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Revision of the genus *Schoenlandella* (Hymenoptera, Braconidae, Cardiochilinae) in the New World, with a potential biological control agent for a lepidopteran pest of bitter gourd (*Momordica charantia* L.)

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Abstract

Schoenlandella Cameron, 1905 is the second largest genus of Cardiochilinae. Most members are recorded from the Old World, with a small number of species in the New World. Herein, the New World species of *Schoenlandella* are revised based on morphological data. This work entails a description of a new species: *S. montserratensis* Kang, **sp. nov.** and potential lepidopteran host information of the new species associated with bitter gourds on the Caribbean Island of Montserrat. *Schoenlandella diaphaniae* (Marsh, 1986) and *S. gloriosa* Mercado & Wharton, 2003 are re-described, and a key to species of New World *Schoenlandella* is provided. The taxonomic status of *Schoenlandella* is discussed.

Keywords

Caribbean Islands, Crambidae, melonworm moth, Neotropical region, parasitoid wasp

Introduction

Schoenlandella Cameron, 1905 is the second largest genus of the subfamily Cardiochilinae (Yu et al. 2016). All the members of the genus, which host data are available, are solitary endoparasitoids of exposed-feeding lepidopteran larvae such as

Chrysodeixis includens (Walker, 1858) (Soybean looper; Noctuidae) and *Chloridea virescens* (Fabricius, 1777) (Tobacco budworm; Noctuidae). Fifty-four species have been included in the genus worldwide, and most members are recorded from the Old World, especially from the Afrotropical and Australian regions (Dangerfield et al. 1999; Mercado and Wharton 2003; Yu et al. 2016). Three species have been recorded from the New World: *S. diaphaniae* (Marsh, 1986), *S. gloriosa* Mercado & Wharton, 2003, and *S. longimala* (Mao, 1945).

Herein, the New World species of *Schoenlandella* are revised. This includes a new species description, potential host information of *S. montserratensis* Kang sp. nov., and a key to species of New World *Schoenlandella*. Previously described species of New World *Schoenlandella* are re-described.

Material and methods

Specimen information

During 2019, braconid wasps collected from a bitter gourd field in Montserrat by Dr Chris Malumphy's team (Fera Science Ltd.) were shipped to the first author (IK). Two specimens were identified as a new species of *Schoenlandella* based on morphological data, and potential lepidopteran hosts were identified.

Specimens were borrowed from the following institutions:

- Fera Sciences Ltd (London, UK);
- Hungarian Natural History Museum (**HNHM**: Budapest, Hungary);
- Illinois Natural History Survey (**INHS**: Champaign, Illinois, USA);
- Museo de Insectos, University of Costa Rica (**MICR**: San José, Costa Rica);
- Texas A&M University Insect Collection (**TAMU**: College Station, Texas, USA).

The holotype and sole paratype of *S. montserratensis* Kang sp. nov. will be deposited in the Natural History Museum in London (**NHML**: London, UK).

Morphological analysis

A Leica MZ75 stereomicroscope was used to examine specimens. Morphological terminology used in this review are mostly based on Dangerfield et al. (1999) and Sharkey and Wharton (1997), supplemented by terms on the Hymenoptera Anatomy Consortium website (http://portal.hymao.org/projects/32/public/ontology/, accessed in September 2020). Terms for surface sculpture follow Harris (1979). The following acronyms are used for morphological terms: T1: first metasomal tergite; T2: second metasomal tergite; T3: third metasomal tergite; T4: forth metasomal tergite; T6: sixth metasomal tergite. Color images were taken with a Visionary Digital BK Plus imaging system (Dun, Inc.) equipped with a Canon EOS

5DS DSLR camera. Multiple images were stacked using Zerene Stacker v.1.04 (Zerene Systems LLC.) and edited in Adobe Photoshop CS 6 and Photoshop CC (Adobe Systems, Inc). Body parts were measured also via Adobe Photoshop CS 6 and Photoshop CC. Each number in parentheses in species descriptions indicate 0.01× the actual size of each body part. The unit of length is mm. For example, 12 and 123 in parentheses (12:123) indicate 0.12 mm and 1.23 mm, respectively. The distribution map of the new species was generated using QGIS 3.10.0 (QGIS Development Team 2019). The Google terrain map was downloaded using QuickMapServices plugin.

Results

Taxonomy

Schoenlandella Cameron, 1905

Schoenlandella Cameron, 1905 (Cameron 1905a). Type Species: *Schoenlandella nigromaculata* Cameron, 1905 (Cameron 1905a) by subsequent designation by Viereck, 1914 (synonymized with *Cardiochiles* Nees, 1819 by Szépligeti, 1911). Removed from synonymy by Whitfield & Dangerfield, 1997.

Ernestiella Cameron, 1905 (Cameron 1905b) synonymized with *Schoenlandella* Viereck, 1914. Type species: *Ernestiella nigromaculata* Cameron 1905 (Cameron 1905b).

Diagnosis (based on Dangerfield et al. (1999) with additions and modifications). Diagnostic characters of *Schoenlandella* were described in Dangerfield et al. (1999), based mostly on Old World species. The following are diagnostic features based on both Old World and New World members.

Members of *Schoenlandella* can be distinguished from species of other cardiochiline genera by the following characters: ***Head*:** possessing 32–44-segmented antenna; densely setose eye (Figs 2C, 4C); two clypeal tubercles with sharp or smooth apical margin (Fig. 1C); short to elongate malar space; bidentate mandible; six-segmented maxillary palpus; four-segmented labial palpus; absence of occipital carina; elongate galea, at least as long as malar space in lateral view (Note: narrower than galeae of members of *Cardiochiles* Nees, 1819) (Figs 1A, 2A, 4A); glossa elongate and deeply bilobed if entirely spread (Fig. 4A). ***Mesosoma*:** notaulus finely crenulate; scutellar sulcus crenulate; posterior scutellum without cup-like pit; pronotum mostly smooth; mesopleuron mostly smooth; epicnemial carina absent; metapleuron rugulose; mesosternal sulcus crenulate; propodeum rugulose; propodeum with completely developed areola. ***Wings*:** stigma of forewing moderate to broad; (RS+M)a of forewing present; 1r of forewing absent; spectral 3r of forewing reaching at basal fifth to half, if absent, examine characters of mouthparts and hypopygium; RS vein of forewing angled or curved (Fig. 4F); 1a of forewing absent

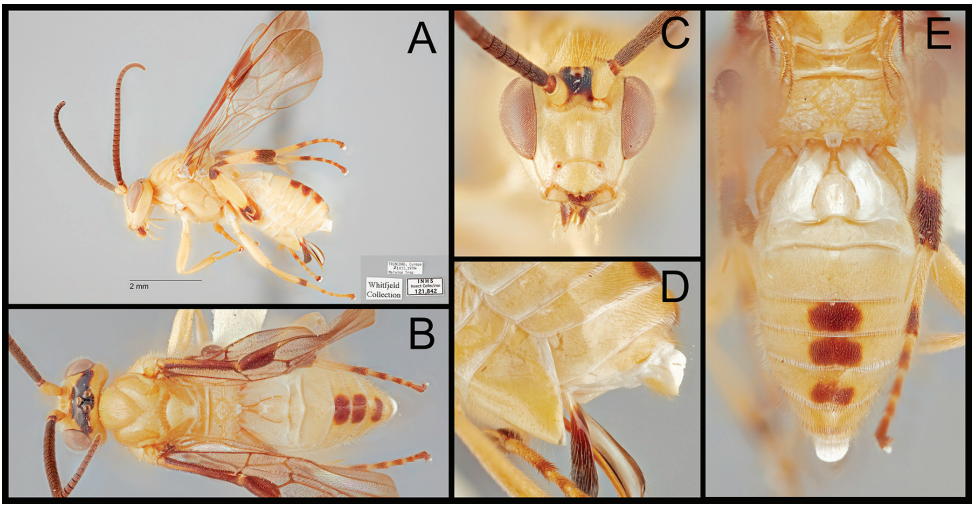


Figure 1. *Schoenlandella diaphaniae*, non-type **A** lateral habitus **B** dorsal habitus **C** anterior head **D** ventro-lateral metasoma **E** dorsal propodeum and mesonotum.

(Note: if present, the vein is nebulous); 2–1A of hind wing usually absent. ***Legs*:** tarsal claw pectinate with sharp or obtuse apical tooth; hind basitarsus cylindrical (Fig. 1A) or slightly expanded (Fig. 4A) (Note: not nearly as expanded as in *Hartemita* Cameron, 1910); ***Metasoma*:** lateral suture of T1 absent posteriorly; T2 and T3 entirely smooth; hypopygium apically acute in lateral view (Fig. 1D); hypopygium uniformly sclerotized (Fig. 1D); median longitudinal fold of hypopygium absent (Fig. 1D) (Note: if present, the fold is entirely sclerotized or only slightly desclerotized (Figs 2D, 4D)); ovipositor slightly downcurved (Figs 1A, 2D); ovipositor sheath < ~0.6 × length of hind tibia.

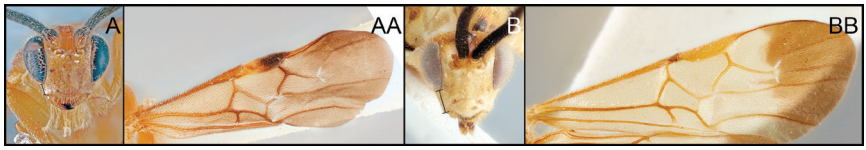
Key to species of the genus *Schoenlandella* of the Neotropical region

1 **A.** Body mostly melanic..... ***S. longimala* (Mao, 1945)** Note: Based on images of the holotype on the NMNH website (https://collections.nmnh.si.edu/search/ento/?ark=ark:/65665/3a9805bdd51964c16838984ab0e197ed9, accessed September 2021)

– **B.** Body mostly orange or yellow pale **2**

2 **A.** Malar space < ~0.33 × longer than eye height in anterior view, **AA.** forewing entirely infuscate ..... ***S. montserratensis* Kang, sp. nov.**

– **B.** Malar space about ~0.50 × longer than eye height in anterior view, **BB.** forewing apically infuscate **3**



3 **A.** Forewing basally hyaline, and stigma entirely melanic, **AA.** apex of clypeal tubercle sharply angled ..... ***S. diaphaniae*** **(Marsh, 1986)**

– **B.** Forewing basally pale yellow, and stigma entirely pale, **BB.** apex of clypeal tubercle relatively smooth ..... ***S. gloriosa*** **Mercado & Wharton, 2003**

Schoenlandella diaphaniae **(Marsh, 1986)**
Fig. 1A–E

Cardiochiles diaphaniae Marsh, 1986 (Marsh 1986)
Schoenlandella diaphaniae (Marsh, 1986) (Dangerfield et al. 1999)

Material examined. ***Non-type specimen*****:** Trinidad and Tobago • 1♀; Curepe, Trinidad and Tobago; 21 Jul. 1978. Malaise Trap. Deposited in INHS.

Diagnosis. Members of *S. diaphaniae* are distinguished from members of *S. gloriosa* by having shorter lower face and malar space (Fig. 1C); basally hyaline forewing (Fig. 1A); stigma entirely melanic (Fig. 1A).

Description. Marsh (1986) described color of the species and some morphological characters in his species description. Here, the species is re-described based on a specimen collected in Trinidad and Tobago.

Body length 4.5–5.8 mm (Marsh 1986). Antenna length: ~4.2 mm. Forewing length: ~5.5 mm. ***Head*****:** Antenna 34-segmented. Eye length ~0.45 × longer than its height (40:89). Dorsal width of lower face as long as its height (81:81); Malar space ~0.40 × longer than height of eye in anterior view (32:80), ~2.13 × longer than basal width of mandible (32:15) (Fig. 1C). Clypeus ~1.53 × longer than its width (49:32); clypeal tubercles with sharp margins (Fig. 1C). Galea as long as malar length in lateral view (32:32), with curved apical margin (Fig. 1A). ***Mesosoma*****:** Scutellar sulcus with five to six crenulae. Postscutellar depression present. Propodeum rugulose; median areola of propodeum diamond-shaped, median length as long as its width; propodeum with median transverse carina reaching lateral margin. Pronotum mostly smooth with incomplete posteroventral carina reaching posterior margin. Mesopleuron mostly smooth and polished; precoxal sulcus medially present with five crenulae. Metapleuron rugulose. Mesosternal sulcus crenulate. ***Legs*****:** Basal spur on mid tibia ~0.83 × mid-basitarsus (49:59). Hind femur medially ~0.33 × broader than its length (45:137). Basal spur on hind tibia ~0.66 × longer than hind basitarsus (60:90). Hind basitarsus cylindrical. Hind tarsal claw pectinate with five teeth; apical tooth basally rounded and apically angled; basal four teeth sharp. ***Wings*****:** Forewing second submarginal cell its maximum width ~2.87 × longer than its maximum length (89:31); 3r absent; Rs broken basally and angled at a basal sixth; stigma about ~3.44 × longer than width medially (93:27).

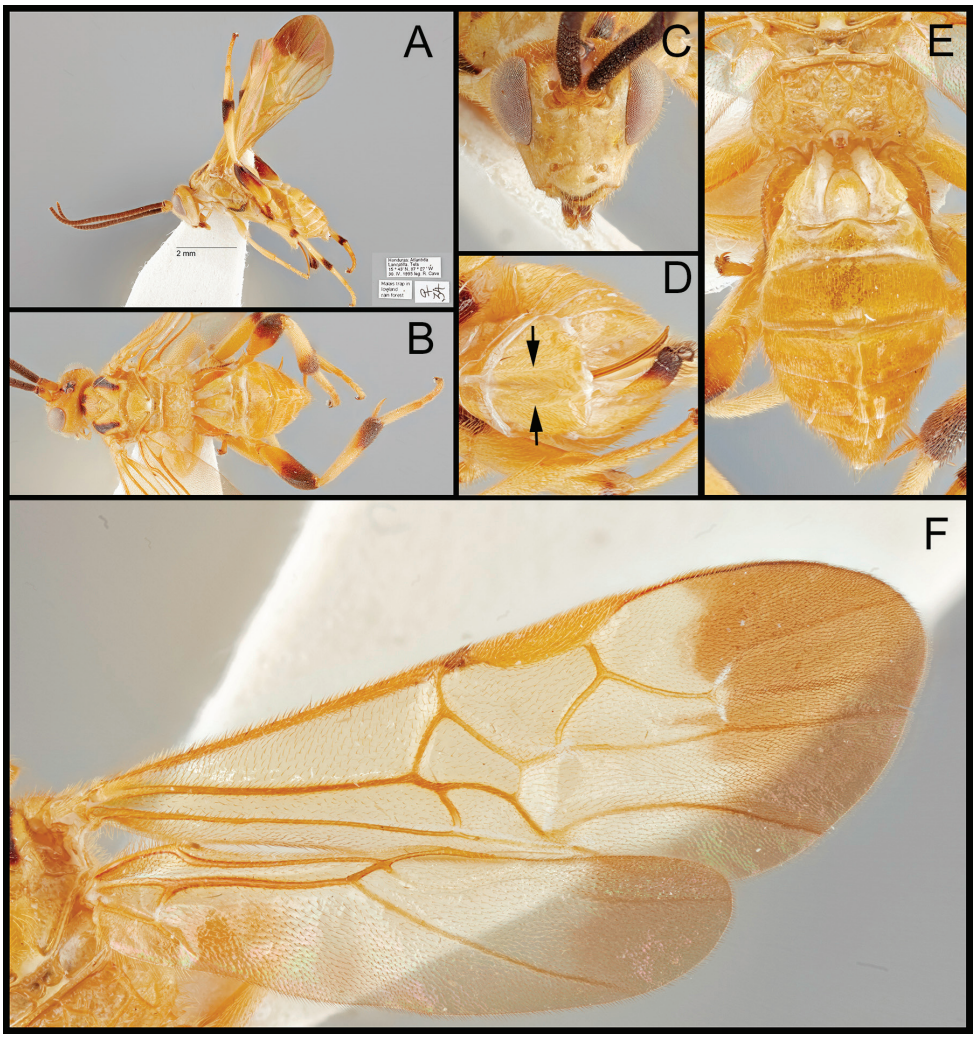


Figure 2. *Schoenlandella gloriosa*, non-type Honduras **A** lateral habitus **B** dorsal habitus **C** anterior head **D** ventral metasoma; arrow: median invagination on hypopygium **E** dorsal propodeum and mesonotum **F** wings.

Hind wing 2–1A present at basal third (Fig. 1A). ***Metasoma*:** Medial length of T1 ~2.59 × longer than medial length of T2 (75:29). Medial length of T2 ~0.22 × longer than its apical width (29:129). T3 about ~1.66 × longer than T2 medially (48:29). Hypopygium entirely sclerotized, medially with shallow area, without median longitudinal fold (Fig. 1D). Ovipositor moderately downcurved. Protruded ovipositor sheath moderately downcurved, ~0.57 × longer than hind tibia (101:176), slightly broadened apically, anterior 2/5 depilous and posterior 3/5 pilose apically with long setae.

Color. Body mostly bright yellow; the following areas melanic: flagellomeres, pedicel mostly, outer scape; ocellary field and frons dorsally, labrum, apical mandible, galea mostly, mid tibia apically, hind coxa apically, hind trochanter and trochantellus, hind

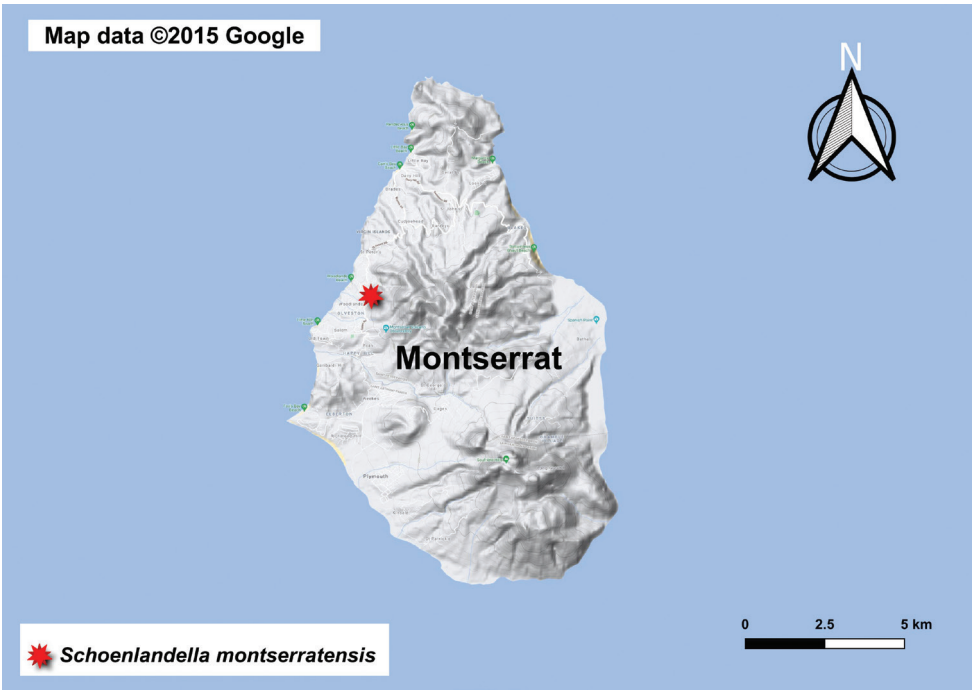


Figure 3. Distribution map of *S. montserratensis* sp. nov. in Montserrat.

femur basally and apically, hind tibia apically, hind tarsomeres apically, entire ovipositor sheath. T4–T6 medially (Fig. 1E). Wings basally hyaline and apically infuscate, C+SC+R vein in forewing mostly melanic, stigma mostly melanic.

Male. See Marsh (1986).

Hosts. *Diaphania nitidalis* (Stall) and *D. hyalinata* (L.) (Marsh 1986).

Distribution. Colombia, Venezuela, and Trinidad and Tobago.

Schoenlandella gloriosa Mercado & Wharton, 2003

Fig. 2A–F

Material examined. ***Paratypes*:** Mexico • 1♀; 3 mi E Papantla, Veracruz, Mexico; 7 Jun. 1965; leg. Burke, Meyer, Schaffner • 1♀; 2 mi SE Tecpan de Galeana, Guerrero, Mexico; 14 Jul. 1966; leg. P.M and P.K Wagner • 2♂; Hotel Covandonga, 12 km S Valles, Ruta 85, San Luis Potosi, Mexico; 27–29 Jun. 1981; leg. C. Porter, L. Stange. Deposited in TAMU. ***Non-type material*:** Costa Rica • 1♀; 10 km NW Cañas, Mojica, Guanacaste, Costa Rica; 26 Sep.–10 Oct. 2011; leg. P. Hanson. Deposited in MICR. Honduras • 1♀; Tela, Lancetilla, Atlántida, Honduras; 15°43'N, 87°27'W; 30 Apr. 1995; leg. R. Cave. 1♀; same as previous except for the collecting date, 15 May. 1995. 1♂; same as previous except the collecting date, 31 Aug. 1995. Deposited in HNHM.

Diagnosis. Members of the *S. gloriosa* are nearly identical to *S. diaphaniae*. The following combination of characters differentiate *S. gloriosa* from *S. diaphaniae*: face

concave; malar space relatively elongate (~0.50 × longer than height of eye in anterior view) (Fig. 2C); two clypeal tubercles with smooth margins (Fig. 2C); forewing basally yellow and apically infuscate; stigma entirely pale; forewing with junction of angled Rs not swollen (Fig. 2F).

Description. Modified from Mercado and Wharton (2003), including additional characters.

Body 5.5–8.0 mm. ***Head*****:** Antenna 32–34-segmented. Eye length ~0.41 × longer than its height (35:85) in lateral view. Dorsal width of lower face ~1.05 × longer than height of lower face (79:75). Clypeus 1.20–1.53 × longer than its width, two clypeal tubercles with smooth margin (Fig. 2C). Malar space 0.47–0.50 × longer than height of eye in anterior view (35:75–40:80), 2.75–3.42 × longer than basal width of mandible (33:12–41:12). Galea 1.30–1.40 × longer than malar length as viewed laterally (43:33–56:40) (Fig. 2A). ***Mesosoma*****:** Scutellar sulcus with 5–7 crenulae. Propodeum with median transverse carina reaching lateral margin. Pronotum weakly carinate medially. Mesopleuron mostly smooth; precoxal sulcus smooth, not reaching posterior margin. ***Legs*****:** Basal spur on mid tibia 0.83–0.90 × mid-basitarsus length. Hind femur medially 0.31–0.32 × broader than its length (52:164–48:155). ***Wings*****:** Forewing: maximum width of second submarginal cell ~2.26× longer than maximum length (113:50); 3r absent; Rs vein angled at basal fourth (Fig. 2F). Hind wing 2–1A present as basal stump (Fig. 2F). ***Metasoma*****:** Medial length of T1 2.00–2.47 × longer than medial length of T2 (78:39–75:30). Medial length of T2 0.21–0.26 × longer than its apical width (30:140–39:149). T3 about 1.46–1.60 × longer than T2 medially (57:39–48:30). Hypopygium evenly sclerotized, median longitudinal fold absent (Note: A weakly depressed medial longitudinal area is present in females collected in Honduras, but never membranous and folded) (Fig. 2D). Ovipositor moderately downcurved. Protruded ovipositor sheaths moderately downcurved, 0.45–0.50 × longer than hind tibia, broadened apically, anteriorly depilous and moderately pilose apically with long setae.

Color. See Mercado and Wharton (2003). Melanic areas of the Costa Rican specimen (female) and Mexican specimens are slightly darker than specimens collected in Honduras.

Male. See Mercado and Wharton (2003).

Host. Unknown.

Distribution. Costa Rica, Honduras, and Mexico.

Schoenlandella longimala (Mao, 1945)

Cardiochiles longimala Mao, 1945 (Mao 1945)
Schoenlandella longimala (Mao, 1945) (Dangerfield et al. 1999)

Type material. ***Holotype*****:** Mexico • ♂, Guadalajara, Mexico; 2 Aug. 1914; Deposited in NMNH.

Diagnosis (based on images of the holotype on the NMNH website). Body mostly black except for legs. Malar space shorter than basal width of mandible. Mouthparts moderately elongated. Scutellar sulcus with six crenulae. Lateral side of scutellum mostly rugulose. Pronotum medially rugose, with median areola anteriorly angled. Forewing entirely infuscate; stigma entirely melanic; 3r vein absent; 1a present as a nebulous vein.

Description. See Mao (1945).

Host. Unknown.

Distribution. Mexico.

***Schoenlandella montserratensis* Kang, sp. nov.**

http://zoobank.org/D22783D0-15B6-422E-9989-34760DA85579

Fig. 4A–F

Material examined. *Holotype*: Montserrat • ♀; 16°45'34.19"N, 62°13'1.58"W; leg. Elvis Gerald (Ref. CM-Mt-2019–41) woodlands, private farm. Single adult on *Momordica charantia* L. (bitter melon), hand caught in a plastic pot. ***Paratype*** same data as for holotype.

Diagnosis. Members of *Schoenlandella montserratensis* sp. nov. are distinguished from other New World *Schoenlandella* species by having shorter malar space (Fig. 4C); longer mouthparts (Fig. 4C); stigma basally pale and apically melanic (Fig. 4F); 3r vein of forewing present at basal half (Fig. 4F).

Description. Body 4.21–4.40 mm. Forewing length: ~4.45 mm (holotype). Antenna length: ~3.25 mm (paratype). ***Head*:** Antenna 34-segmented (paratype). Eye length ~0.52 × longer than its height (31:60). Malar space slightly shorter than basal width of mandible. Clypeus ~2.08 × longer than its width (50:23); two clypeal tubercles with smooth margins. Galea ~2.12 × longer than malar space in lateral view (36:17), apically narrowed. ***Mesosoma*:** Scutellar sulcus with five crenulae. Propodeal median transverse carina reaching lateral margin. Pronotum medially crenulate, ventrally costate. Mesopleuron mostly smooth; precoxal sulcus strongly crenulate with ~10 crenulae, not reaching posterior margin. ***Legs*:** Basal spur on mid tibia ~0.88 × mid-basitarsus (30:34). Basal spur on hind tibia ~0.68 × longer than hind basitarsus (36:53). Hind basitarsus laterally broaden. Tarsal claw pectinate with five teeth; apical tooth obtuse, other remaining teeth sharp. ***Wings*:** Forewing second submarginal cell width ~2.79 × longer than height (78:28); 3r apparently present at basal half and slightly curved; Rs angled at basal two-fifths; stigma about ~3.36 × longer than wide medially (74:22); 1a absent (Fig. 4F). Hind wing 2–1A absent (Fig. 4F). ***Metasoma*:** Medial length of T1 ~2.68 × longer than medial length of T2 (59:22). Medial length of T2 ~0.20 × longer than its apical width (22:110). T3 entirely smooth, ~1.27 × longer than T2 medially (28:22). Hypopygium surface entirely sclerotized with a distinct median longitudinal fold (Fig. 4D). Ovipositor slightly downcurved; protruded ovipositor sheath ~0.40 × longer than hind tarsus, broadened apically.

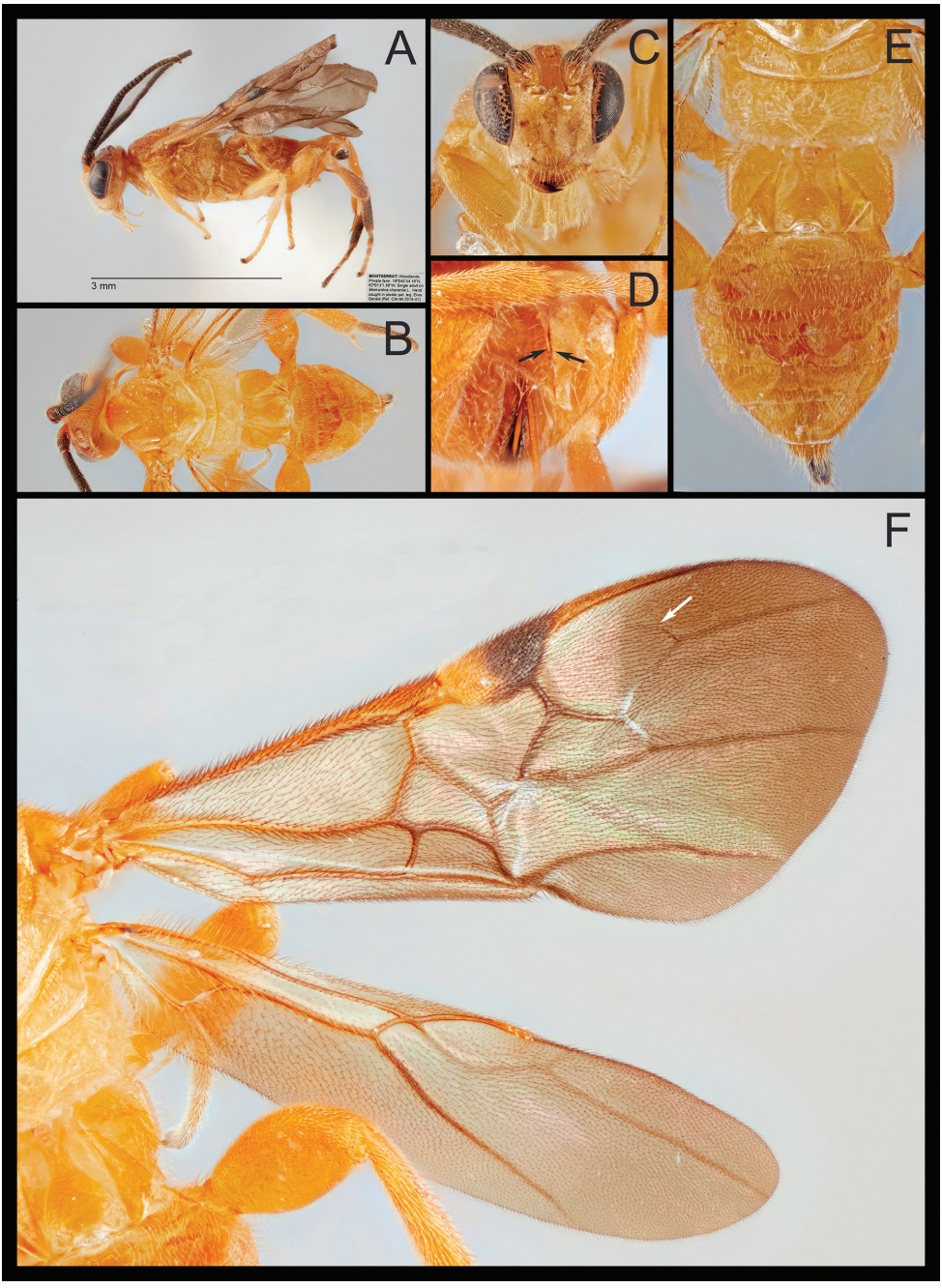


Figure 4. *Schoenlandella montserratensis*, sp. nov. **A** lateral habitus **B** dorsal habitus **C** anterior head **D** ventral metasoma; arrow: median fold on hypopygium **E** dorsal propodeum and mesonotum **F** wings; arrow: 3r vein on forewing.

Color. Body mostly pale orange; the following areas melanic: apical scape, pedicel, flagellomere, apical mandible, hind tarsus, external ovipositor sheaths. Wings entirely lightly infuscate, stigma dark brown at apical half.

Etymology. This species is named after the collecting site, "Montserrat", a volcanic Caribbean Island.

Host. Unknown but see details in the following discussion section.

Distribution. *Schoenlandella montserratensis* sp. nov. is only known from Montserrat (Fig. 3).

Discussion

Taxonomic status of *Schoenlandella* and character discussion

The validity of the taxonomic status of *Schoenlandella* Cameron has fluctuated several times before the current work. Dangerfield et al. (1999) indicated that species of *Schoenlandella* could be easily distinguished from all other cardiochiline genera based on the following five characters: conspicuously setose eyes; long and deeply bilobed glossa; elongate blade-like galea; presence of spectral 3r of forewing (if absent, members of the genus have relatively short mouthparts); evenly sclerotized hypopygium (if a median longitudinal fold is present, the surface is not membranous). The genus was resolved as a monophyletic group in the phylogeny in Dangerfield et al. (1999) based on morphological data. However, Mercado and Wharton (2003) and Papp (2014) indicated difficulty in distinguishing members of *Schoenlandella* from those of *Cardiochiles* Nees. Dangerfield et al. (1999) and Mercado and Wharton (2003) retained *Schoenlandella* as a valid genus, and the latter author subsumed the genus into *Cardiochiles* as a subgenus. Edmardash et al. (2018) treated *Schoenlandella* as a valid genus.

Only one study partially indicated genus-level relationships of Cardiochilinae. Murphy et al. (2008) presented three phylogenies based on seven genes. Even though the phylogenies focused on subfamily-level relationships of microgastroid subfamilies, genus-level relationships of five cardiochiline genera were included. *Cardiochiles* and *Schoenlandella* were resolved as polyphyletic in a clade with a rare Australian genus, *Gwenia* Dangerfield, Austin & Whitfield in their Maximum Parsimony phylogeny. However, the other two phylogenies resulting from Maximum Likelihood and Bayesian phylogenetic analyses using the same molecular data indicated that members of each genus were well-clustered even though they were recovered as paraphyletic. It should be noted that Murphy et al. (2008) treated *C. minutus* (Cresson) as a member of *Schoenlandella* and indicated *Cardiochiles* and *Schoenlandella* were polyphyletic. We treat *S. minuta* in Murphy et al. (2008) as *C. minutus* (Cresson) since Mercado and Wharton (2003) transferred the species to *Cardiochiles*.

In the current work, we examined specimens of both New World and Old World *Schoenlandella* species. Old World members mostly possess and share the five diagnostic characters defined by Dangerfield et al. (1999). We confirmed that specimens of

S. montserratensis sp. nov. collected in Montserrat are the first New World species having the five diagnostic characters. Of the other three New World species, specimens of *S. diaphaniae* and *S. gloriosa* were examined, and morphological characters of *S. longimala* were confirmed based on descriptions of Mao (1945) and images of the holotype on the NMNH website (https://collections.nmnh.si.edu/search/ento/, accessed September 2020). All New World species have dense eye setae consistent with Old World members. Dangerfield et al. (1999) indicated that most *Schoenlandella* members possess elongate mouthparts. Tucker et al. (2012) discussed two hypotheses regarding the elongation of mouthparts of the Afrotropical agathidine genus *Camptothlipsis* Enderlein and preferred the hypothesis that the members with elongate mouthparts are specialized nectar feeders, dependent on flowers that their host caterpillars feed on. This has been confirmed in the case of *Agathis malvacearum* Latreille (Juhala 1967). Most other cardiochilines as well as members of *Heteropteron* Brullé, which was resolved as the most ancestral cardiochiline genus (Dangerfield et al. 1999; Murphy et al. 2008) possess short mouthparts. The elongate mouthparts most likely evolved independently in *Schoenlandella*. Some Old World members and the three New World species in the current work possess relatively shorter mouthparts than most *Schoenlandella* species (but narrower and longer than the typical mouthparts of *Cardiochiles*). This seems to be a secondary loss due to environmental changes like host flower traits. In addition, IK confirmed that females of *S. diaphaniae* and *S. gloriosa* do not possess the median membranous fold or area in the hypopygium. The hypopygial character of *S. longimala* could not be confirmed because the holotype is male. Additionally, most *Schoenlandella* members possess an angled RS vein in the forewing, which is not present in *Cardiochiles*. They also have relatively longer second submarginal cells than members of *Cardiochiles*. Despite the contradictory opinions of Papp (2014) and Murphy et al. (2008), we treat *Schoenlandella* as a valid genus as in Dangerfield (1999) and Mercado and Wharton (2003) and place the New World species in the genus. IK is conducting molecular analysis to generate a phylogeny to determine genus-level relationships of cardiochilines based on a larger taxon sample than previous research. We expect that the phylogeny will help resolve the taxonomic issue in the near future and predict that *Schoenlandella* will be confirmed as a valid genus with support of shared morphological characters such as elongate mouthparts, angled Rs vein and elongated submarginal cell of the forewing, and evenly sclerotized surface of the hypopygium.

Potential host information of *S. montserratensis* sp. nov.

Female adults of *S. montserratensis* sp. nov. were collected in a bitter gourd field in Montserrat in 2019. Four potential lepidopteran host species were collected in the same location in the same period: *Diaphania hyalinata* (L., 1767) (Melonworm moth; Crambidae); *Plutella xylostella* (L. 1758) (Diamondback moth; Plutellidae); *Calpodes ethlius* (Larger canna leafroller; Hesperiidae), and unidentified bagworm (Psychidae) (Dr Chris Malumphy pers. comm.). Among these species, the melonworm moth caterpillars were the most serious pests in the field. Because other *Schoenlandella* species chiefly attack caterpillars of Crambidae and Noctuidae (Ta-

Table 1. Host information of each *Schoenlandella* species prior to the current study.

Schoenlandella species	Lepidopteran host	Source(s)
S. diaphaniae (Marsh, 1986)	*Diaphania hyalinata* (L., 1767) (Crambidae)	(Marsh 1986)
S. fulva (Cameron, 1907)	*Omiodes indicata* (F., 1775) (Crambidae), *Spoladea recurvalis* (F., 1775) (Crambidae), *Pramadea lunalis* (Guenée, 1854) (Crambidae)	(Odak and Dhamdhere 1968)
S. goosei (Dangerfield & Austin, 1995)	*Crocidolomia pavonana* (F., 1794) (Crambidae)	(Dangerfield and Austin 1995)
S. hymeniae (Fischer & Parshad, 1968)	*Spoladea recurvalis* (F., 1775) (Crambidae)	(Fischer and Parshad 1968)
S. nigromaculata Cameron, 1905	*Helicoverpa armigera* (Hübner, 1808) (Noctuidae)	(Nyiira 1970)
S. sahelensis (Huddleston & Walker, 1988)	*Heliocheilus albipunctella* (de Joannis, 1925) (Noctuidae)	(Bhatnagar 1988) (Huddleston and Walker 1988)
S. trimaculata Cameron, 1905	*Helicoverpa armigera* (Hübner, 1808) (Noctuidae)	(Coaker 1959) (Risbec 1960)
S. uniformis (Turner, 1918)	*Helicoverpa sp.* (Noctuidae)	(Chadwick and Nikitin 1976) (Dangerfield and Austin 1995)
S. variegata (Szépligeti, 1913)	*Helicoverpa armigera* (Hübner, 1808) (Noctuidae)	(Bhatnagar 1988) (Huddleston and Walker 1988)

ble 1), the melonworm moth caterpillar may be the preferred host of *S. montserratensis* sp. nov. If females of the new species are host specific and attack the melonworm moth caterpillars as expected, females of *S. montserratensis* sp. nov. should be developed as effective biological control agents for the melonworm moth. Detailed biology of *S. montserratensis* sp. nov. and its host range will need to be confirmed in further investigations (i.e., rearing caterpillars and collecting parasitoids of the host caterpillars). Future studies should investigate the effectiveness of *S. montserratensis* sp. nov. to parasitize the melonworm moth and determine its potential as a biological control agent against melonworm moth.

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References

Ashmead WH (1894) Report upon the parasitic Hymenoptera of the island of St. Vincent. Linnean Society 25: 56–254.

Ashmead WH (1900) Report upon the Aculeate Hymenoptera of the islands of St. Vincent and Grenada, with additions to the parasitic Hymenoptera and a list of the described Hy-

menoptera of the West Indies. Transactions of the Entomological Society of London 48: 207–367. https://doi.org/10.1111/j.1365-2311.1900.tb02379.x

Bhatnagar VS (1988) New records of Cardiochiles (Braconidae: Hymenoptera) on *Heliothis armigera* (Hb.) and *Raghuva albipunctella* de Joannis in the Sahel. Current Science 57(16): 904–905.

Brullé GA (1846) Suites á Buffon: histoire naturelle des insects: hyménoptéres. Paris Roret 4: 1–689. https://doi.org/10.5962/bhl.title.9005

Cameron P (1905a) On the Hymenoptera of the Albany Museum, Grahamstown, South Africa (First paper). Record of the Albany Museum 1: 161–175.

Cameron P (1905b) On the phytophagous and parasitic Hymenoptera collected by Mr. E. Green in Ceylon. Spolia zeylanica 3: 67–143.

Cameron P (1907) Descriptions of two new genera and four new species of Indian parasitic Hymenoptera. Zeitschrift für Systematische Hymenopterologie und Dipterologie 7: 462–466.

Coaker TH (1959) Investigations on *Heliothis armigera* (Hb.) in Uganda. Bulletin of Entomological Research 50(3): 487–506. https://doi.org/10.1017/S0007485300053062

Cresson, E. (1873). Descriptions of North American Hymenoptera, No. 5. The Canadian Entomologist 5(3): 51–54. https://doi.org/10.4039/Ent551-3

Dangerfield PC, Austin AD (1995) Revision of the Australasian species of Cardiochilinae (Hymenoptera: Braconidae). Invertebrate Systematics 9(3): 387–445.

Dangerfield PC, Austin AD, Whitfield JB (1999) Systematics of the world genera of Cardiochilinae (Hymenoptera: Braconidae). Invertebrate Systematics 13(6): 917–976. https://doi.org/10.1071/IT98020

Edmardash YA, Gadallah NS, Sharkey MJ (2018) Revision of the subfamily Cardiochilinae Ashmead, 1900 (Hymenoptera: Braconidae) in Egypt, with new records and a new species. Journal of Natural History 52(5–6): 269–297. https://doi.org/10.1080/00222933.2017.1420834

Enderlein G (1920) Zur Kenntnis aussereuropäischer Braconiden. Archiv für Naturgeschichte (A) 84: 51–224. https://doi.org/10.5962/bhl.part.13627

Fischer M, Parshad B (1968) A new reared braconid-fly (Hymenoptera) from India. Polskie Pismo Entomologiczne 38: 807–810.

Harris RA (1979) Glossary of surface sculpturing. Occasional Papers in Entomology 28: 1–31.

Huddleston T, Walker AK (1988) *Cardiochiles* (Hymenoptera: Braconidae), a parasitoid of lepidopterous larvae, in the Sahel of Africa, with a review of the biology and host relationships of the genus. Bulletin of Entomological Research 78(3): 435–461. https://doi.org/10.1017/S0007485300013201

Juhala C (1967) Notes on parasitic Hymenoptera associated with a Gelechiid moth, *Metzneria lappella*, in the Common Burdock, and description of a new species of *Agathis* (Braconidae). Annals of the Entomological Society of America 60(1): 95–97.

Latreille PA (1805) Histoire naturelle generale et particulière des crustacés et des insectes 13. F. Dufart, Paris, 432 pp. https://doi.org/10.5962/bhl.title.15764

Mao YT (1945) Synopsis of the Mexican species of *Cardiochiles* Nees (Hymenoptera: Braconidae). Pan-Pacific Entomologist 21(4): 125–134.

Marsh PM (1986) A new species of Cardiochiles (Hymenoptera: Braconidae) introduced into Florida to control *Diaphania* spp. (Lepidoptera: Pyralidae). Proceedings of the Entomological Society of Washington 88(1): 131–133.

Mercado I, Wharton RA (2003) Mexican cardiochiline genera (Hymenoptera: Braconidae), including a preliminary assessment of species-groups in *Toxoneuron* Say and *Retusigaster* Dangerfield, Austin and Whitfield. Journal of Natural History 37(7): 845–902. https://doi.org/10.1080/00222930110097167

Nees von Esenbeck CG (1819) Appendix ad JLC Gravenhorst conspectum generum et familiarum Ichneumonidum, genera et familias Ichneumonidum adscitorum exhibens. Nova Acta Leopid. Carol. 9: 299–310.

Nyiira ZM (1970) A note on the natural enemies of lepidopterous larvae in cotton bolls in Uganda. Annals of the Entomological Society of America 63(5): 1461–1462. https://doi.org/10.1093/aesa/63.5.1461

Odak SC, Dhamdhere SV (1970) New record of Hymenopterous parasites of *Sylepta lunalis* Guen (Lepidoptera: Pyralidae), a pest of grapevines. Indian Journal of Entomology 32(4): e395.

Papp J (2014) A revisional study on Szépligeti's cardiochiline type specimens deposited in the Hungarian Natural History Museum, Budapest (Hymenoptera, Braconidae: Cardiochilinae). Annales Historico-Naturales Musei Nationalis Hungarici 106: 169–214.

QGIS Development Team (2019) QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

Risbec J (1960) Les parasites des insectes d'importance économique en Afrique tropicale et à Madagascar. Agronomie Tropicale 15: 624–655.

Say T (1836) Descriptions of new species of North American Hymenoptera, and observation on some already described. Boston Journal of Natural History 1(3): 209–305.

Sharkey MJ, Wharton RA (1997) Morphology and terminology. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, No 1, Washington DC, 19–37.

Szépligeti V (1911) Braconidae der I. Zentral-Afrika-Expedition. Wissenschaftliche Ergebnisse der Deutschen Zentral-Afrika Expedition 1907–1908 3: 393–418.

Szépligeti V (1913) Neue afrikanische Braconiden aus der Ungarischen National-Museums. Annales historico-naturales Musei Nationalis Hungarici 11: 592–608.

Tucker ET, Sharkey MJ, Stoelb SAC (2012) A new species-group of *Camptothlipsis* (Braconidae, Agathidinae) from South Africa, with notes on the evolution of long mouthparts. Journal of Hymenoptera Research 24: 59–74. https://doi.org/10.3897/JHR.24.1909

Turner RE (1918) VII. – Notes on the Braconidæ in the British Museum. – II. On the Australian species of Cardiochilinae and Doryctinae. Annals and Magazine of Natural History 1(1): 49–57. https://doi.org/10.1080/00222931808562286

Viereck HL (1914) Type species of the genera of ichneumon flies. US Government Printing Office 83: 1–186. https://doi.org/10.5479/si.03629236.83.1

Whitfield JB, Dangerfield PC (1997) Subfamily Cardiochilinae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World genera of the family Braconidae (Hymenoptera). International Society of Hymenopterists, Washington DC 1: 176–183.

Yu DS, van Achterberg CV, Horstmann K (2016) Taxapad 2016, Ichneumonoidea 2015. Database on flash-drive. Ottawa, Ontario.