eye rounded; proboscis length greater than head length; position of antenna in middle of frons; flagellum shape stylate; palpus present; thorax with postpronotal lobes enlarged, medially contiguous to form collar; legs not greatly elongated, tibial spines absent; pulvilli present; subcutellum slightly enlarged; wing hyaline, markings absent; costa ending in radial field;

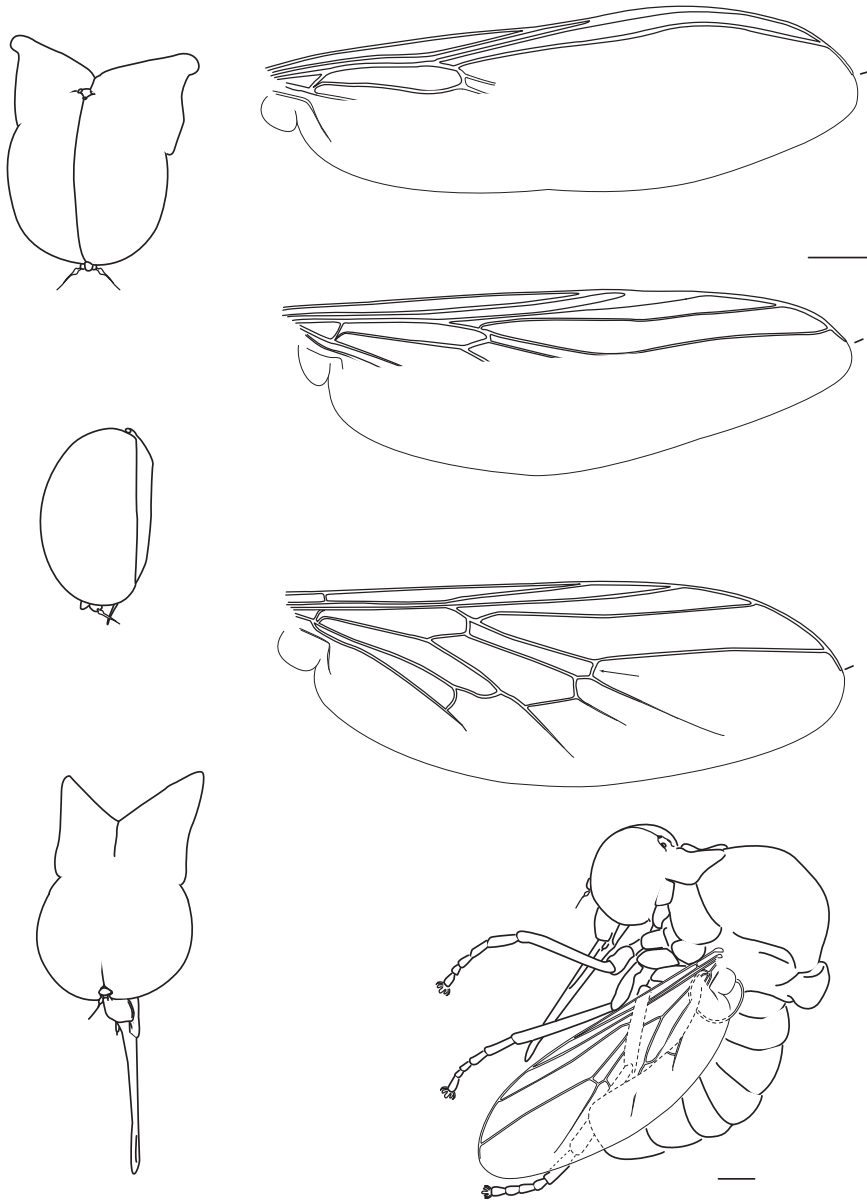


Figure 1. *Quasi fisheri* gen. et sp. n. **A** head and postpronotal lobes, anterior **B** wing **C** head, lateral. *Schlingerella irwini* gen. et sp. n. **D** wing. *Eulonchiella eocenica* Meunier **E** head and postpronotal lobes, anterior **F** habitus *in situ*, lateral. Scale line = 0.2 mm.

costal margin straight in both sexes; humeral crossvein present; alula well developed; anal lobe not enlarged; R_{2+3} present; R_{4+5} present as single vein; radial veins meeting wing margin before wing apex; cell r_{4+5} bisected by crossvein 2r-m, narrow elongate; discal cell present, closed apically; medial veins M_1 , M_2 and M_3 present; medial veins



Figure 2. *Eulonchiella eocenica* Meunier (Baltic Amber). Body length = ca. 4.5 mm.

tapered and faint towards margin; cell m_3 absent; CuA_1 joining M_3 and petiolate, not reaching wing margin; CuA_2 fused to A_1 , not reaching wing margin, petiolate; abdomen smooth, shape rounded, cylindrical, similar width to thorax.

Comments. The above diagnosis is based on a neotype male of *Eulonchiella eocenica* Meunier deposited in the Poinar collection (#DB 10-12) (to be ultimately housed in CAS). Hennig (1966) discussed this monotypic genus based on drawings by Meunier (1910) and a drawing provided by Frank Hull (published in Hennig 1966) before the type was destroyed. The enlarged abdomen in the drawing by Hull indicates that the original type was a female. The specimen examined herein is a male based on the narrower abdomen, despite the genitalia being obscured by an opaque mass. Like many Baltic Amber taxa, *Eulonchiella* is closely related to a group of Afrotropical genera including *Dimacrocolus*, *Parahelle* and *Thyllis* (Hennig 1966), all with relatively complete wing venation. *Eulonchiella* can be differentiated from all other Philopotinae genera by the legs not being elongate, eyes not pilose, wing venation relatively complete, proboscis elongate and palpi being present.

Quasi gen. n.

urn:lsid:zoobank.org:act:CD9618A4-E458-4B16-A7D6-0D188D77042E

<http://species-id.net/wiki/Quasi>

Figs 1A–C, 3–5

Type species. *Quasi fisheri* sp. n.

Diagnosis. Body shape arched; colouration non-metallic pale brown; head width slightly smaller than thorax width; shape hemispherical; postocular ridge and occiput



Figure 3. *Quasi fisheri* gen. et sp. n., male, anterolateral view [Morphbank: 693076]. Body length = 6.0 mm.



Figure 4. *Quasi fisheri* gen. et sp. n., male, dorsal view [Morphbank: 693077]. Body length = 6.0 mm.

rounded; posterior margin of eye rounded; eyes bare; three ocelli present, medial ocellus slightly smaller; position of antennae on head nearer to mouthparts; eyes contiguous above antennal base, not contiguous below; palpi absent; proboscis much shorter than head length; flagellum shape stylate, apex with terminal seta; thorax with postpronotal lobes enlarged, medially contiguous to form collar; subscutellum not enlarged, barely visible; legs with tibial spines absent; pulvilli present; legs not greatly elongated; wing hyaline, markings absent; costa ending in radial field; costal margin straight; humeral crossvein absent; radial veins meeting wing margin before wing apex; R_1 slightly inflated distally at pterostigma; R_{2+3} present, reaching wing margin; R_{4+5} present as very



Figure 5. *Quasi fisheri* gen. et sp. n., male, anterior view [Morphbank: 693078]. Body length = 6.0 mm.

short, single vein, not reaching wing margin; medial vein complement with only one M vein present; discal cell absent; medial vein very short, not reaching wing margin; cell m_3 absent; crossvein 2r-m absent; Cu reduced, not reaching wing margin; anal lobe not enlarged; alula well developed; abdomen smooth, shape rounded, cylindrical, similar width to thorax.

Etymology. Derived from Latin *quasi*, appearing as if resembling; referring to the likeness of this species to members of *Terphis*.

Comments. This genus is represented by only a single species *Q. fisheri* sp. n. from Veracruz, Mexico. It is closely related to *Terphis* and *Philopota* based on reduction in wing veins. The position of the antennae, proximate to the reduced mouthparts, reduced wing venation and absence of abdominal tubercles readily differentiates this genus from all other philopotine genera.

***Quasi fisheri* sp. n.**

urn:lsid:zoobank.org:act:373C7B1F-51DF-4D7C-95FC-F91060433501

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

Type material. **Holotype** male, MEXICO: Veracruz: Córdoba, 12-25.vii.1964, E. Fisher, D. Verity [18.896, -96.923] (CSCA).

Description. Medium body size (male body: 6.0 mm), male wing almost as long as the body (male wing: 5.3 mm); *Head.* Eyes, antennae, face and occiput brown, occiput as narrow as the ocellar tubercle, ocelli brown, antennal tubercle brown and smaller than pedicel. *Thorax.* Postpronotal lobes, mesothorax, scutellum, subscutellum and coxae light brown with darker longitudinal markings, legs and lower calypter yel-

lowish brown, pulvilli yellow, tarsal claws black, haltere yellow, wing hyaline with yellow veins. *Abdomen*. Tergites brown, with lateral margins yellow, sternites dark brown.

Male genitalia. The genitalia were not dissected because the holotype is the only specimen available. Genitalic dissection is not necessary to diagnose the genus, since it can be differentiated based on external characters.

Etymology. This species is named in honor of Eric Fisher, the collector of the only known specimen of this unusual species.

***Schlingeriella* gen. n.**

urn:lsid:zoobank.org:act:99EAC1BE-4A6F-43E0-B61A-6460BF68694E

<http://species-id.net/wiki/Schlingeriella>

Figs 1D, 6–7

Type species. *Schlingeriella irwini* sp. n.

Diagnosis. Body shape arched; colouration non-metallic dark brown; head width much smaller than thorax (female) or slightly smaller than thorax (male); head spherical; postocular ridge and occiput extended posteriorly into slight ridge; posterior margin of eye rounded; eyes bare; position of antennae on head near middle of frons, slightly nearer to mouthparts; eyes contiguous above antennal base, not contiguous below; palpi present; proboscis longer than head; antennal flagellum stylate, apex with terminal seta; thorax with postpronotal lobes enlarged, medially contiguous to form collar; subscutellum enlarged; legs not greatly elongated; tibial spines absent; pulvilli present; wing hyaline, markings absent; costa ending in radial field; costal margin straight in both sexes; humeral crossvein absent; radial veins meeting wing margin before wing apex; R_1 inflated distally at pterostigma; R_{2+3} present; R_{4+5} present as single vein, slightly curved anteriorly midway; veins M_1 , M_2 and M_3 present; discal cell absent; medial veins reaching wing margin (or nearly so); cell m_3 absent; crossvein 2r-m absent; Cu reduced, not reaching wing margin; anal lobe not enlarged; alula well developed; abdomen smooth, rounded, cylindrical in shape, similar width to thorax (male) or greatly rounded, inflated (female).

Etymology. This genus is named in honor of Evert I. Schlinger, not only a collector of specimens of this species, but a foremost expert on world Acroceridae taxonomy and patron of dipterology.

Comments. This genus is represented by only a single species (*S. irwini* sp. n.) from New Caledonia. Winterton et al. (2007) included DNA sequences for this genus in their phylogenetic analysis of the family, placing it close to the New Zealand genus *Helle*. *Schlingeriella* gen. n. can be differentiated from all other philopotine genera by a combination of the following characters: inflated vein R_1 apically, medial veins mostly reaching the wing margin, absence of all wing cells except cell *br*, apilose eyes and elongate mouthparts. There is dramatic sexual dimorphism in body size, with females considerably larger than the diminutive males; males of this genus are some of the smallest acrocerids known.



Figure 6. *Schlingeriella irwini* gen. et sp. n., male, lateral view [Morphbank: 693079]. Body length = 2.4 mm.



Figure 7. *Schlingeriella irwini* gen. et sp. n., female, lateral view [Morphbank: 693080]. Body length = 4.4 mm.

***Schlingeriella irwini* sp. n.**

urn:lsid:zoobank.org:act:9AF204C7-FA7F-4DBC-B71D-4FFFCE367FB4
http://species-id.net/wiki/Schlingeriella_irwini

Genbank accessions. AY144402.1, AY140881.1, AF539888.1

Type material. Holotype male, New Caledonia: Riviere Bleue, refuse area, 700', 28.xi.1992 E. & M. Schlinger, at *Scaveola* flower, prey of green crab spider [-22.112, 166.677] (MNHN) (EIS013911).

Paratypes. New Caledonia: 3 males, 1 female, Riviere Bleue, same data as holotype (CAS, EIS013912, 013913) (CSCA, 013914, 013915); male, Riviere Bleue, 600', 19.6 km on Riviere Bleue Road. M.T., 16-17.xi.1992, E. & M. Schlinger coll. (EIS013910); female, Riviere Bleue, 700', Malaise, 6-16.xi.1992, E. & M. Schlinger, D. Webb; 1 male, 1 female [abdomen only], Mt. Nihgua, Nov. 2000, E. I. Schlinger & L. J. Boutin [voucher specimens from Winterton et al. (2007)] (EIS007431, male; EIS011170, female) (CAS); 1 female, Col d'Amieu Forestry Camp, 450m 17-18.x.1978, J. S. Dugdale, Malaise trap [-21.576, 165.740] (EIS013909) (CAS); 1 male, Mt. Ouin, 1100m, 9.xi.2002, C. Burwell & G. Monteith, pyrethrum, trees & logs (-22.016, 166.466) (QM).

Description. Male with small body size (male body: 2.4 mm) and wing as long as the body (male wing: 2.5 mm), female with medium body size (female body: 4.4 mm) and wing longer than the body (female wing: 6.0 mm). *Head.* Eyes, occiput and ocellar tubercle dark brown, occiput wider than the face; ocelli shining light brown, antennal tubercle shining black, antennae light brown, face black, clypeus shining brown, as long as the antennae, proboscis yellow. *Thorax.* Uniform dark brown with short whitish pile; coxae yellow, legs dark yellow, femora with darker yellow-brown suffusion, lower calypter and haltere pale yellow, wings hyaline with brown veins. *Abdomen.* Dark brown; female tergites I-II entirely brown, tergites III-VI with the anterior half yellow and the posterior half brown, sternites brown.

Etymology. This species is named in honour of Michael E. Irwin.

Key to world genera of living and fossil Philopotinae

- | | |
|---|---|
| 1 | Wing venation reduced, with only one basal cell (br) present (Fig. 1B, D) ...7 |
| – | Wing venation relatively complete, with additional cells d, bm, cu-p and basal r_{4+5} present (Fig. 1E) 2 |
| 2 | Palpi present 4 |
| – | Palpi absent..... 3 |
| 3 | Eyes densely pilose (South Africa and Madagascar) ... <i>Thyllis</i> Erichson, 1840 |
| – | Eyes very sparsely pilose or bare (Madagascar)..... <i>Parabelle</i> Schlinger, 1961 |
| 4 | Eyes pilose 6 |
| – | Eyes apilose..... 5 |
| 5 | Eyes contiguous below antennae; humeral crossvein present; vein R_1 not inflated (Baltic amber) (Figs 1E-G, 2) <i>Eulonchiella</i> Meunier, 1912 |
| – | Eyes separate below antennae; humeral crossvein absent; vein R_1 inflated at pterostigma (New Zealand) <i>Helle</i> Osten Sacken, 1896 |
| 6 | Legs relatively very long; male with tufted projection at the base of costa (Madagascar) <i>Dimacrocolus</i> Schlinger, 1961 |
| – | Legs of normal length; male without tufted projection at the base of costa (South America) <i>Megalybus</i> Philippi, 1865 |
| 7 | Eyes pilose 12 |

- Eyes apilose..... 8
- 8 Mouthparts equal to, or longer than head length 9
- Mouthparts much shorter than head length 10
- 9 Wing veins reaching wing margin; M_2 not connected to M vein, unsclerotized and discontinuous basally; vein R_1 inflated at pterostigma (New Caledonia) (Figs 1D, 6–7) ***Schlengeriella* gen. n.**
- Wing veins not reaching wing margin (Hennig 1966: Fig. 11), M_2 originating on M vein, sclerotized and continuous basally; vein R_1 not inflated at pterostigma (Baltic amber) ***Prophilopota* Hennig, 1966**
- 10 Three pairs of tubercles present on segments II - IV of abdomen; occiput extended posteriorly to form an acute ridge (South America) ***Terphis* Erichson, 1840**
- Abdomen without tubercles; occiput rounded, not extended posteriorly... 11
- 11 Antenna on ventral side of head, adjacent to mouthparts; abdomen conical (Mexico) (Figs 1A-C, 3–5) ***Quasi* gen. n.**
- Antennae on lower front side of head, but not adjacent to mouthparts; abdomen rounded (Africa) ***Africaterphis* Schlinger, 1968**
- 12 Large hemispherical head; posterior margin of eye emarginate; mouthparts shorter than head; occiput rounded; postpronotal lobes proximate but not contiguous medially (Baltic amber) ***Archaeterphis* Hauser & Winterton, 2007**
- Head smaller and almost spherical, eye not emarginate posteriorly; mouthparts elongate, longer than head, occiput extended posteriorly to form acute ridge; postpronotal lobes contiguous medially..... 13
- 13 Palpi present (Palearctic) ***Oligoneura* Bigot, 1878**
- Palpi absent (Neotropical) ***Philopota* Wiedemann, 1830**

Systematics of Philopotinae

While two groups can be differentiated within Philopotinae based on reduction of wing venation, three clades have been identified by Winterton et al. (2007) largely corresponding to three biogeographical regions.

Philopota genus group— This genus group comprises *Africaterphis* from Africa, the Palearctic *Oligoneura*, *Archaeterphis* and *Prophilopota*, and new world genera *Philopota*, *Megalybus*, *Quasi* gen n. and *Terphis*. *Archaeterphis* is a very distinctive genus, closely related to the extant genus *Africaterphis* (Hauser & Winterton, 2007). *Prophilopota* is presumably more closely related to *Oligoneura*, since both genera share the presence of maxillary palpi and similar shape of the antennal tubercle (Schlinger, 1971). *Quasi* gen n. is closely related to *Philopota* and in particular, *Terphis*. This genus shares with *Terphis* the insertion of the antennae on the lower side of head, reduced mouthparts, presence of relatively well-developed subscutellum and substantial reduction of the wing venation, the latter being less reduced in *Philopota*. In addition, both *Philopota*

and *Quasi* gen n. lack the abdominal tubercles present in *Terphis*, and share a conical abdomen, instead of a swollen one that characterizes *Terphis*. Genera in the *Philopota* genus group are found in the northern and southern hemispheres with greater diversity in the New World (four genera). All genera in this group have reduced wing venation except *Megalybus*, the sister genus to the clade (Winterton et al. 2007).

Helle genus group– *Schlingeriella* gen n. was included in the study by Winterton et al. (2007) as “undescribed genus New Caledonia”. It is closely related to the New Zealand genus *Helle*, since they both have apilose eyes, well developed palpi, elongate mouthparts and an inflation of the vein R_1 at the pterostigma. *Schlingeriella* gen n. is differentiated from *Helle* by its small body size and the reduced wing venation.

Thyllis genus group– This group contains genera with complete wing venation including three Afrotropical genera (*Dimacrocolus*, *Parabelle* and *Thyllis*) and the Palaearctic genus *Eulonchiella*. *Dimacrocolus* and *Parabelle* are endemic to Madagascar while *Thyllis* is found in both Madagascar and South Africa.

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The genus *Andraca* (Lepidoptera, Endromidae) in China with descriptions of a new species

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Abstract

The six species of the genus *Andraca* Walker hitherto known from China are reviewed, and a new species, *A. gongshanensis*, sp. n., described from Yunnan Province, China. Adults and male genitalia of all examined species are illustrated, together with a distributional map. A key to all seven Chinese *Andraca* species is provided. The types of the new species are deposited in SCAU (South China Agricultural University, Guangzhou, China) and HUNAU (Hunan Agricultural University, Changsha, China).

Keywords

Taxonomy, Lepidoptera, Endromidae, *Andraca*, new species, China

Introduction

The genus *Andraca* was established by Walker (1865) with *Andraca bipunctata* Walker 1865 as its type-species, a species well known as one of the most serious pests of tea plants (Chu and Wang 1996). It was placed in family Bombycidae for over 150 years, but was recently transferred to family Endromidae based on the molecular study of Zwick et al. (2011). Kishida (1993) reported *A. theae* and *A. olivacea* from Taiwan. Chu and Wang (1993) recorded three *Andraca* species from China: *A. bipunctata* is widely distributed in central and southern China, *A. henosa* Chu & Wang, 1993 was listed from Yunnan, and *A. hedra* Chu & Wang, 1993 from Hainan and Fujian; in this paper, they also included *Andraca gracilis* Butler 1885, which is currently placed in the genus *Pseudandraca* Miyata, 1970. Yang (1995) added one species, *A. flavamaculata* Yang, 1995, to the Chinese *Andraca* fauna. Owada et al. (2002) reviewed three species of *Andraca* from Vietnam and provided a world checklist. Zolotuhin and Witt (2009) recorded five *Andraca* species from Vietnam, describing two new species, *A. stueningi* Zolotuhin & Witt, 2009 and *A. melli* Zolotuhin & Witt, 2009, and newly treating two taxa, *A. trilochoides roepkei* Bryk, 1944 and *A. olivacea olivacens* Mell, 1958, as subspecies of *A. trilochoides* Moore, 1865 and *A. olivacea* Matsumura, 1927 respectively. At present, the genus *Andraca* consists of eight species ranging from the Himalayas to Southeast Asia.

In the present paper, seven Chinese *Andraca* species are reviewed, including the description of one new species *A. gongshanensis*, sp. n. The early stages of *Andraca theae* (Matsumura 1909) are described in detail. A key to the seven Chinese *Andraca* species is provided.

Materials and methods

Specimens of the new species were collected by light trap. The types of previously described species in the Natural History Museum, London, UK (BMNH) were examined. Other materials examined in this study are preserved in SCAU and HUNAU. Morphological terminology used in descriptions follows Lemaire and Minet (1999).

Taxonomy

Andraca Walker, 1865

<http://species-id.net/wiki/Andraca>

Andraca Walker, 1865, *List Specimens lepid. Insects Colln Br. Mus.*, 32: 581. (Type species: *Andraca bipunctata* Walker, 1865, *List Specimens lepid. Insects Colln Br. Mus.*, 32: 582, by monotype. Type locality: Hindostan, India.)

Pseudoeupterote Shiraki, 1911, *Catalogue Insectorum Noxiorum Formosarum*: 48. (Type species: *Oreta theae* Matsumura, 1909, *Thousand Insects of Japan*, 1: 582, by monotype. Type locality: Formosa (=Taiwan)). Type-species designation by monotype.

Description. Forewing weakly falcate. Ground color varying from shades of brown to sandy grey.

Male genitalia. Uncus apically single-pointed to weakly indented; gnathos with two long, basally broad, upcurved arms; valvae basally broad, sclerotized, long or medium length; aedeagus short with apex truncated, cornuti present or absent.

Female genitalia (*A. bipunctata*). Eighth segment curved deeply, ventral margin of ostium bursae extends posteriorly as a broad bilobed plate, ductus bursae sclerotized distal to mid-point, tapering to half width; distal half unsclerotized with slight torsion, corpus bursae lacking a signum.

Distribution. Oriental Region, S & E Palearctic.

Remarks. *Andraca* species have sometimes been described in *Mustilia* (e.g., Chu and Wang 1993, 1996), and misidentification has also been frequent (Chu and Wang 1993, 1996). *Andraca* was considered to belong to 'the *Mustilia* lineage' of Prismostictinae Forbes, 1955 (Holloway 1987; Minet 1994; Lemaire and Minet 1999; Holloway et al. 2001). Our own unpublished work also shows that *Andraca* is close to *Mustilia* Walker, 1865 and *Mustilizans* Yang, 1995, based on phylogenetic analysis of mitochondrial and nuclear DNA sequences (*COI* + *18S* + *28S*) (Wang 2010).

Sevastopulo (1938) described the fully grown larvae of the type species. The larvae are gregarious, have short hairs covering the body, and are often heavily parasitized. Pupation is in a thin cocoon of brown silk spun among leaves.

Key to the Chinese *Andraca* species

- | | | |
|---|--|------------------------------------|
| 1 | Apex of forewing falcate..... | 2 |
| – | Apex of forewing not falcate | 5 |
| 2 | Uncus broad, gnathos extremely swollen medially..... | <i>A. bipunctata</i> |
| – | Uncus narrow, gnathos not swollen..... | 3 |
| 3 | Apex of valva boot-shaped | <i>A. flavamaculata</i> comb. rev. |
| – | Apex of valva rounded or truncate | 4 |
| 4 | Apex of valva rounded, gnathos long..... | <i>A. olivacea</i> |
| – | Apex of valva truncate, gnathos short..... | <i>A. gongshanensis</i> sp. n. |
| 5 | Apex of valva bifurcate..... | <i>A. theae</i> |
| – | Apex of valva rounded | 6 |
| 6 | Gnathos not swollen | <i>A. apodecta</i> |
| – | Gnathos extremely medially swollen | <i>A. melli</i> |

***Andraca bipunctata* Walker, 1865**

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

Figs 1–A, 2–A

Andraca bipunctata Walker, 1865, *List Specimens lepid. Insects Colln Br. Mus.*, 32: 582.

Type locality: Hindustan, India.

Andraca bipunctata Walker, 1862: Chu & Wang, 1993, *Sinozoologia*, 10: 241.

Andraca henosa Chu & Wang, 1993, *Sinozoologia*, 10: 242. Type locality: Yunnan, China.

Andraca henosa Chu & Wang: Chu & Wang, 1996, *Fauna Sinica Insecta*, 5: 55.

Description. Male (China): wingspan 42–45 mm, length of forewing 21–23 mm, antenna length 6–8 mm (Fig. 1-A). Male genitalia (Fig. 2-A): uncus broad, duck beak-shaped; gnathos long, finger-shaped; vesica with a cluster of strong spinose cornuti

Female genitalia: see above under generic entry.

Material Examined. [CHINA] 2♂♂, western Yunnan, 2005-VI-15, Ming-Yi Tian leg.; 2♂♂, Dulongjiang, Yunnan Province, 2006-VII-21, Min Wang & Xiao-Ling Fan leg.; 1♂1♀, Gongshan Mountain, Yunnan Province, 2006-VII-22, Min Wang & Xiao-Ling Fan leg.

Host. *Camellia sinensis* (Theaceae), *Camellia Assamica* (Theaceae), *Camellia oleifera* (Theaceae).

Distribution. China (Yunnan); India.

Remarks. This widely distributed species is rather variable in coloration and size. Moore (1865) described *A. trilochoides* from a brighter and grayish individual. This taxon was later synonymized with *A. bipunctata* by Hampson, ([1893]), an action that was followed by Strand (1924).

Andraca bipunctata is closely related to *A. angulata* Kishida, 1993 (Nepal and India: Sikkim), *A. theae* (Taiwan) and *A. stuenyingi* (Vietnam). These four species form the *bipunctata* group, and share the following characteristics: 1) male hindtibia with one pair of spurs; 2) two dorsally-directed projections present on subapical part of valva; 3) external surface of aedeagus partially covered with hair-like spines; 4) a cluster of strong spinose cornuti on vesica.

Larvae of *A. bipunctata* are well-known serious pests of tea trees, *Camellia sinensis* (Theaceae) (Banerjee 1982; Chang 1989; Chen et al. 1992; Panigrahi 1995; Ho et al. 1996; Upadhyay et al. 2001).

***Andraca olivacea* Matsumura, 1927**

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

Figs 1–B, 2–B

Andraca olivacea Matsumura, 1927, *J. Coll. Agric. Hokkaido. Univ.*, 19: 50. Type locality: Formosa (=Taiwan), China.

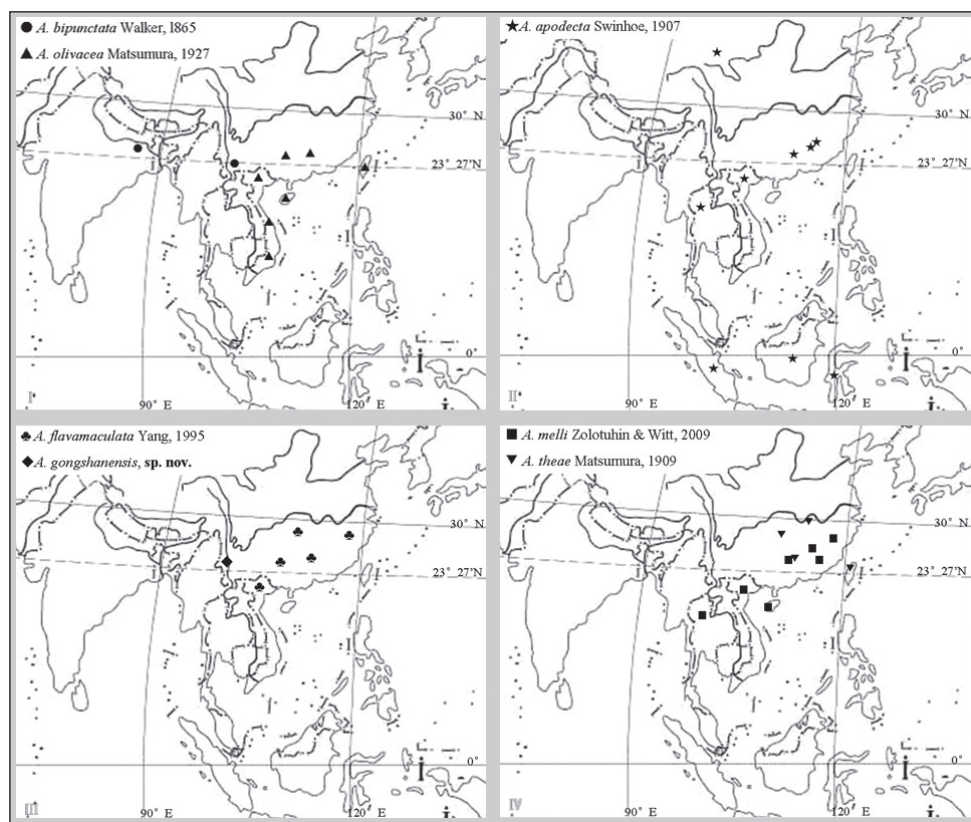


Figure 1. Distributional map of *Andraca* spp. from China.

Andraca hedra Chu & Wang, 1993, *Sinozool.*, 10: 233. Type locality: Hainan, China.

Andraca hedra Chu & Wang; Chu & Wang, 1996, *Fauna Sinica Insecta*, 5: 58.

Andraca olivacea: Owada *et al.*, 2002, *Spec. Bull. Jpn. Soc. Coleopterol.*, 5: 464; Kishida, 1992, *Lepidoptera of Taiwan*, 1 (2): 153.

Description. Male: wingspan 36–38 mm, length of forewing 16–20 mm, antenna length 5–7 mm (Fig. 1-B). Hindtibia with two pairs of spurs; hindwings with Rs and M1 connate. Male genitalia (Fig. 2-B): uncus thick and round; valva simple, basal half broad and terminal half narrow; distal margin of aedeagus with strong lateral spines; vesica with a cluster of spinose cornuti.

Material Examined. [CHINA] 1 ♂, Shimentai Provincial Nature Reserve, Yingde City, Guangdong Province, 2001-VII-24, Min Wang & Guo-Hua Huang leg.; 1 ♂, same data but 2001-IX-22; 3 ♂♂, same data but 2002-VI-11, Guo-Hua Huang leg.; 1 ♂, Nanling National Nature Reserve, Ruyuan City, Guangdong Province, 2002-VII-23, Guo-Hua Huang leg.; 4 ♂♂, same data but 2003-III-29–31; 1 ♂, same data but 2003-VI-22; 2 ♂♂, same data but 2003-VIII-7; 2 ♂♂, same data but 2003-VIII-18; 5 ♂♂, same data but 2004-IV-23; 1 ♀, same data but 2004-IV-24; 2 ♂♂, same data

but 2006-IX-18, Liu-Sheng Chen leg.; 1 ♂, same data but 2008-VI-7, Min Wang leg.; 1 ♂, same data but 2008-VI-7; 1 ♂, same data but 2009-IV-1, Hou-Shuai Wang leg.; 1 ♂, same data but 2009-VIII-10; 1 ♂, same data but 2009-IV-1; 1 ♂, same data but 2009-VIII-10; 1 ♂, Maoershan National Nature Reserve, Xingan City, Guangxi Province, 2003-III-3, Min Wang & Guo-Hua Huang leg.; 6 ♂♂, Jianfengling National Nature Reserve, Ledong City, Hainan Province, 2003-XI-29–31, Guo-Hua Huang & Min Wang leg.; 1 ♂, same data but 2007-X-23, Min Wang leg.

Host. *Ficus concinna* var. *pusillifolia* (Moraceae).

Distribution. China (Taiwan, Guangdong, Guangxi, Hainan); Vietnam.

Remarks. Wang (1995) provide a fine color illustration of a fresh living male. Owada et al. (2002) considered *Andraca olivacens* from Fukien (= Fujian) to the synonym of *A. olivacea*, whereas Zolotuhin and Witt (2009) treated it as a subspecies thereof. We do not comment further on which of these two alternatives may be the most appropriate status for this taxon because we have not seen the types of *A. olivacens*.

***Andraca apodecta* Swinhoe, 1907**

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

Figs 1–C, 2–C

Andraca apodecta Swinhoe, 1907, *Ann. Mag. nat. Hist.*, 19 (7): 49. Type locality: Sumatra, Indonesia.

Andraca apodecta Swinhoe: Holloway, 1976, *Malayan Nature Society*: 85; Zolotuhin & Witt, 2009, *Entomofauna*, 261.

Description. Male: wingspan 37–39 mm, length of forewing 15–18 mm, antenna length 6–8 mm (Fig. 1-C). Head covered with reddish-brown hairs; forewing with black discal spot, smooth outer margin and apically not falcate. Male genitalia (Fig. 2-C): uncus triangular, apical half truncate; valva with two subapical, dorsally-directed projections; aedeagus short, curved slightly without cornuti, external surface without hair-like spines.

Material Examined. [CHINA] 2♂♂, Jinzhongshan Mountain, Longlin City, Guangxi Province, 2007-VII-31, Liu-Sheng Chen leg..

Host. Unknown.

Distribution. China (Guangxi, Yunnan, Fujian, Shaanxi), Vietnam, Thailand (Chiang Mai, Nan), Indonesia (Sumatra, Borneo, Sulawesi).

Remarks. The species was first recorded from China (Yunnan, Fujian, Shaanxi) by Zolotuhin and Witt (2009) and is here recorded from Guangxi for the first time.

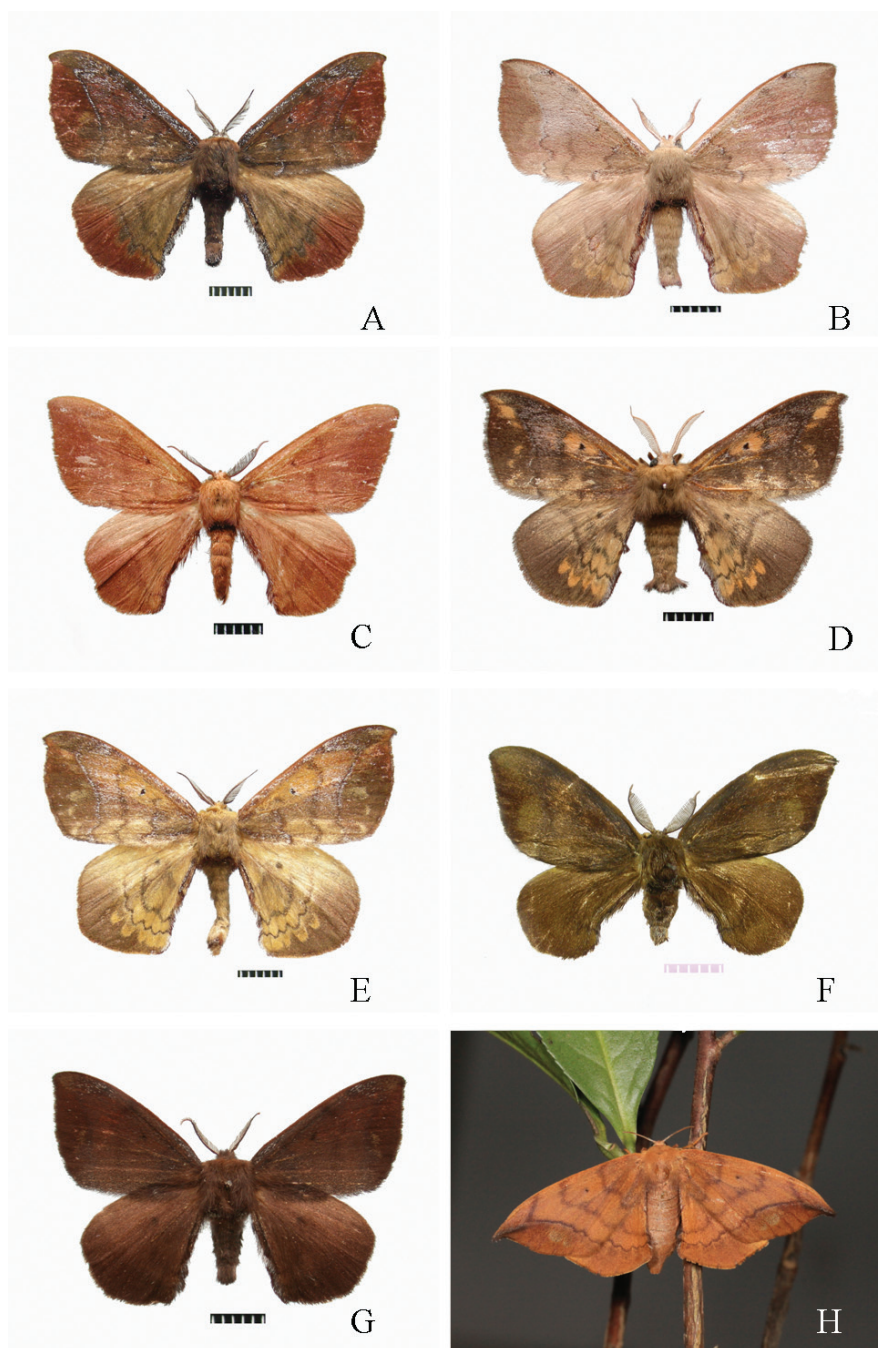


Figure 2. Adult male *Andraca* spp. **A** *A. bipunctata* Walker, 1865 from Yunnan **B** *A. olivacea* Matsumura, 1927 from Guangdong **C** *A. apodecta* Swinhoe, 1907 from Guangxi **D** *A. flavamaculata* Yang, 1995 from Guangdong **E** *A. gongshanensis*, sp. n., Holotype, from Yunnan **F** *A. melli* Zolotuhin & Witt, 2009 from Guangdong **G** *A. theae* Matsumura, 1909 from Hunan Province **H** *A. theae* Matsumura, 1909 from Hunan Province (in field).

***Andraca flavamaculata* Yang, 1995, comb. rev.**

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

Figs 1–D, 2–D

Andraca flavamaculata Yang, 1995, *Insects of Baishanzu Mountain, Eastern China*: 354.

Type locality: Zhejiang, China.

Andraca nabesan Kishida & Owada, 2002, *Spec. Bull. Jpn. Soc. Coleopterol.*, (5): 464;

Huang & Wang, 2004, *Entomotaxonomia*, 26(1): 47. Type locality: Cao Bang, Vietnam.

Description. Male: wingspan 40–44 mm, length of forewing 20–22 mm, antenna length 6–7 mm (Fig. 1-D). Body stout. Forewing apex falcate; outer edge smooth and straight; tornus almost rectangular. Male genitalia (Fig. 2-D): uncus long with apex finger-shaped; tegumen broad with numerous long setae; valvae basally broad, strongly sclerotized, apex of valva boot-shaped; sacculus broad, with a strong dorsal spike; saccus short and narrow; aedeagus short but strong and straight, distally with a large number of spines.

Material Examined. [CHINA] 2 ♂♂, Nanling National Nature Reserve, Ruyuan City, Guangdong Province, 2002-III-15, Guo-Hua Huang leg.; 2 ♂♂, same data but 2003-II-23; 5 ♂♂, same data but 2003-III-29 ~ 31; 1 ♂, same data but 2003 -VIII-30; 1 ♂, same data but 2006-IX-17, Zhen Li leg.; 2 ♂♂, Maoershan National Nature Reserve, Xingan City, Guangxi Province, 2003-III-03, Min Wang & Guo-Hua Huang leg.; 3 ♂♂, Mangshan Nature Reserve, Yizhang City, Hunan Province, 2003-III-31, Guo-Hua Huang leg.; 1 ♂, Jiuwandashan National Nature Reserve, Guangxi Province, 2003-VII-30, Guo-Hua Huang leg.

Host. Unknown.

Distribution. China (Zhejiang, Hunan, Guangdong, Guangxi); Vietnam.

Remarks. Yang (1995) described the species from Zhejiang, China. The species is similar to *Andraca olivacea* but can be distinguished by the following characters: aedeagus straight; gnathos not prominent. Zolotuhin and Witt (2009) synonymized *A. nabesan* Kishida & Owada, 2002 with *A. flavamaculata*, which they also transferred to *Pseudandraca* species based on features of the genitalia. We accept the synonymy but do not agree with the generic transfer, because we do not consider that the diagnostic feature of *Pseudandraca* given by Miyata (1970), a valva with a “long distinct projection” is present in *A. flavamaculata*. We therefore transfer *A. flavamaculata* comb. rev. back to *Andraca*.

***Andraca gongshanensis* sp. n.**

[urn:lsid:zoobank.org:act:E5DD5FB7-554B-48A6-9EF3-65F1699E9897](http://species-id.net/wiki/Andraca_gongshanensis)

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

Figs 1–E, 2–E

Description. Male: wingspan 46–48 mm, length of forewing 22–24 mm, antenna length 5–8 mm (Fig. 1-E). Antenna bipectinate except apex. Wings ground color

dark brow with dark brow fasciae and reddish-yellow patterns, which is consisting of antemedian, discocellar, postmedian fascia, and reddish-yellow patterns nearly placed on the wholly wings but termen. Forewing apex falcate; outer edge smooth and straight; tornus almost rectangular. Hindwing with anal margin straight; outer margin angled at vein M_3 , straight above and below this.

Male genitalia (Fig. 2-E): uncus long with wedge-shaped apex; tegumen broad; gnathos very well developed, arms upcurved; valvae basally broad with many long setae, strongly sclerotized, caudally constricted to a spatulate apex; sacculus broad, without a dorsal spike; aedeagus short but strong and straight, distally with a large number of spines.

Holotype. ♂, Gongshan Mountain, Yunnan Province, China, 2006-VII-22, Min Wang & Xiao-Ling Fan leg., deposited in Department of Entomology, SCAU; **Paratypes**, 2 ♂♂, same data as holotype but 2006-VII-21.; 1 ♂, same data as holotype but 2006-VII-23; deposited in Institute of Entomology, HUNAU.

Host. Unknown.

Distribution. China (Yunnan).

Etymology. The specific epithet refers to the type locality (Gongshan Mountain, China).

Remarks. This new species is very similar to *A. flavamaculata*, but can be distinguished by the following characters of the male genitalia: *A. gongshanensis*, sp. n. with uncus apex wedge-shaped, apex of valva constricted and truncate, sacculus without a strong dorsal spike. And *A. flavamaculata* with uncus apex finger-shaped, apex of valva boot-shaped; sacculus broad, with a strong dorsal spike.

Externally, *A. gongshanensis* is paler than *A. flavamaculata*.

Andraca melli Zolotuhin & Witt, 2009

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

Figs 1–F, 2–F

Andraca melli Zolotuhin & Witt, 2009, *Entomofauna*, Suppl. 16: 262. Type locality: Guangdong, China.

Description. Male: wingspan 37–39 mm, length of forewing 15–18 mm, antenna length 5–7 mm (Fig. 1-F). Antenna bipectinate except apex. Head thinly covered with brown-green hairs. Forewing: apically bluntly pointed; outer edge smooth and straight, tornus nearly rectangular. Hindwings distinctly angled at vein M_3 , straight above and below this.

Male genitalia (Fig. 2-F): uncus bluntly triangular with long hairs; tegumen broad; gnathos with two extremely medially swollen arms; valvae flattened, strongly sclerotized, apex narrower and truncate with a dorsally directed projection from the middle; sacculus short and broad; aedeagus short, strongly curved, with a compact group of long, thick needle-shaped cornuti on dorsal surface.

Material Examined. [CHINA] 2 ♂♂, Nanling National Nature Reserve, Ruyuan City, Guangdong Province, 2007-VI-23, Liu-Sheng Chen collected larvae and reared to adult.

Host. *Camellia sinensis* (Theaceae), *Camellia oleifera* (Theaceae), *Fraxinus pennsylvanica* (Oleaceae) and *Ternstroemia japonica* (Ternstroemiaceae), *Pentaphylax euryoides* Gardn. & Champ. (Pentaphylacaceae) (new host record).

Distribution. China (Zhejiang, Jiangxi, Fujian, Guangdong, Hainan); Vietnam; Thailand.

Remarks. *A. melli* was first described by Zolotuhin and Witt (2009), who also reported on the biology of this species.

Andraca theae Matsumura, 1909

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

Figs 1–G, 1–H, 2–G, 2–H

Oreta theae Matsumura, 1909, *Thousand Insects of Japan*, 1: 86. Type locality: Formosa (= Taiwan), China.

Description. Male: wingspan 35–37 mm, length of forewing 17–19 mm, antenna length 6–7 mm (Figs 1–G, 1–H). Head densely covered with dark brown hairs; antenna bipectinate except apex. Forewing apex inconspicuously falcate, exterior margin straight. Forewing and hindwing each with a dark discal spot.

Male genitalia (Fig. 2–G): uncus triangular with apex narrowly spatulate; tegumen broad; gnathos elongate, medially inflated; saccus short and broad; valvae bifurcate apically; dorsal margin with a subapical hump; aedeagus bowed with dense apical spines.

Material Examined. [CHINA] 1 ♂, Nanling National Nature Reserve, Ruyuan City, Guangdong Province, 2003-III-29, Guo-Hua Huang leg.; 1 ♂, same data to the former, except 2003-VIII-12, Guo-Hua Huang & De-Yu Xin leg.; 2 ♂♂, Taipei City, Taiwan Province, 2009-VIII-15, Shipher Wu leg.; 10 ♂♂, Wuyunjie National Nature Reserve, Taoyuan City, Hunan Province, 2010-VII-2, collected the larvae in the field by Mr. Hong-Chun Zhou, got the adults from the larvae bred in the entomological laboratory of Hunan Agricultural University by Dr. Guo-Hua Huang; 3 ♂♂, Houxi Town, Huangshan City, Anhui Province, 2010-VI-28, the adults from the larvae collected in the field and bred in laboratory by Dr. Guo-Hua Huang.

Host. *Camellia sinensis* (Theaceae).

Biology. This species is widely distributed in Taiwan and Southern China. The larvae were found on *Camellia sinensis* in Hunan Province; photographs of the early stages were taken in June to August, 2010 (Figs 3–A to 3–H).

Distribution. China (Taiwan, Guangdong, Hunan, Anhui).

Remarks. The species is easily separated from its congeners by the apically bifurcate valvae.

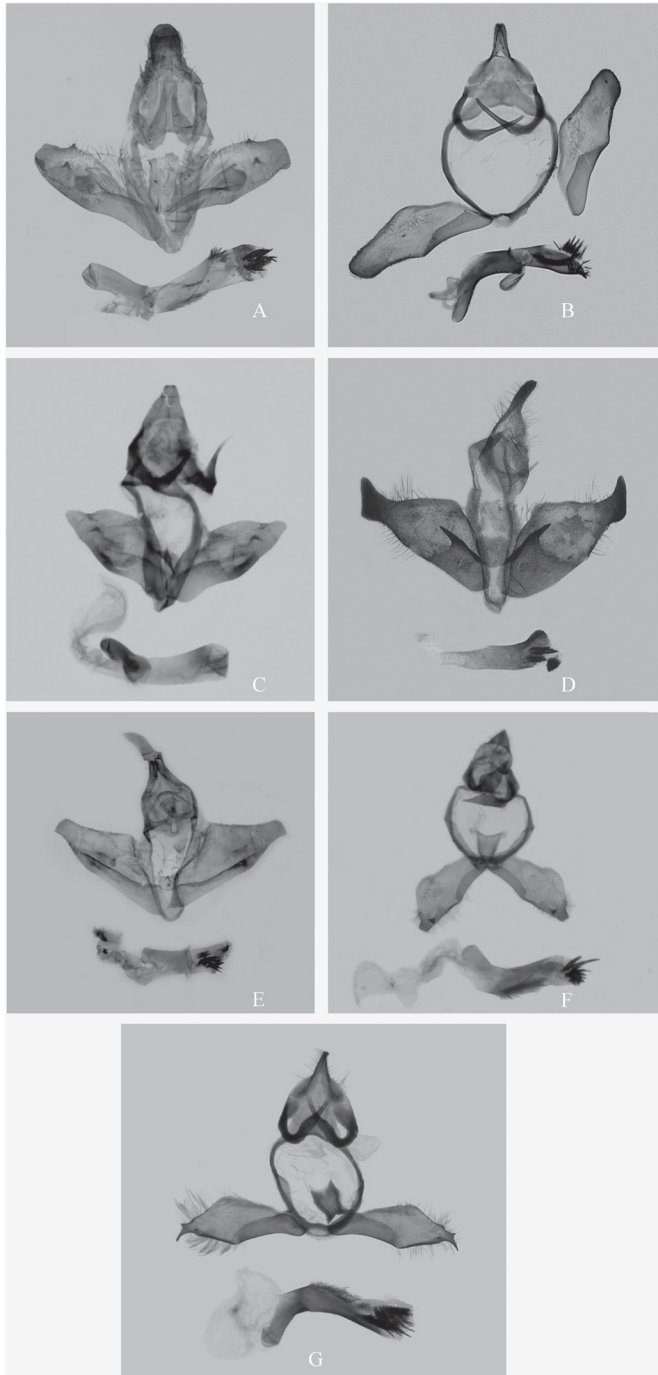


Figure 3. Male genitalia of Chinese *Andraca* spp. **A** *A. bipunctata* Walker, 1865 from Yunnan **B** *A. olivacea* Matsumura, 1927 from Guangdong **C** *A. apodecta* Swinhoe, 1907 from Guangxi **D** *A. flavamaculata* Yang, 1995 from Guangdong **E** *A. gongshanensis*, sp. n., Holotype, from Yunnan **F** *A. melli* Zolotuhin & Witt, 2009 from Guangdong **G** *A. theae* Matsumura, 1909 from Hunan Province.

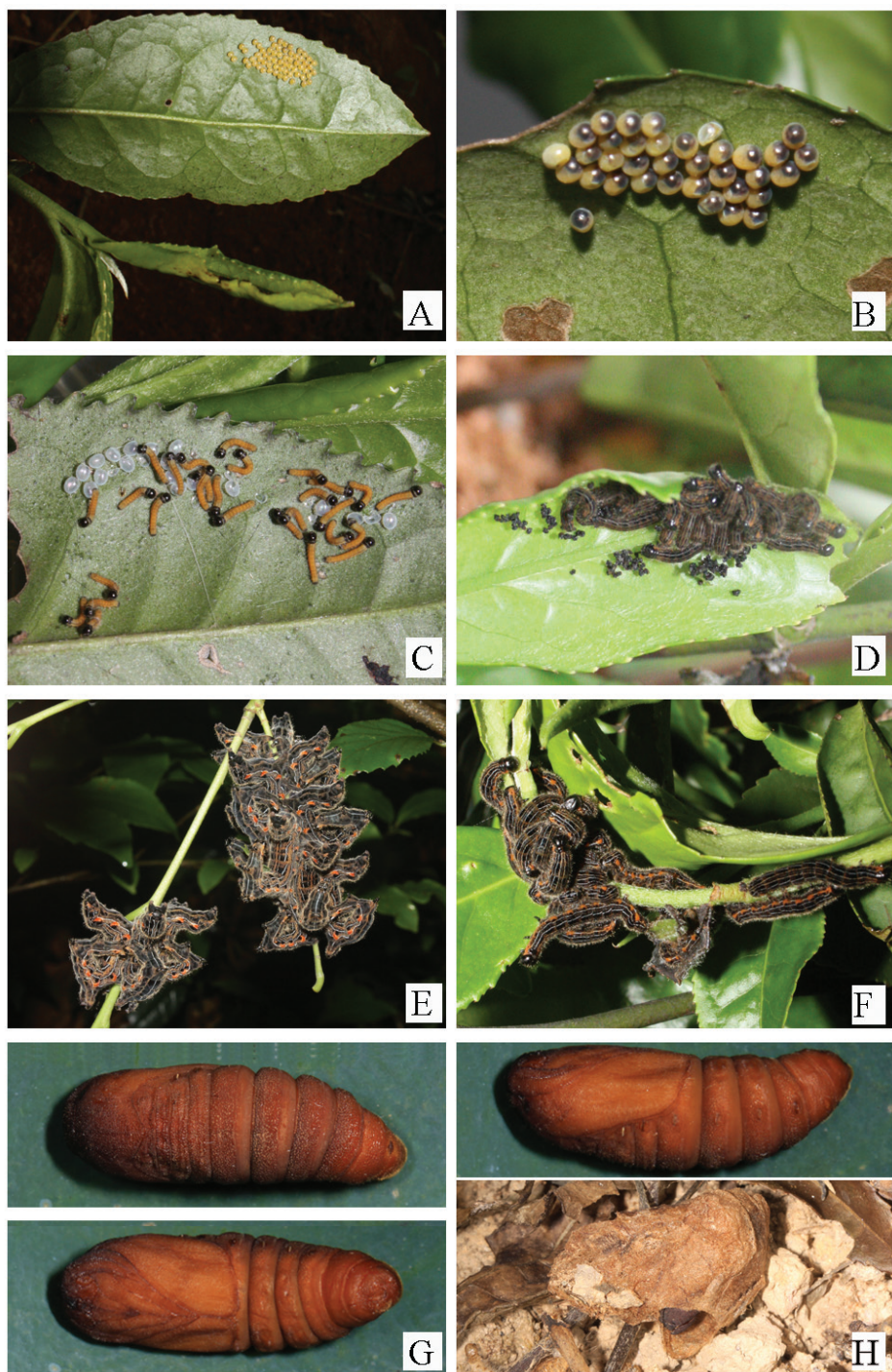


Figure 4. The early stages of *Andraca theae* Matsumura, 1909 from Hunan Province **A–B** Eggs **C** First larvae **D** Third larvae **E–F** Final larvae **G–H** Pupa and cocoon.

Acknowledgments

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Host insect species of *Ophiocordyceps sinensis*: a review

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Abstract

Ophiocordyceps sinensis (\equiv *Cordyceps sinensis*) is one of the most valued medicinal fungi in China, used for its invigorating effects in strengthening the body and restoring energy. The fungus parasitizes larvae of moths and converts them into sclerotia from which the fungus fruiting body grows. Since the late 1950s, considerable effort has been devoted to the study of host insects related to the fungus. In the present paper, the research history of insect species associated with *O. sinensis* is briefly reviewed and an extensive literature survey is presented. Ninety-one insect names, spanning 13 genera, related to host insects of *O. sinensis* are investigated. The relationships between the reported insect species and *O. sinensis* are analyzed. Fifty-seven of these are considered as recognizable potential host species of the fungus distributed throughout the Tibetan Plateau, whilst eight are considered as indeterminate hosts and 26 as non-hosts. Among the names of recognizable potential host insects, three are invalid (*nomen nudum*) and require further study. This work provides basic information for management of the insect resources and for the conservation and sustainable use of *O. sinensis*.

Keywords

Cordyceps, Fungi, Hepialidae, host insects, *Ophiocordyceps*

Introduction

Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora is an ascomycete fungus, which is also known as the Chinese Caterpillar Fungus or “Dong Chong Xia Cao” (winter worm, summer grass) in Chinese, or “Hia Tsao Tong Tchong”

and “Hea Tsaon Tsong Chung” in early English translations (Pegler et al. 1994). The fungus parasitizes larvae of moths belonging to the order Lepidoptera, especially *Hepialus/Thitarodes*. The infected larva is converted into a sclerotium covered by the intact exoskeleton of the insect to withstand the winter, which is regarded as “winter worm”. In the late spring or summer of the next year, a clavate stroma of the fungus grows from the sclerotium and emerged from the ground appearing as a herb, which is regarded as “summer grass” (Pegler et al. 1994, Yao 2004). As a valued Chinese herb and tonic, *O. sinensis* has a long history of use and a high reputation of value both in China and abroad. In Traditional Chinese Medicine (TCM), the fungus is believed to nourish the lungs and kidneys (Wu 1757). It has also been shown in recent studies to have multiple pharmacological effects, including immunomodulating (Wu et al. 2006), hypocholesterolemic (Koh et al. 2003), hypoglycemic (Zhang et al. 2006), anti-tumor (Wu et al. 2005), anti-oxidation (Dong and Yao 2008) and anti-aging (Ji et al. 2009) activities.

The natural product of *O. sinensis* for medicinal use is actually a combination of the fungus and an insect larva. The fungus parasitizes underground dwelling larvae of moths and converts them into sclerotia, from which the fruiting body of the fungus grows (Pegler et al. 1994, Wang 1995, Yao 2004). *Ophiocordyceps sinensis* is endemic to the Tibetan Plateau, with a distribution covering five provinces in China, i.e., Gansu, Qinghai, Sichuan, Tibet and Yunnan. It may be found in alpine meadow and shrub habitat from an altitude of 3000 m up to the snow-line (Wang 1995, Yao 2004). The natural production of the fungus is limited owing to its strict host-specificity, confined geographic distribution and over exploitation by humans in recent decades. It is therefore currently listed as an endangered species under the second class of state protection (State Forestry Administration and Ministry of Agriculture 1999).

Insect host species of *O. sinensis* belong to the family Hepialidae (Lepidoptera) (Chu et al. 2004). Since the late 1950s, much effort has been devoted to study the insect species related to the fungus in China. In 1958, researchers from the Institute of Zoology, Chinese Academy of Sciences, began their investigation in some parts of Qinghai and Sichuan provinces. The first report on host insects of *O. sinensis* in China was on *Hepialus armoricanus* Oberthür (= *Thitarodes armoricanus* Oberthür, Chu 1965) and then followed by studies of biological characteristics of the moth (Chen et al. 1973). The research on Hepialidae diversity and taxonomy grew rapidly in China during the 1980s, leading to a series of publications of new taxa, including four new genera, 71 new species and one subspecies (see Chu and Wang 1985a, b; Liang et al. 1988; Wang 1990; Wu 1992; Li et al. 1993; Fu et al. 1991, 2002; Yang 1993, 1994; Yang et al. 1991a, 1992a, 1995; Liang 1995; Yang and Jiang 1995; Shen and Zhou 1997; Yan 2000; Wang et al. 2001; Chu et al. 2004; Zhang et al. 2007; Tu et al. 2009). A number of attempts have been made to summarize the insect species associated with *O. sinensis* and various numbers of host species were recorded, e.g., five by Yin (1987); eleven by Yin et al. (1991) without a name list; two, 22 and 23 by Jiang (1989, 1991, 2001); 22 by Chen and Jin (1992); 20 by Long (1992); 37 by Liu et al. (1995); 19 by Li (1996); 38 by Dong

and Luo (1996); 31 by Wang et al. (1996) and 37 by Yang (1998). Recently, Chu et al. (2004) published the volume on Hepialidae and Epiplemididae in the Fauna Sinica, in which seven genera and 82 species or subspecies of Hepialidae in China were listed, and 14 species in six genera were believed to be hosts of *O. sinensis* but the names were not given in that list. However, in two other recent publications (Liu et al. 2005, 2006), 66 and 69 insect names were listed respectively as the hosts of the fungus. However, all these accounts, except Chu et al. (2004), provided only the number or a list of insect names without any relevant information to determine whether they are hosts of the fungus or not. Therefore, the number of insect host species of *O. sinensis* and the relationship between those insects and the fungus remain unclear. To clarify this situation, an extensive survey of the literature on the host of *O. sinensis* was carried out to gather all the insect names related to the fungus in the literature and to analyze the relationship between the insect species and the fungus. The results of this work are reported here.

Recently, a global inventory of the suborder Exoporia, comprising Mnesarchaeoidea and Hepialoidea, was presented by Nielsen et al. (2000), in which the systematic position of many taxa was checked and adjusted. Nielsen et al.'s classification system for Hepialidae is adopted in this study.

Methods

Based upon an exhaustive literature search, a total of 4793 publications related to *Cordyceps/Ophiocordyceps* and *Hepialus/Thitarodes*, in either English or Chinese, were gathered. Those publications relevant to host insects of *O. sinensis*, including reports on taxonomy, checklists, fauna, biological characteristics, ecology and geographical distribution were examined for information about these insects. All the insect names associated with *O. sinensis* were assessed based on the following criteria to determine their relationship with the fungus. Taxa which met both of the following requirements were considered as recognizable potential insect host species of *O. sinensis*: (1) The distribution areas of the insect overlapped that of *O. sinensis*, which was determined on the basis of field collections made by this research group during the years 2000–2010, examination of herbarium specimens, and another exhaustive literature analysis carried out in this laboratory (Li et al. in press). (2) The insect was reported from an altitude above 3000 m on the Tibetan Plateau. However, stem-boring insects were excluded as hosts of the fungus, even if they were hepialid and distributed above 3000 m within the distribution areas of *O. sinensis*, because the fungus infects only subterranean root-boring insects. Species of root-borers lacking altitude information were considered as indeterminate hosts of *O. sinensis* requiring further confirmation, despite the overlap of distribution areas with *O. sinensis*. Species falling in both of the following circumstances were deemed not to be host insects of *O. sinensis*: the distribution of the insect was outside that of *O. sinensis* and below an altitude of 3000 m.

Results

A total of 91 names in 13 genera of Hepialidae were found in the literature search. They are listed in alphabetical order in Table 1, together with geographic distribution, altitude, main references and the relationship with *O. sinensis* as determined by this study. Insect names used in the references, if different from that in Nielsen et al. (2000), are also given. There are 67 names in the references being combined in different genera by Nielsen et al. (2000) and a total of 71 species were originally described from China. Twenty four species described in the literature were not included in Nielsen et al. (2000).

Fifty-seven species are considered here as recognizable potential host insects of *O. sinensis*, whilst eight as indeterminate hosts and 26 as non-hosts. The recorded altitude ranges of the recognized potential host insects were found to vary from 2800 to 5100 m. The distribution areas of these species covered 26 provinces in China and more than 12 other countries. Three of the recognizable potential host names are invalid (*nomen nudum*).

Table 1. Potential insect hosts of *Ophiocordyceps sinensis*.

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Bipectilus yunnanensis</i> Chu & Wang, 1985	Yunnan Province: Lijiang County [‡]	3200	Chu and Wang 1985a, Nielsen 1988	P	
<i>Bipectilus zhejiangensis</i> Wang, 2001 [§]	Zhejiang Province: Anji County [‡] ; Fujian Province	—	Wang et al. 2001, Huang 2006, Wu 2007	N	
<i>Endoclita anhuiensis</i> (Chu & Wang, 1985)	Anhui Province: Yuexi County [‡]	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus anhuiensis</i> Chu & Wang, 1985
<i>Endoclita davidi</i> (Poujade, 1886)	Sichuan Province: Baoxing and Danba Counties; Fujian and Guangxi Provinces	3600	Chu and Wang 1985b, Yang 1998, Chu et al. 2004	P	<i>Hepialus davidi</i> Poujade, 1886; <i>Phassus giganodus</i> Chu & Wang, 1985
<i>Endoclita excrescens</i> (Butler, 1877)	Sichuan Province: Yingjing County; Anhui, Hebei, Heilongjiang, He'nan, Jilin, Liaoning, Shandong and Shanxi Provinces; Inner Mongolia Autonomous Region; Japan	—	Chu et al. 2004	N	<i>Phassus excrescens</i> (Butler, 1877) ; <i>Phassus camphorae</i> Sasaki, 1908
<i>Endoclita fujianodus</i> (Chu & Wang, 1985)	Fujian Province [‡]	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus fujianodus</i> Chu & Wang, 1985
<i>Endoclita jingdongensis</i> (Chu & Wang, 1985)	Yunnan Province: Jingdong County [‡] , Xishuangbanna Prefecture [‡]	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus jingdongensis</i> Chu & Wang, 1985

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Endoclita nodus</i> (Chu & Wang, 1985) [‡]	Anhui Province: Yuexi County [‡] ; Guangxi, Guizhou, Hainan, Hu'nan, Jiangxi and Zhejiang Provinces	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus nodus</i> Chu & Wang, 1985
<i>Endoclita signifer</i> (Walker, 1856) [‡]	Hu'nan Province	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus hunanensis</i> Chu & Wang, 1985
<i>Endoclita sinensis</i> (Moore, 1877) [‡]	Fujian, Guangdong, Guangxi, Hainan, Hebei, He'nan, Hubei, Hu'nan, Jiangxi, Shandong, Shanxi, Sichuan, Yunnan and Zhejiang Provinces; Shanghai Municipality; D.P.R. Korea; India; Japan; Sri Lanka	—	Chu et al. 2004	N	<i>Phassus sinensis</i> Moore, 1877; <i>Phassus herzi</i> Fixsen, 1887
<i>Endoclita xizangensis</i> (Chu & Wang, 1985) [‡]	Tibet Autonomous Region: Nyalam County [‡]	—	Chu and Wang 1985b, Wang et al. 1996, Chu et al. 2004	N	<i>Phassus xizangensis</i> Chu & Wang, 1985
<i>Endoclita yunnanensis</i> (Chu & Wang, 1985) [‡]	Yunnan Province: Jinghong Municipality [‡] ; Guangdong and Hainan Provinces	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus yunnanensis</i> Chu & Wang, 1985
<i>Gazoryctra ganna</i> (Hübner, [1808])	Qinghai Province: Zadoi County; Heilongjiang Province; Inner Mongolia Autonomous Region; Northern Europe; Russia	3900 [§]	Chu and Wang 1985a, Wang et al. 1996, Yang 1998, Chu et al. 2004, Karsholt and Nieukerken 2010	P	<i>Hepialus ganna</i> (Hübner, [1808])
<i>Gazoryctra macilentus</i> (Eversmann, 1851)	Hebei and Heilongjiang Provinces; Inner Mongolia Autonomous Region; Eastern Siberia; Mongolia	340–1300	Wang et al. 1996, Yang 1998, Chu et al. 2004	N	<i>Hepialus macilentus</i> Eversmann, 1851
<i>Hepialiscus jiangbeiensis</i> Chu & Wang, 2004 [§]	Chongqing Municipality [‡]	—	Chu et al. 2004	N	
<i>Hepialiscus ledongensis</i> Chu & Wang, 2004 [§]	Hainan Province: Ledong County [‡]	—	Chu et al. 2004	N	
<i>Hepialiscus nepalensis</i> (Walker, 1856)	Tibet Autonomous Region: Nyalam County; India; Nepal; Sikkim	—	Chu and Wang 1985a, Wang et al. 1996, Chu et al. 2004	I	<i>Hepialiscus flavus</i> Chu & Wang, 1985
<i>Hepialus bibelteus</i> Shen & Zhou, 1997 [§]	Yunnan Province: Deqên County [‡]	4500	Shen and Zhou 1997, Chu et al. 2004	P	
<i>Hepialus biruensis</i> Fu, 2002 [§]	Tibet Autonomous Region: Biru County [‡]	4400–4700	Fu et al. 2002, Chu et al. 2004	P	
<i>Hepialus dinggyeensis</i> Chu & Wang, 2004 [§]	Tibet Autonomous Region: Dinggyê County [‡]	—	Chu et al. 2004	I	

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Hepialus gangcaensis</i> Chu & Wang, 2004 [§]	Qinghai Province: Gangca County [‡]	3195 [¶]	Chu et al. 2004	P	
<i>Hepialus guidera</i> Yan, 2001 [§]	Qinghai Province: Guide County	3400–3600	Yan 2001a, Li et al. 2002, Li and Li 2004	P, IN	<i>Hepialus guidera</i> Yan, 2001
<i>Hepialus hainanensis</i> Chu & Wang, 2004 [§]	Hainan Province: Ledong County [‡]	—	Chu et al. 2004	N	
<i>Hepialus humuli</i> (Linnaeus, 1758)	Heilongjiang Province; Europe and Siberia	—	Chu et al. 2004, Karsholt and Nieukerken 2010	N	
<i>Hepialus lagii</i> Yan, 2001 [§]	Qinghai Province: Guide County	3400–3600	Yan 2001b; Yan 2001c, Li et al. 2002, Li and Li 2004, Zhang et al. 2009	P, IN	
<i>Hepialus latitegumenis</i> Shen & Zhou, 1997 [§]	Yunnan Province: Deqên County [‡]	4500	Shen and Zhou 1997, Chu et al. 2004	P	
<i>Hepialus maquensis</i> Chu & Wang, 2004 [§]	Gansu Province: Maqu County [‡]	3300 [¶]	Chu et al. 2004	P	
<i>Hepialus namensis</i> Chu & Wang, 2004 [§]	Tibet Autonomous Region: Damxung County [‡]	4200 [¶]	Chu et al. 2004	P	
<i>Hepialus namlinensis</i> Chu & Wang, 2004 [§]	Tibet Autonomous Region: Namling County [‡]	3704 [¶]	Chu et al. 2004	P	
<i>Hepialus pui</i> Zhang, Gu & Liu, 2007 [§]	Tibet Autonomous Region: Nyingchi County [‡]	4100–5000	Zhang et al. 2007	P	
<i>Hepialus xiaojinensis</i> Tu, Ma & Zhang 2009 [§]	Sichuan Province: Xiaojin [‡] and Jinchuan County [‡]	3500–4800	Tu et al. 2009	P	
<i>Hepialus xingazeensis</i> Chu & Wang, 2004 [§]	Tibet Autonomous Region: Xigazê Prefecture [‡]	—	Chu et al. 2004	I	
<i>Hepialus yadongensis</i> Chu & Wang, 2004 [§]	Tibet Autonomous Region: Yadong County [‡]	—	Chu et al. 2004	I	
<i>Hepialus yongshengensis</i> Chu & Wang, 2004 [§]	Yunnan Province: Yongsheng County [‡]	—	Chu et al. 2004	I	
<i>Hepialus zadoiensis</i> Chu & Wang, 2004 [§]	Qinghai Province: Zadoi County [‡]	3900 [¶]	Chu et al. 2004	P	
<i>Magnificus jiuzhiensis</i> Yan, 2000 [§]	Qinghai Province: Jigzhi County [‡]	3800–3900	Yan 2000	P	
<i>Magnificus zhiduoensis</i> Yan, 2000 [§]	Qinghai Province: Zhidoi County [‡]	4400–4600	Yan 2000	P	
<i>Napialus chenzhouensis</i> Chu & Wang, 2004 [§]	Hu'nan Province: Chenzhou City [‡] ; Shanghai Municipality	—	Chu et al. 2004, Chen and Wang 2006	N	
<i>Napialus chongqingensis</i> Wu, 1992	Chongqing Municipality [‡]	—	Wu 1992, Chu et al. 2004	N	
<i>Napialus hunanensis</i> Chu & Wang, 1985	Hu'nan Provinces: Changsha City [‡] ; Guangdong, Guangxi, Hainan, and Jiangxi Provinces	—	Chu and Wang 1985a, Wang et al. 1996, Chu et al. 2004	N	

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Napialus jiangxiensis</i> Chu & Wang, 2004 [§]	Jiangxi Province: Taihe County [‡]	—	Chu et al. 2004	N	
<i>Palpifer sexnotatus</i> (Moore, 1879)	Sichuan and Taiwan Provinces; Kashmir; India; Sri Lanka; Japan	—	Chu et al. 2004	N	
<i>Parahepialiscus borneensis</i> (Pfitzner in Pfitzner & Gaede, 1933)	Hu'nan Province; Malaysia	—	Chu et al. 2004	N	<i>Hepialiscus borneensis</i> Pfitzner, 1933
<i>Pharmacis carna</i> ([Denis & Schiffermüller], 1775)	Sichuan Province: Luhuo County; Europe	3050 [¶]	Chu et al. 2004, Karsholt and Nieukerken 2010	P	<i>Hepialus carna</i> ([Denis & Schiffermüller], 1775)
<i>Pharmacis fusconebulosa</i> (De Geer, 1778)	Sichuan Province: Kangding District; Europe; Russia	3500 [¶]	Chu et al. 2004, Yu 2004, Karsholt and Nieukerken 2010	P	<i>Hepialus fusconebulosa</i> (De Geer, 1778); <i>Hepialus gallicus</i> Lederer, 1852
<i>Pharmacis pyrenaicus</i> (Donzel, 1838)	Sichuan Province: Dègè County; Southwest Europe	3880 [¶]	Chu et al. 2004, Karsholt and Nieukerken 2010	P	<i>Hepialus alticola</i> Oberthür, 1881
<i>Sthenopsis regius</i> (Staudinger, 1896)	—	—	Yin 1987	N	<i>Phassus regius</i> (Staudinger, 1896)
<i>Sthenopsis roseus</i> (Oberthür, 1911)	Hubei Province	—	Chu and Wang 1985b, Chu et al. 2004	N	<i>Phassus miniatus</i> Chu & Wang, 1985
<i>Thitarodes albipictus</i> (Yang, 1993)	Yunnan Province: Deqên County [‡]	4500–4800	Wang et al. 1996, Yang 1993	P	<i>Hepialus albipictus</i> Yang, 1993
<i>Thitarodes altaicola</i> (Wang, 1990)	Xinjiang Uygur Autonomous Region [‡]	1300–1800	Wang 1990, Yang 1998, Chu et al. 2004	N	<i>Hepialus altaicola</i> Wang, 1990
<i>Thitarodes anomopterus</i> (Yang, 1994)	Yunnan Province: Jianchuan [‡] and Lijiang Counties [‡]	2800–3100	Yang 1994, Yang 1998	P	<i>Hepialus anomopterus</i> Yang, 1994
<i>Thitarodes armoricanus</i> (Oberthür, 1909)	Gansu, Qinghai, Sichuan and Yunnan Provinces; Tibet Autonomous Region; Xinjiang Uygur Autonomous Region	3600–5000	Chu 1965, Chen et al. 1973, Yang et al. 1987, Chu et al. 2004	P	<i>Hepialus armoricanus</i> Oberthür, 1909
<i>Thitarodes baimaensis</i> (Liang in Liang et al., 1988)	Yunnan Province: Deqên County [‡]	4500–4900	Liang et al. 1988, Yang 1998	P	<i>Hepialus baimaensis</i> Liang, 1988
<i>Thitarodes baqingensis</i> (Yang & Jiang, 1995)	Tibet Autonomous Region: Baqên County [‡]	4600–4800	Yang and Jiang 1995	P	<i>Hepialus baqingensis</i> Yang and Jiang, 1995

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Thitarodes callinivalis</i> (Liang, 1995)	Tibet Autonomous Region; Yunnan Province : Deqên County [‡]	4300–4600	Liang 1995, Yang 1998	P	<i>Hepialus callinivalis</i> Liang, 1995
<i>Thitarodes cingulatus</i> (Yang & Zhang in Yang et al., 1995)	Gansu Province: Wenxian County [‡]	3200–3800	Yang et al. 1995, Yang 1998	P	<i>Hepialus cingulatus</i> Yang & Zhang, 1995
<i>Thitarodes damxungensis</i> (Yang in Yang & Jiang, 1995)	Tibet Autonomous Region: Damxung County [‡]	4500–4680	Yang and Jiang 1995	P	<i>Hepialus damxungensis</i> Yang, 1995
<i>Thitarodes deqinensis</i> (Liang in Liang et al., 1988)	Yunnan Province: Deqên County	4200–4700	Liang et al. 1988, Yang et al. 1992b	P	<i>Hepialus deqinensis</i> Liang, 1988
<i>Thitarodes dongyuensis</i> (Liang in Yang et al., 1992)	Tibet Autonomous Region: Markam County; Yunnan Province: Deqên County	4000–4700	Yang et al. 1992b, Yang et al. 1996, Hu and Zha 2010	P, IN	<i>Hepialus dongyuensis</i> Liang in Yang et al., 1992
<i>Thitarodes ferrugineus</i> (Li, Yang & Shen, 1993)	Yunnan Province: Deqên County [‡]	4200–4700	Yang et al. 1992b, Li et al. 1993, Chu et al. 2004	P	<i>Hepialus ferrugineus</i> Li, Yang & Shen, 1993
<i>Thitarodes gonggaensis</i> (Fu & Huang in Fu et al., 1991)	Sichuan Province: Kangding County [‡]	3800–4400	Fu et al. 1991, Yang 1998, Chu et al. 2004	P	<i>Hepialus gonggaensis</i> Fu & Huang, 1991
<i>Thitarodes jialangensis</i> (Yang, 1994)	Tibet Autonomous Region: Zogang County [‡]	4000–4600	Yang 1994, Chu et al. 2004	P	<i>Hepialus jialangensis</i> Yang, 1994
<i>Thitarodes jianchuanensis</i> (Yang, 1994)	Yunnan Province: Jianchuan County [‡]	2900–3500	Yang 1994, Yang 1998	P	<i>Hepialus jianchuanensis</i> Yang, 1994
<i>Thitarodes jinshaensis</i> (Yang, 1993)	Yunnan Province: Deqên County [‡]	4600	Yang 1993, Chu et al. 2004	P	<i>Hepialus jinshaensis</i> Yang, 1993
<i>Thitarodes kangdingensis</i> (Chu & Wang, 1985)	Sichuan Province: Kangding County [‡]	3600–4500	Chu and Wang 1985a, Yang et al. 1991b, Chu et al. 2004	P	<i>Hepialus kangdingensis</i> Chu & Wang, 1985
<i>Thitarodes kangdingroides</i> (Chu & Wang, 1985)	Sichuan Province: Kangding County [‡]	4200	Chu and Wang 1985a, Yang 1998, Chu et al. 2004	P	<i>Hepialus kangdingroides</i> Chu & Wang, 1985
<i>Thitarodes lijiangensis</i> (Chu & Wang, 1985)	Yunnan Province: Lijiang County [‡]	3500–4400	Chu and Wang 1985a, Yang 1998, Chu et al. 2004	P	<i>Hepialus lijiangensis</i> Chu & Wang, 1985
<i>Thitarodes litangensis</i> (Liang, 1995)	Sichuan Province: Litang [‡] and Batang County; Tibet Autonomous Region	4300–4700	Liang 1995, Yang 1996, Yang 1998	P	<i>Hepialus litangensis</i> Liang, 1995
<i>Thitarodes luquensis</i> (Yang & Yang in Yang et al., 1995)	Gansu Province: Luqu County [‡]	4276–4300	Yang et al. 1995, Yang 1998	P	<i>Hepialus luquensis</i> Yang & Yang, 1995

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Thitarodes markamensis</i> (Yang, Li & Shen, 1992)	Tibet Autonomous Region: Markam County [‡] ; Yunnan Province: Deqên County	4500–4900	Yang et al. 1992a,b, Yang 1998	P	<i>Hepialus markamensis</i> Yang, Li & Shen, 1992
<i>Thitarodes meiliensis</i> (Liang in Liang et al., 1988)	Yunnan Province: Deqên County [‡]	3650–4700	Liang et al. 1988, Wang et al. 1996, Yang 1998	P	<i>Hepialus meiliensis</i> Liang, 1988
<i>Thitarodes menyuanicus</i> (Chu & Wang, 1985)	Gansu Province: Jishishan County; Qinghai Province: Hualong, Menyuan [‡] and Tongren Counties	—	Chu and Wang 1985a, Ma et al. 1995, Yang 1998	I	<i>Hepialus menyuanicus</i> Chu & Wang, 1985
<i>Thitarodes nebulosus</i> (Alpheraky, 1889)	Qinghai Province: Yushu Prefecture; Tibet Autonomous Region: Amdo [‡] and Damxung Counties [‡] , Nagqu Prefecture	4500	Yin 1987, Yang 1998, Chu et al. 2004	P	<i>Hepialus nebulosus</i> Alpheraky, 1889
<i>Thitarodes oblifurcus</i> (Chu & Wang, 1985)	Qinghai Province: Yushu Prefecture [‡] ; Sichuan Province: Kangding County	4000–4500	Chu and Wang, 1985a, Gao et al. 1992, Yang 1998	P	<i>Hepialus oblifurcus</i> Chu & Wang, 1985
<i>Thitarodes pratensis</i> (Yang, Li & Shen, 1992)	Yunnan Province: Deqên County [‡]	4350	Yang et al. 1992a	P	<i>Hepialus pratensis</i> Yang, Li & Shen, 1992
<i>Thitarodes renzhiensis</i> (Yang in Yang et al., 1991)	Yunnan Province: Deqên County [‡]	3880–5100	Yang et al. 1991a, Wang et al. 1996, Yang 1998	P	<i>Hepialus renzhiensis</i> Yang, 1991
<i>Thitarodes sichuanus</i> (Chu & Wang, 1985)	Sichuan Province [‡] : Aba Prefecture, Emei and Kangding Counties; Chongqing Municipality	3600–3800	Chu and Wang 1985a, Wang et al. 1996, Yang 1998, Chu et al. 2004	P	<i>Hepialus sichuanus</i> Chu & Wang, 1985
<i>Thitarodes varians</i> (Staudinger, 1896)	Sichuan Province: Batang County; Tibet Autonomous Region: Qamdo County	4500	Yin 1987, Yang 1998	P	<i>Hepialus varians</i> Staudinger, 1896
<i>Thitarodes xizangensis</i> (Chu & Wang, 1985)	Tibet Autonomous Region: Nyalam County [‡]	2200	Chu and Wang 1985a, Wang et al. 1996	N	<i>Forkalus xizangensis</i> Chu & Wang, 1985
<i>Thitarodes xunhuaensis</i> (Yang & Yang in Yang et al., 1995)	Qinghai Province: Xunhua County [‡]	3800	Yang et al. 1995, Yang 1998	P	<i>Hepialus xunhuaensis</i> Yang & Yang, 1995
<i>Thitarodes yeriensis</i> (Liang, 1995)	Yunnan Province: Deqên County [‡]	4500–4700	Liang 1995, Yang 1998	P	<i>Hepialus yeriensis</i> Liang, 1995
<i>Thitarodes yulongensis</i> (Liang, 1988)	Yunnan Province: Lijiang County [‡]	4150–4500	Liang et al. 1988, Wang et al. 1996, Yang 1998	P	<i>Hepialus yulongensis</i> Liang, 1988
<i>Thitarodes yunlongensis</i> (Chu & Wang, 1985)	Yunnan Province: Yunlong [‡] and Dali Counties; Hainan Province	3600–4200	Chu and Wang 1985a, Wang et al. 1996, Yang 1998, Chu et al. 2004	P	<i>Hepialus yunlongensis</i> Chu & Wang, 1985

Insect name	Geographic distribution	Altitude (m)	Main references	Status of host insect [†]	Different name in the main references
<i>Thitarodes yunnanensis</i> (Yang, Li & Shen, 1992)	Yunnan Province: Jianchuan [‡] , Lanping [‡] , Lijiang [‡] and Weixi Counties	3600–4100	Yang et al. 1992a,b, Wang et al. 1996, Yang 1998	P	<i>Hepialus yunnanensis</i> Yang, Li & Shen, 1992
<i>Thitarodes yushuensis</i> (Chu & Wang, 1985)	Qinghai Province: Yushu Prefecture [‡] , Batang, Chindu and Zadoi Counties; Gansu Province	4500–4900	Chu and Wang, 1985a, Yang et al. 1991b, Yang 1998, Ma et al. 1995	P	<i>Hepialus yushuensis</i> Chu & Wang, 1985
<i>Thitarodes zaliensis</i> (Yang, 1994)	Tibet Autonomous Region: Markam County [‡]	4600–4900	Yang 1994, Yang 1998	P	<i>Hepialus zaliensis</i> Yang, 1994
<i>Thitarodes zhangmoensis</i> (Chu & Wang, 1985)	Tibet Autonomous Region: Nyalam County [‡]	2200	Chu and Wang 1985a, Wang et al. 1996	N	<i>Hepialus zhangmoensis</i> Chu & Wang, 1985
<i>Thitarodes zhayuensis</i> (Chu & Wang, 1985)	Tibet Autonomous Region: Zayü [‡] and Markam Counties; Yunnan Province: Deqên and Gongshan County	4200–4400	Chu and Wang 1985a, Yang et al. 1987, Yang 1998	P	<i>Hepialus zhayuensis</i> Chu & Wang, 1985
<i>Thitarodes zhongzhiensis</i> (Liang, 1995)	Yunnan Province: Deqên County [‡]	4000–4600	Liang 1995, Wang et al. 1996	P	<i>Hepialus zhongzhiensis</i> Liang, 1995
<i>Triodia nubifer</i> (Lederer, 1853)	Sichuan Province: Kangding Prefecture; Central Asia	—	Chu et al. 2004	I	<i>Hepialus nubifer</i> Lederer, 1853
<i>Triodia sylvina</i> (Linnaeus, 1761)	Sichuan Province: Kangding County; Central Asia; Central Europe and Northern Europe	—	Chu and Wang 1985a, Chu et al. 2004, Karsholt and Nieuwerkerken 2010	I	<i>Hepialiscus sylvinus</i> (Linnaeus, 1761)

[†] The status of host insect of *O. sinensis* determined in this study: I = indeterminate host, N = non-host, IN = invalid name, P = potential host;

[‡] Type-locality;

[§] Names not included in Nielsen et al. (2000);

[‡] Stem-borers;

[¶] The lowest altitude of the reported locality in China.

Discussion

Through an extensive literature survey, all the Hepialidae species reported from China were listed and analyzed using detailed information on their geographic distribution, altitude and nomenclature. The relationships between the insect species and *O. sinensis* were clarified based on available information. The data provided here serve as a foundation for further investigations on the conservation biology of this endangered fungal species and its insect hosts.

Species in different genera of Chinese hepialids can be divided into two categories according to the feeding strategy of the larvae (Chu and Wang 1985a, b; Chu et al. 2004): stem-borers (12 taxa) and root-borers (79 taxa). The stromata of *O. sinensis* are produced directly on the dead larvae of hepialids which were tunneling under the ground (Wang 1995, Yao 2004, Sung et al. 2007), and the host larvae of the fungus feed on plant roots underground (Chen et al. 1973, Shen et al. 1983, Wang 1995, Yao 2004). Therefore, the stem-borers, including nine in *Endoclita*, one in *Palpifer* and two in *Sthenopis* (Table 1), apparently can not be hosts of *O. sinensis*. The remaining 79 taxa found in this survey were categorized as potential hosts, indeterminate hosts, or non-hosts assessed based on the criteria described in the methods. Fourteen of the 79 root-borers were ruled out as hosts of *O. sinensis*, including 1 *Bipectilus*, 1 *Gazoryctra*, 2 *Hepialiscus*, 2 *Hepialus*, 4 *Napialus*, 1 *Parahepialiscus* and 3 *Thitarodes* species (Table 1), because they have not been reported from the distribution area of *O. sinensis* and were found below the elevation of 3000 m, either far away from the Tibetan Plateau (12 species), e.g., *Bipectilus zhejiangensis* from Zhejiang Province, *Hepialus hainanensis* from Hainan Province, etc., or on the Plateau (two species), e.g., *Thitarodes xizangensis* and *T. zhangmoensis*, which were found in Zhangmu Town in Tibet Autonomous Region, where the altitude range is from 1700 to 2400 m (People's Government of Tibet Autonomous Region, 2011) and no evidence for the occurrence of *O. sinensis* has been found (Li et al. in press).

Eight species, including 1 *Hepialiscus*, 4 *Hepialus*, 1 *Thitarodes* and 2 *Triodia* species (Table 1), are considered as indeterminate hosts of *O. sinensis*. While the distribution ranges of these species are within that of *O. sinensis*, they lack an altitude record and require further confirmation before being considered as potential hosts of *O. sinensis*, e.g., *Hepialus yadongensis*, *Triodia sylvina*, etc.

Fifty-seven taxa are recognized as potential hosts of *O. sinensis*, including 1 *Bipectilus*, 1 *Endoclita*, 1 *Gazoryctra*, 12 *Hepialus*, 2 *Magnificus*, 3 *Pharmacis* and 37 *Thitarodes* species (Table 1). The distribution ranges of these insects overlap that of *O. sinensis*. Altitude information for these insects was reported in three ways in the literature: (1) The altitude range of the insect was reported unambiguously above 3000 m, e.g., *Thi-*

tarodes baimaensis, *T. meiliensis*, etc. (37 species). Among these, the lowest altitude of 3200 m was reported for *T. cingulatus* (Yang 1998). (2) The altitude range of the species was not specified, but the types were collected at an elevation above 3000 m, e.g., *T. baqingensis*, *Magnificus jiuzhiensis*, etc. (11 species). The lowest altitude of the type locality is at 3200 m for *B. yunnanensis* (Chu and Wang 1985a). (3) There is no data reported on the altitude range for the species or the type specimen, but the altitude of the recorded localities of the moth were above 3000 m, e.g., *Hepialus gangcaensis*, *Pharmacis carna*, etc. (nine species). The lowest altitude for the locality of this group is 3050 m for *P. carna* (Chu et al. 2004) in Luhuo County, Sichuan Province, where the occurrence *O. sinensis* was confirmed (Li et al. in press).

Three names of the recognizable potential host insects are invalid (*nomen nudum*) because no full description of the species was published in the literature, although the names appeared several times in various publications (Table 1). Among them, *Thitarodes dongyuensis* was described by Yang (1992) as '*Hepialus dongyuensis*' and deemed as a *nomen nudum* in Nielsen et al. (2000), while *Hepialus guidera* and *H. lagii* were described by Yan (2001a, b) and recognized as *nomen nudum* in the present study. Further study is required to describe these species in full.

Species of *Hepialus* and *Phassus* described from China after 1984 have been transferred to *Thitarodes* and *Endoclita* respectively by Nielsen et al. (2000). Most of these species were described on the male genitalia and occasionally venation of one or very few individuals but not all morphological characteristics of the adult (Nielsen et al. 2000). However, the structure of the valve on male genitalia was still employed recently as the sole basis for classification in the revision of Chinese *Hepialus* by Zou et al. (2010). Further, disparate and incongruent regional taxonomies were regarded as developing rapidly for the Chinese Hepialidae (Nielsen et al. 2000), but the situation has not been changed much. As seen in this study, 24 names listed in Table 1 were not included in Nielsen et al. (2000). Two of them were described pre-2000 and apparently missed by Nielsen and his colleagues, while the remaining 22 were newly described after the year 2000 (Table 1). It seems that further study, especially robust phylogenetic hypotheses from molecular data, of these taxa is required to clarify their taxonomic status and generic placement.

Natural production of *O. sinensis* has been declining significantly over the last few decades while the market demands on the fungus have increased sharply in recent years. Clarification of the host insects of *O. sinensis* will provide basic information for management of the insect resources and for the conservation and sustainable use of the fungus. This work has gathered the available information on the host insects of *O. sinensis* and will lay a foundation for further studies of the relationship between the fungus and its hosts, especially their co-evolution (an ongoing research project based on DNA sequence analyses in this laboratory), and also for the cultivation of this valuable fungus for massive production.

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Callosphcodes, a little-known bee (Hymenoptera, Halictidae, *Sphecodes*)

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Abstract

Callosphcodes Friese, 1909, a synonym or perhaps subgenus of *Sphecodes* Latreille, 1804, is known on the basis of one female of *Sphecodes ralunensis* (Friese, 1909) from New Britain and one female and one male of a similar species, *Sphecodes manskii* (Rayment, 1935) from northeastern Australia. The male is here described for the first time and the females of the two species are compared for the first time. In spite of considerable collecting, only these three specimens have appeared in over a century. Descriptions and illustrations are provided.

Keywords

Apoidea, Anthophila, Halictinae, Halictini, Sphecodina, *Sphecodes*, New Britain, Bismarck Archipelago, Australia, taxonomy, cleptoparasite

Introduction

Even in parts of the world where there has been little investigation of the bee fauna, taxa of bees so distinctive as to have received genus-group names a century or more ago have usually been collected several times so that multiple specimens are now known. *Callosphcodes* Friese, 1909, however, until now has been known from only two female specimens of different species from localities over 1500 km apart. A third specimen, a male, is herein reported for the first time. To judge by the lack of pollen manipulating

and carrying structures in females, this is a cleptoparasitic group. Many cleptoparasites are uncommon, and it seems possible that *Callosphécodes* is a rare insect, not only in collections but also in the field.

We follow various earlier authors in considering *Callosphécodes* to be a synonym or possibly a subgenus of *Sphecodes* Latreille, 1804, which is the most common and widespread genus of cleptoparasitic Halictinae. This cleptoparasitic group was given subtribal status as the Sphecodina in the tribe Halictini (subfamily Halictinae) in the phylogenetic study by Pesenko (2000). Nonetheless, the two species that have been placed in *Callosphécodes* have a distinctive appearance different from that of the many other species of *Sphecodes*. Such other species are 4 to 15 mm in length, usually black with a partly or wholly red metasoma, but males in particular may be entirely black. A female at a host cell destroys the egg of the host and replaces it with her own. Further information on *Sphecodes* biology can be found in works by Ordway (1964), Eickwort and Eickwort (1972), Torchio (1975), Sick et al. (1994), and summarized by Michener (2000, 2007).

History

Callosphécodes was proposed as a subgenus of *Sphecodes* by Friese (1909) but in the same paper, in describing the included species, *Callosphécodes* was treated as a genus. The only species included at that time was *Callosphécodes ralunensis* Friese (1909), based on a single female presumably from Ralum, New Britain, in the Bismarck Archipelago (04°21'S, 152°17'E). By error, Friese (1925) indicated that *Callosphécodes* had been described from Australia in 1912. It was separated from typical *Sphecodes* by its large size (but it is much smaller than the larger typical *Sphecodes*) and by the metallic blue black metasoma. Meyer (1920) repeated Friese's description and because of the metallic coloration, suggested that *Callosphécodes* was close to the neotropical genus *Temnosoma* Smith (1853). The latter, however, is a very different cleptoparasite of the halictid tribe Augochlorini.

Subsequent views on the position of *Callosphécodes* have varied from a distinct genus (Friese 1925) to synonymy with *Sphecodes* (Michener 1944, 1978, 2000, 2007) or a subgenus of *Sphecodes* (Michener, 1965). These viewpoints were not based on additional information about the type species, for the type and only known specimen of *S. ralunensis* was not reexamined. After inquiring about the specimen from personnel of the Magyar Természettudományi Múzeum, Budapest, and the Museum für Naturkunde der Humboldt-Universität, Berlin, Michener (2000, 2007) concluded that the specimen was probably lost. It has been found, however, in good condition in the Berlin museum and was borrowed for study by C.R.; all the labels were illustrated by Rasmussen and Ascher (2008, fig. 8).

A second specimen of *Callosphécodes* was described as *Mellitidia manskii* (Rayment 1935) on the basis of a single female collected in 1934 by Martin J. Manskii at Cairns (16°55'S, 145°46'E) in northern Queensland, Australia. It is not clear why it

was placed by Rayment in a nomiine genus whose females, unlike cleptoparasites, have a strong scopa. Placement of this species in the genus *Sphecodes* was by Michener (1965), who saw the type, but association with *Callosphécodes* was not certain since the type of *S. ralunensis* was not then available. The holotype of *S. manskii* is in the Australian National Insect Collection, Canberra, and has been borrowed by C.R. for direct comparison with that of *S. ralunensis*. They are very similar, certainly both constituting the *Callosphécodes* group. Michener (1978) and Cardale (1993) included *S. manskii* not merely in *Sphecodes* but in the subgenus *Sphecodes s.str.*

Also, in the Australian National Insect Collection, was found a male, judged on the basis of similarity to the female and on geography, to be *S. manskii*. It was collected in 1980 by Josephine C. Cardale in Mount Webb National Park (15.045S, 145.07E), Queensland, Australia, about 100 km from Cairns, the type locality for *S. manskii*.

When reviewing the cleptoparasitic groups of Halictidae, Michener (1978) differentiated the genera such as *Eupetersia* Blüthgen, 1928, from *Sphecodes*; see also Michener (2000, 2007). It is apparent that *Callosphécodes*, contrary to earlier suggestions (Michener, 1978), is not the same as any such genera but, as we have indicated above, does not differ appreciably from ordinary *Sphecodes*. The principle difference mentioned in the literature between such *Sphecodes* and *Callosphécodes* is the metallic blue, greenish or purplish black metasoma of the latter, independently mentioned by both Friese and Rayment in describing the two species. Yet, at least at present, the metallic tints of the specimens are extremely feeble, scarcely detectable, the metasoma being essentially black.

Description

The following descriptive comments, largely following the pattern of Michener's (1978) account of *Sphecodes*, are based on the three known specimens of the *Callosphécodes* group, that is *Sphecodes ralunensis* and *manskii* (Figs 1, 6 and 13). The description of *Sphecodes* by Michener (1978) indicates the variation in many characters among the species of the genus. Notes below on the genus *Eupetersia* are inserted to counter the suggestion mentioned in Michener (2000, 2007) that *Callosphécodes* might be a senior synonym of *Eupetersia*.

Both sexes: Black, metasomal terga with feeble bluish, purplish, or blue green metallic tints (Figs 2 and 7); wings strongly infuscated (fig. 12). Punctuation of head and thorax coarse (fig. 4; moderately fine in *Eupetersia*); punctures of mesoscutum, especially posteriorly, widely separated (by much more than puncture diameter) by shining surface (fig. 5). Head in facial view much wider than long, clypeus more than twice as wide as long (Figs 3 and 10). Eyes hairless. Hairs of antennal flagellum all very short. Preoccipital carina strong and distinct. Posterior end of hypostomal carina with tooth (fig. 11). Pronotum with horizontal surface of collar almost absent medially, forming lateral angle below which a vertical ridge extends downward; vertical ridge approaching or merging with a more laterally directed ridge that extends toward coxal base; another carina from lateral angle extends across posterior lobe of pronotum. Anterior



Figure 1–5. Holotype female of *Sphecodes ralunensis*: **1** lateral habitus **2** metasoma **3** facial aspect **4** dor-solateral aspect of head and pronotum **5** dorsal aspect of mesosoma and head.

extremity of mesoscutum convex. Scutellum gently biconvex because of feeble longitudinal median depression. Propodeum with dorsal area strongly areolate, about as long as scutellum, area broadly rounded posteriorly (fig. 9); posterior and lateral surfaces of propodeum with few short plumose hairs in addition to longer hairs. Wings with hairs rather long and dense throughout (as in *Eupetersia*); stigma moderate; marginal cell pointed at apex; free part of marginal cell beyond submarginal cells longer than part subtended by submarginal cells, which part extends well beyond apex of stigma. Second and third submarginal cells each receiving a recurrent vein (fig. 12). First metasomal tergum broader than long. Second tergum in lateral view with base somewhat



Figure 6–12. Holotype female of *Sphecodes manskii*: **6** lateral habitus **7** metasoma **8** dorsal habitus **9** mesosoma including propodeum **10** facial aspect **11** hypostomal carina with tooth at posterior end **12** forewing pattern.



Figure 13–14. Male of *Sphecodes manskii*: **13** dorsal habitus; **14** dorsolateral aspect of head and pronotum.

depressed forming weak constriction between first and second terga. Posterior margins of terga 2 – 4 broadly depressed, hairless, impunctate.

Female: Mandible with large subapical tooth (fig. 10; unlike *Eupetersia*). Labrum with broad, flat apical process about two thirds as broad as long. Legs robust, hind femur about three times as long as broad; basitibial plate elevated; long hairs on outer side of hind tibia plumose; hind tibial spine finely serrate. Fifth metasomal tergum, unlike preceding terga, with apical margin fringed except middle part of margin which has smooth, hairless area in front of fringeless part of margin. Pygidial plate broader than in *Eupetersia*.

Male: Antennae longer than those of female, flagellum thickened (fig. 13; unlike *Eupetersia*), somewhat crenulate, first flagellar segment broader than long, second longer than first, both first and second shorter than subsequent segments but not very short as in *Eupetersia*. Labrum not visible on specimen. Second hind tarsal segment longer than third, base broader than base of third. Gonocoxite finely striate, without margined depression as in *Eupetersia*. Gonocoxite with basal setose lobe (Figs 15 and 16).

Specific differences: The holotypes (both females) are very similar and we have no way of knowing whether the differences between them are specific differences or indicate variation within a species. The differences (observed by CR) are as follows: Lateral margin of propodeum (immediately below metanotum) in *S. ralunensis* largely areolate, in *S. manskii* widely strigulate and less areolate. Gena of *S. ralunensis* sparsely covered with plumose, light colored setae, in *S. manskii* densely covered with white setae. Flagellum in *S. ralunensis* ferruginous (fig. 3), in *S. manskii* dark brown (fig. 10). Measurements are as follows for the *S. ralunensis* holotype female: Total body length about 10 mm; forewing length (including tegula) 8.8 mm; head width 3.1 mm; head length (anterior margin of clypeus to summit of vertex) 2.5 mm; mesoscutum width 2.1; mesoscutum length 2.0 mm. The *S. manskii* holotype female: Total body length about 12 mm; forewing length (including tegula) 9.5 mm; head width 3.2 mm; head length (anterior margin of clypeus to summit of vertex) 2.5 mm; mesoscutum width 2.3; mesoscutum length 2.0 mm.

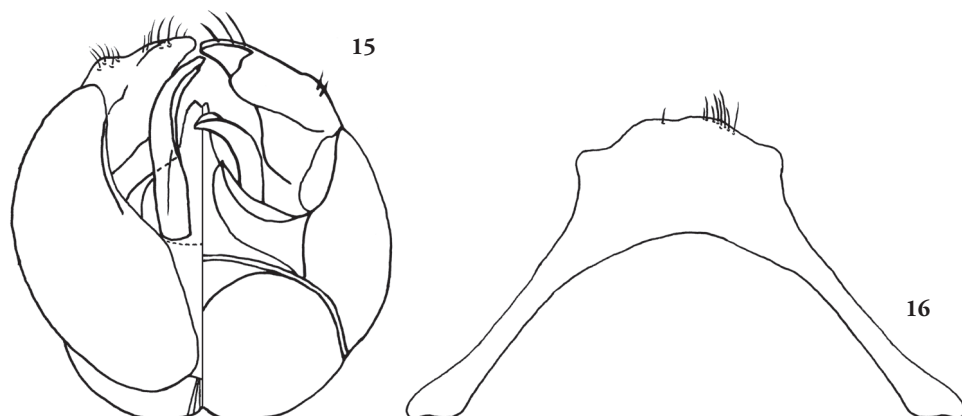


Figure 15–16. Male genitalia of *Sphecodes manskii*: **15** Dorsalventral view of genitalia; **16** 7th metasomal sternum.

Male *S. manskii*: Total body length about 11 mm; forewing length (including tegula) 8.1 mm; head width 2.9 mm; head length (anterior margin of clypeus to summit of vertex) 2.5 mm; mesoscutum width 2.3; mesoscutum length 2.2 mm.

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