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New species of *Daidalotarsonemus* and *Excelsotarsonemus* (Acari, Tarsonemidae) from the Brazilian rainforest

José Marcos Rezende[1], Antonio Carlos Lofego[2], Ronald Ochoa[3], Gary Bauchan[4]

1 *Programa de Pós-Graduação em Biologia Animal, São Paulo State University, São José do Rio Preto, SP 15054-000, Brazil* **2** *Departamento de Zoologia e Botânica, São Paulo State University, São José do Rio Preto, SP 15054-000, Brazil* **3** *Systematic Entomology Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD 20705, USA* **4** *Electron and Confocal Microscopy Unit, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD 20705, USA*

Corresponding author: *José Marcos Rezende* (jmrezende@live.com)

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Abstract

Three new species of Tarsonemidae, *Daidalotarsonemus oliveirai* Rezende, Lofego & Ochoa, **sp. n.**, *Excelsotarsonemus caravelis* Rezende, Lofego & Ochoa, **sp. n.** and *Excelsotarsonemus tupi* Rezende, Lofego & Ochoa, **sp. n.** are described and illustrated. Measurements for these species are provided, as well as drawings, phase contrast (PC), differential interference contrast (DIC) and low temperature scanning electron microscopy (LT-SEM) micrographs. Some characters, which have not been used or clearly understood, are described herein. Biological, ecological and agricultural aspects about the role of these species in the rainforest and its surrounding environment are briefly discussed.

Keywords

Atlantic Forest, canopy, faunistics, LT-SEM, systematics, Tarsonemoidea, Trombidiformes

Introduction

Currently, *Daidalotarsonemus* De Leon (Acari, Prostigmata, Tarsonemidae) consists of 26 described species (Lin and Zhang 2002, Lofego et al. 2005, Sousa et al. 2014). It is one of the few genera of Tarsonemidae which have been documented on all continents, except Antarctica (Lindquist 1986, Lin and Zhang 2002). The known geographical distribution of *Excelsotarsonemus* Ochoa & Naskręcki is much more restricted, previously recorded only from Costa Rica. The two genera are closely related and considered to be sister genera (Ochoa et al. 1995, Ochoa and OConnor 1998). Both are considered to be plant inhabiting taxa, apparently with a preference for plants located in humid places, where there is an abundance of fungi, bacteria and lichens. In Brazil, the Amazon and Atlantic Rainforests are biomes which fit these requirements, because of their high temperature and rainfall index.

In recent years, significant advances in microscopy have expanded our knowledge of the morphological characters of organisms, which has led to a better understanding of the taxonomy and ecology of species (Fisher and Dowling 2010). One of most effective techniques that has been integrated to study mite morphology and biology is Low Temperature Scanning Electron Microscopy (LT-SEM), in which a sample is instantly frozen with liquid nitrogen, making a frozen snap-shot of the specimen as it occurs in nature available for microscopic study (Bolton et al. 2014). This procedure is critical for understanding not only external morphology, but also ecological and behavior characteristics, not accessible using light microscopy.

The objective here is to describe new species of *Daidalotarsonemus* and *Excelsotarsonemus* found in a rainforest in Brazil using phase contrast (PC), differential interference contrast (DIC) light microscopy and LT-SEM microscopy techniques. The LT-SEM study led to a better understanding of the morphology of these species and their respective genera and is discussed herein.

Material and methods

Several leaves of *Annona muricata* L. (Annonaceae), *Theobroma cacao* L. (Malvaceae) and *Spondias purpurea* L. (Anacardiaceae) were collected in and the area surrounding a section of the rainforest near Santa Cruz State University campus (UESC), 14°47'45"S; 39°10'18"W, Ilhéus, Bahia State, Brazil. The region is characterized by having high relative humidity (75–90%) and high precipitation (100–330 mm/month) indexes throughout the year. Mites collected in the study were prepared and analysed using three different microscopy techniques: phase contrast (PC), differential interference contrast (DIC) and low temperature scanning electron microscopy (LT-SEM). The terminology used herein follows that of Lindquist (1986), except fot the gnathosomal setae *dgs* and *vgs* (Magowski and Di Palma 2000). For each structure, all the measurements are provided in micrometers (μm), followed by the range of all specimens measured in parentheses, including the holotype. The following abbreviations are used for institutions where the types were deposited: Acari Collection of the Departamento de Zoologia e Botânica (DZSJRP), São Paulo State University, São José do Rio Preto, São Paulo, Brazil; United States National Museum of Natural History (USNM), Smithsonian Institution, housed in Beltsville, Maryland 20705, USA.

Specimens were prepared and observed with an LT-SEM using the same techniques as described in Bolton et al. (2014). Briefly, live specimens were secured to 15 cm × 30 cm copper plates using ultra smooth, round (12 mm diameter), carbon adhesive tabs (Electron Microscopy Sciences, Inc., Hatfield, PA). The specimens were frozen in a Styrofoam box, by placing the plates on the surface of a pre-cooled (-196 °C) brass bar whose lower half was submerged in liquid nitrogen (LN_2). After 20–30 seconds, the holders containing the frozen samples were transferred the Quorum PP2000 cryo-prep chamber (Quorum Technologies, East Sussex, UK) attached to an S-4700 field emission scanning electron microscope (Hitachi High Technologies America, Inc., Dallas, TX). The specimens were etched inside the cryotransfer system to remove any surface contamination (condensed water vapour) by raising the temperature of the stage to -90 °C for 10–15 minutes. Following etching, the temperature inside the chamber was lowered below -130 °C, and the specimens were coated with a 10 nm layer of platinum using a magnetron sputter head equipped with a platinum target. The specimens were transferred to a pre-cooled (-130 °C) cryostage in the SEM for observation. An accelerating voltage of 5 kV was used to view the specimens. Images were captured using a 4pi Analysis System (Durham, NC). For the PC and DIC micrographs, it was used a Zeiss Axioscope™ microscope with differential interference contrast (DIC) 100× Plan Apochromatic objective with a NA 1.4. For the drawings, it was used a Leica® DM 2500 microscope with a drawing tube attached. Images were sized and placed together to produce a single illustrative plate using the software Adobe® Photoshop CS 5.0 and Adobe® Illustrator CS 5.0.

Results

Daidalotarsonemus oliveirai **Rezende, Lofego & Ochoa, sp. n.**

http://zoobank.org/4929C981-2DE8-4145-9C2F-6FBF54B92F67
Figs 1–14

Diagnosis. Females of the new species are most similar to those of *Daidalotarsonemus jamesbakeri* Smiley (1969) and *D. folisetae* Lofego & Ochoa (Lofego et al. 2005), because of the irregular ornamentation pattern on the prodorsum and the similar shape of the setae *e*. However, *Daidalotarsonemus oliveirai* sp. n. has the tergite C with a W-shaped reticulate pattern in central area and longitudinal, wavy interrupted ridges laterally, whereas in *D. jamesbakeri* and *D. folisetae* the reticulation is uniform on all tergites, with longitudinal continuous ridges. The shape of setae *e* is also different among the three species, being cordate in *D. oliveirai*, acicular in *D. jamesbakeri*, and phylliform

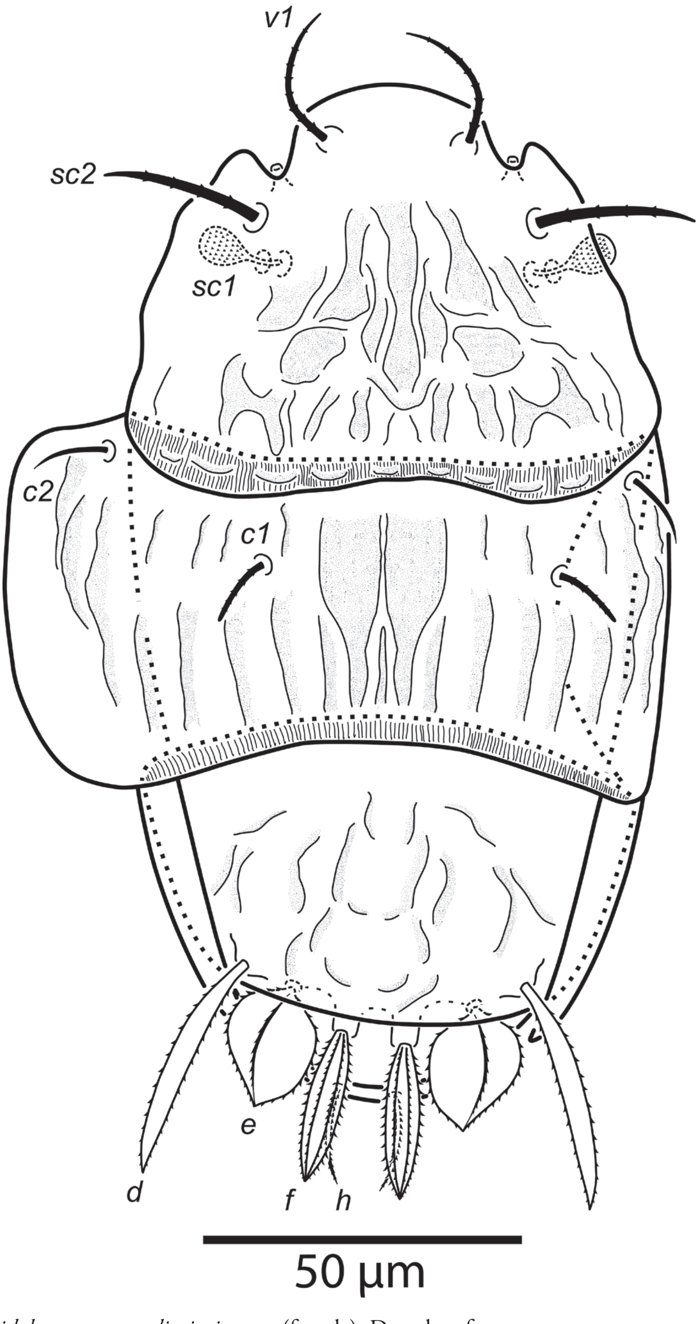

Figure 1. *Daidalotarsonemus oliveirai* sp. n. (female). Dorsal surface.

in *D. folisetae*. Males are similar to *Daidalotarsonemus deleoni* Smiley (1967), by the shape and length of almost all dorsal setae, except the setae *sc1*. In *D. oliveirai*, the relative length of the setae *sc1*/*sc2* is 1:0.6, whereas in *D. deleoni* is 1:0.3.

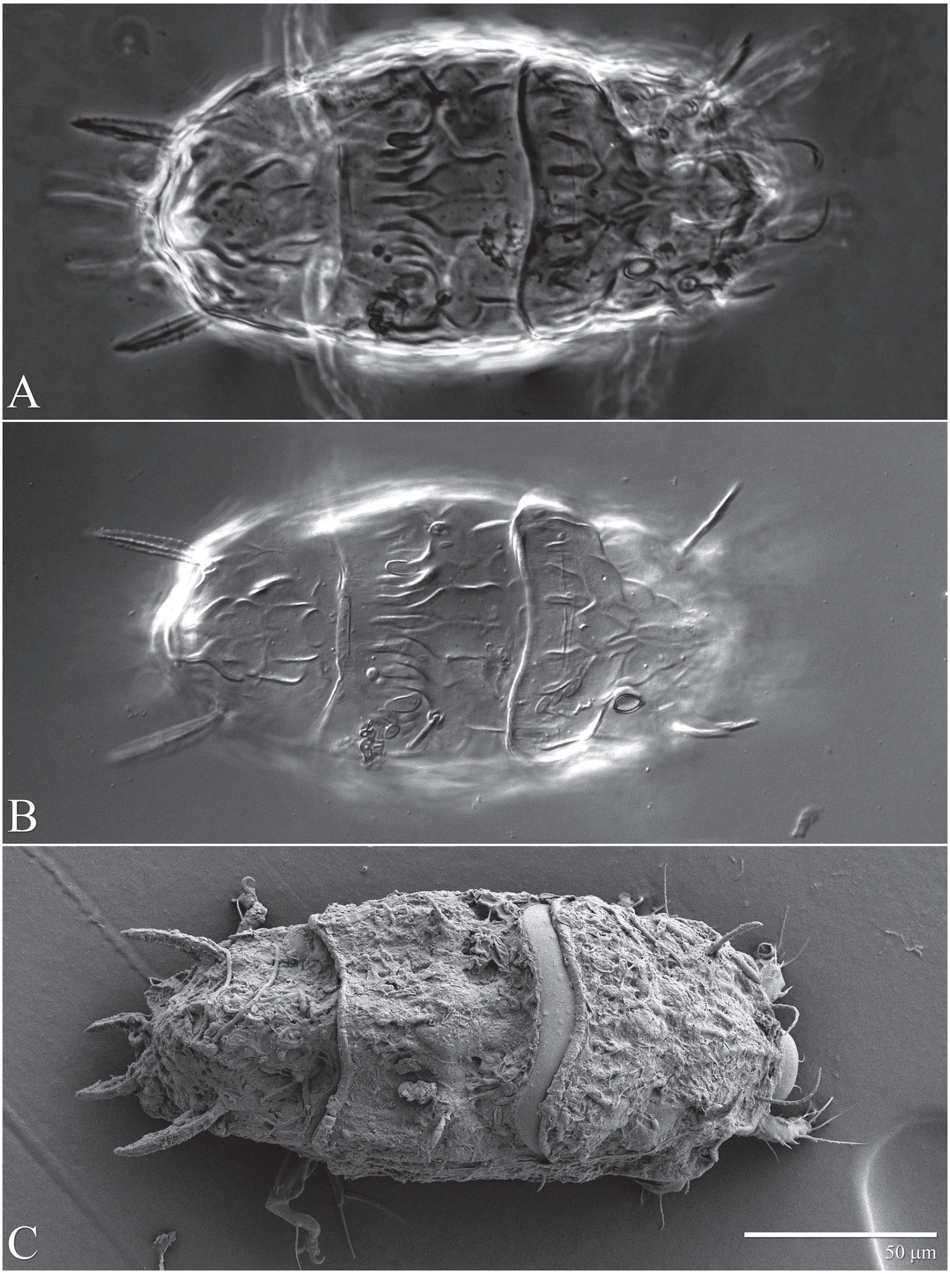

Figure 2. *Daidalotarsonemus oliveirai* sp. n. (female). Dorsal micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

Adult female (6 specimens measured). Gnathosoma (Figs 3 and 6): partially covered by the prodorsum. Subtriangular in ventral view, length 24 (23–26), maximum width 21 (19–23); dorsal apodeme distinct. Setae *dgs* 9 (8–10) and *vgs* 6 (6) smooth;

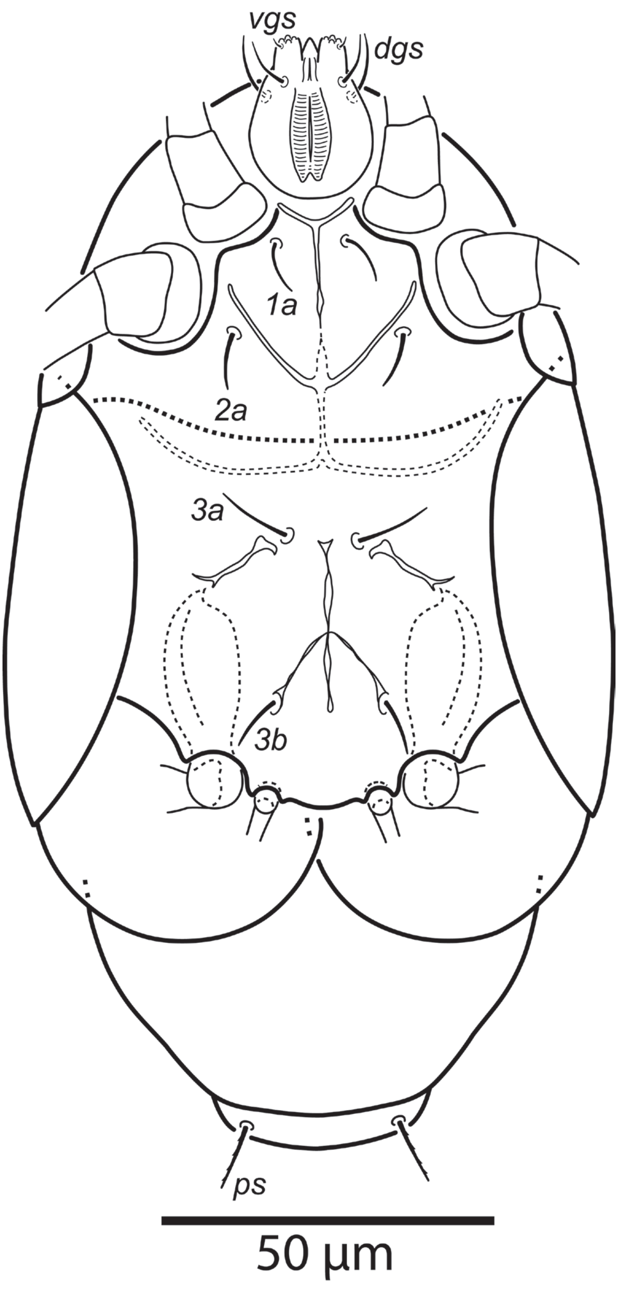

Figure 3. *Daidalotarsonemus oliveirai* sp. n. (female). Ventral surface.

palps moderately long 9 (8–11), with two small subterminal setae and terminal projections. Pharynx fusiform, 19 (18–23) long and 6 (5–7) wide at maximum width. Gnathosoma, idiosoma and legs covered with tiny dimples, each around 0.3 (0.2–0.5) in diameter.

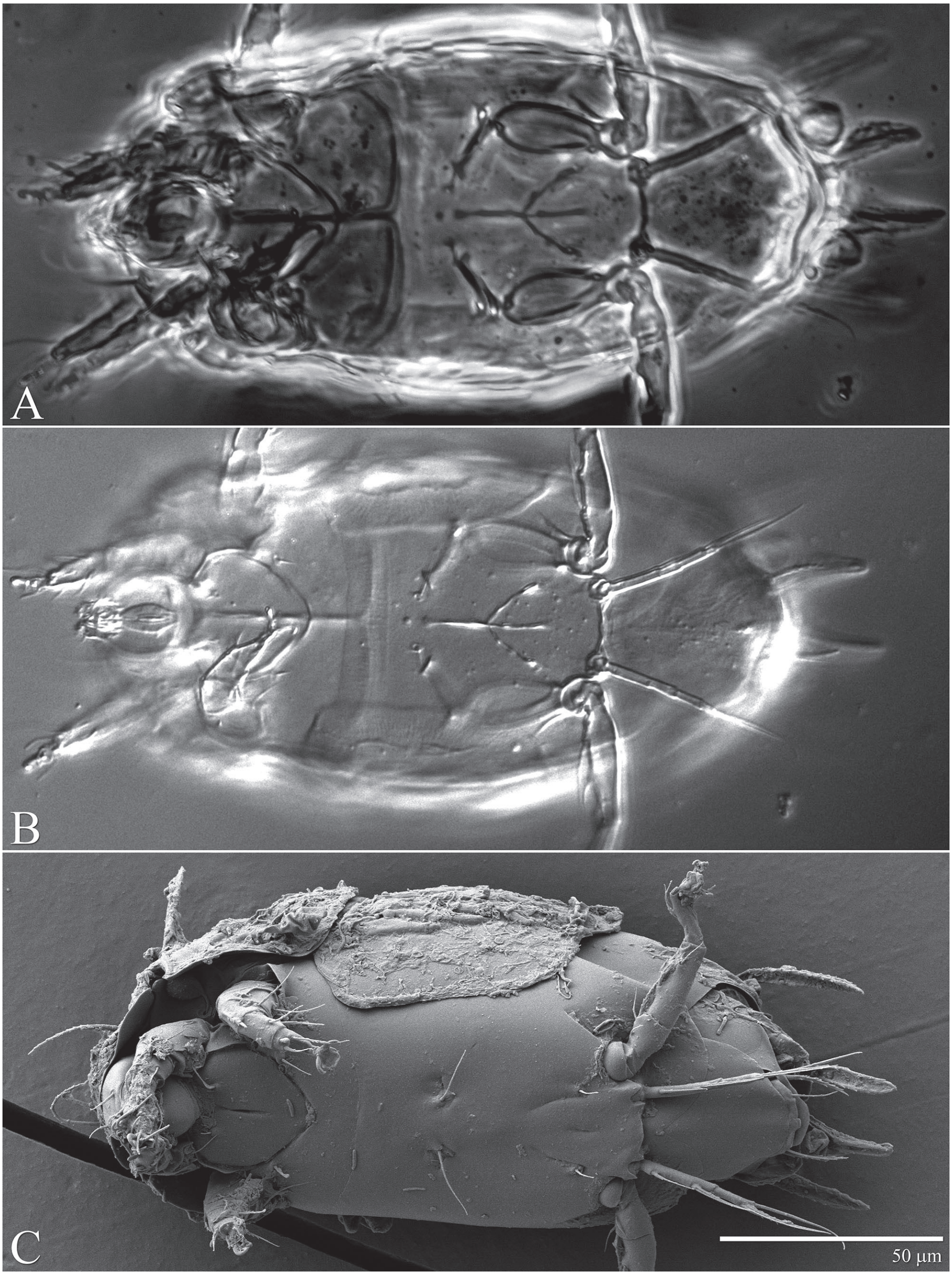

Figure 4. *Daidalotarsonemus oliveirai* sp. n. (female). Ventral micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

Idiosoma – dorsum (Figs 1–2): length 179 (170–188), width at level of *c1* 82 (75–90); prodorsal shield with irregular ornamentation covers the gnathosoma. Entire dorsum covered with cerotegument (Fig. 2C). Stigma located near lateral notch of

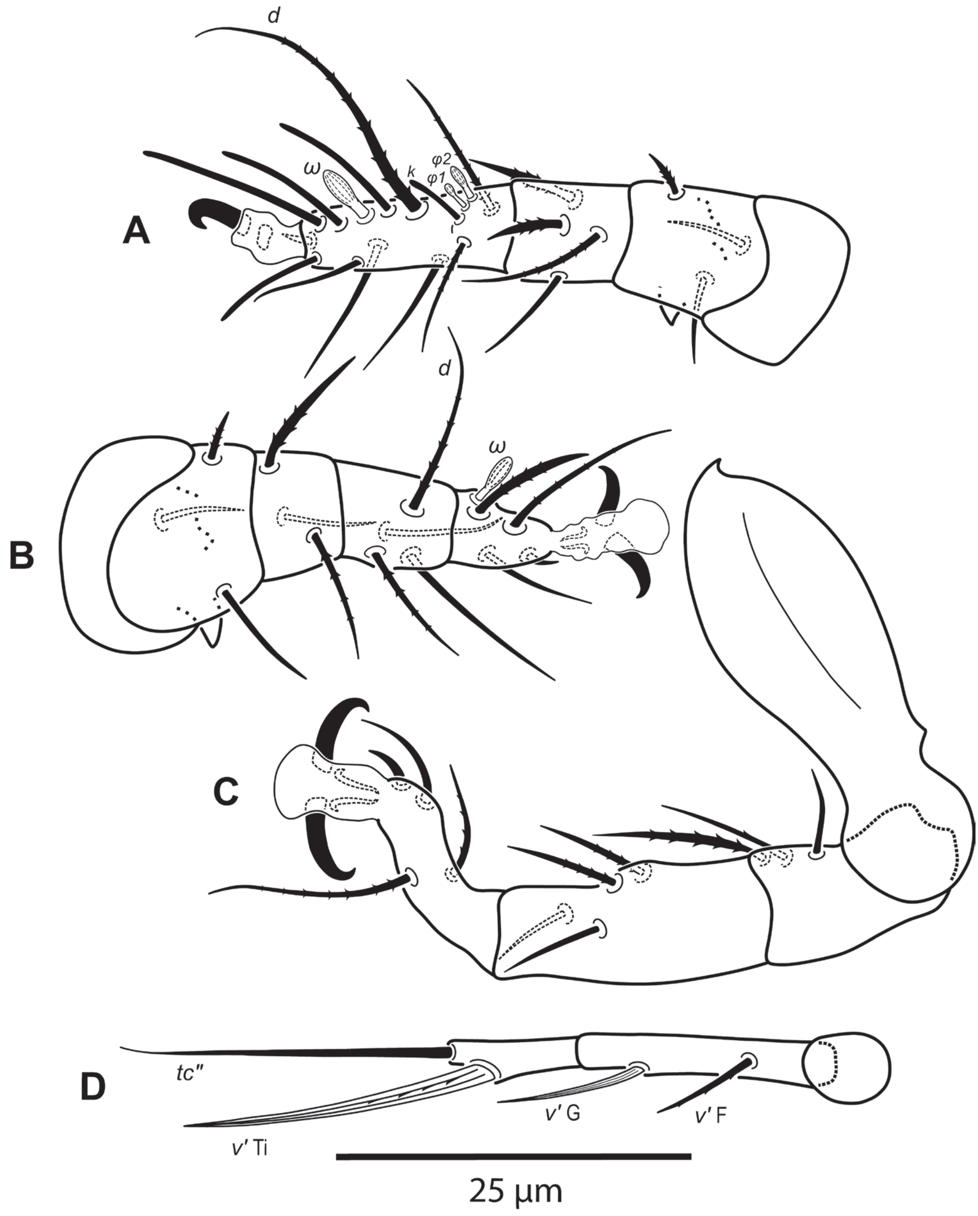

Figure 5. *Daidalotarsonemus oliveirai* sp. n. (female). **A** leg I **B** leg II **C** leg III **D** leg IV.

prodorsal shield, which is equidistant to the *v1* and *sc2* setal bases. Tergite C with a W-shaped reticulate pattern in central area and longitudinal, wavy uninterupted ridges laterally; tergite D ornamented with regular sculpturing. Lengths of the setae: *v1* 23 (22–25), *sc1* 11 (10–12) (Fig. 7C), *sc2* 28, *c1* 11 (10–12), *c2* 11 (10–12), *d* 33 (31–35), *e* 15 (15–16), *f* 24 (23–25) and *h* 24 (24–25). Maximum width of expanded setae:

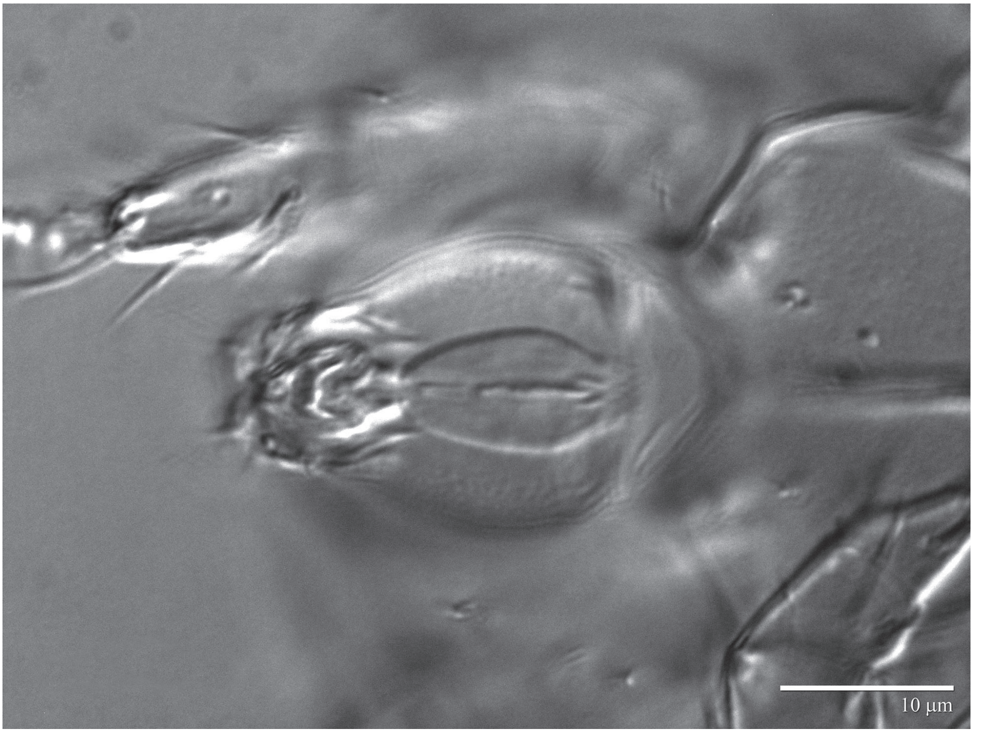

Figure 6. *Daidalotarsonemus oliveirai* sp. n. (female). Detail of the gnathosoma.

d 6 (5–7), *e* 15 (14–16) and *f* 7 (7–8). All dorsal setae serrate, except for *c2* smooth. Bothridial setae *sc1* capitate, with tiny spines. Setae *v1*, *sc2*, *c1*, *c2* and *h* setiform; setae *d*, *e* and *f* inserted on tubercles (Fig. 7D-E). Setae *d* linear and *e* cordate, both with a central serrate vein; *f* lanceolate, with two serrate veins. Distances between dorsal setae: *v1–v1* 25 (24–27), *sc2–sc2* 46 (44–48), *v1–sc2* 23 (23–24), *c1–c1* 50 (49–53), *c2–c2* 82 (76–88), *c1–c2* 27, *d–d* 44 (40–48), *f–f* 10, *e–f* 12 (11–13) and *h–h* 16 (14–17). Seta *sc2* inserted anteriorly to *sc1*. Dorsal cupules not easily seen.

Idiosoma – venter (Figs 3-4): setae *1a* 6 (6–7), posteriad of apodemes 1; *2a* 9 (9), posterolaterad of apodemes 2; *3a* 14 (13–15) near anteriomedial margins of apodemes 3; *3b* 11 (11–12) on posterior margins of apodemes 4. Apodeme 1 conspicuous, fused to anterior end of prosternal apodeme. Apodeme 2 long and fused to the prosternal apodeme. Prosternal apodeme conspicuous from junction with apodeme 1 to the middle portion of sejugal apodeme. Sejugal apodeme uninterrupted, with a single median indentation. Apodeme 3 with a constriction near the anterior end, extending diagonally from proximity of base of seta *3a* to anterior margin of trochanter III; apodeme 4 extending diagonally from the middle of the poststernal apodeme to base of seta *3b*. Poststernal apodeme bifurcated anteriorly. Tegula wide 12 (11–13) and very short, 4 (4–5) (Fig. 7F); posterior margin slightly arched. Seta *ps* 12 (11–13) serrate. Ventral surface covered with tiny dimples (Fig. 7F).

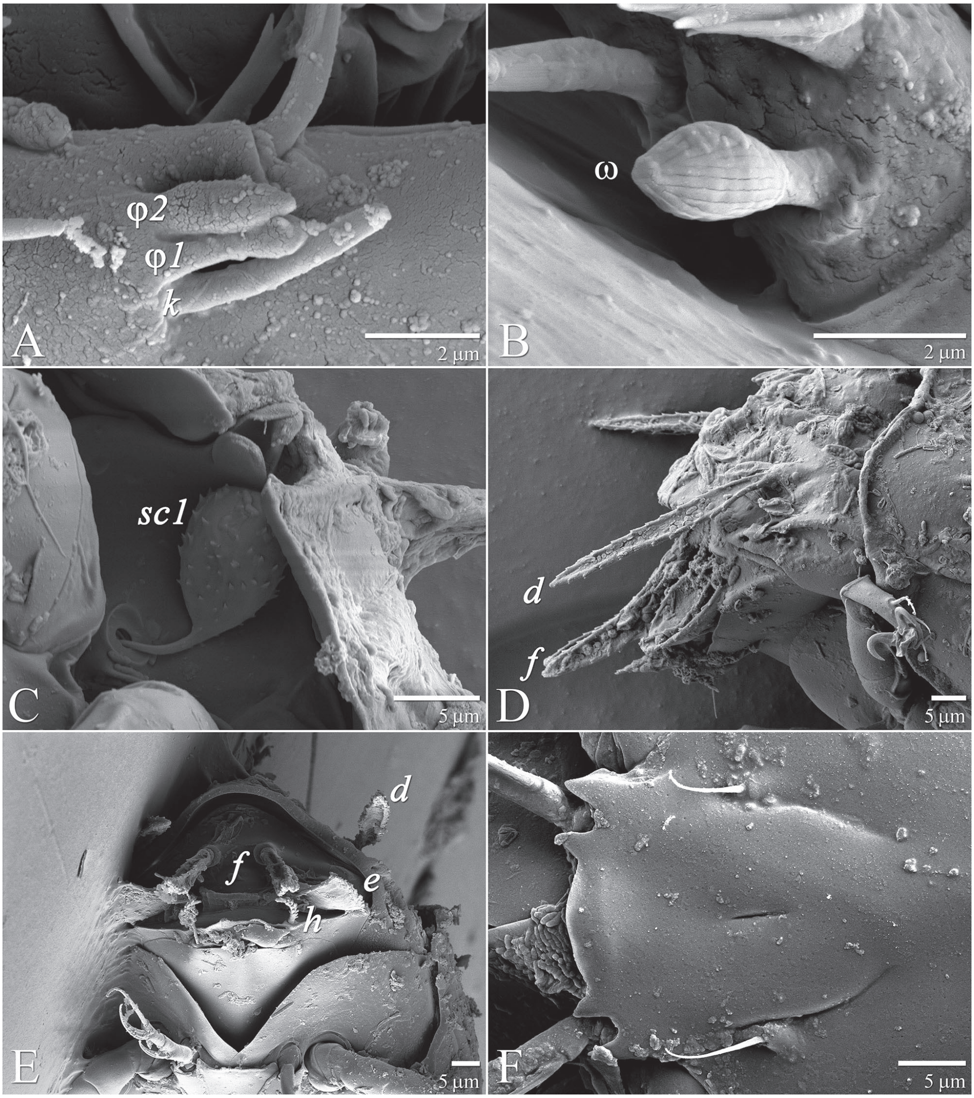

Figure 7. *Daidalotarsonemus oliveirai* sp. n. (female). **A** sensorial cluster of tibia I **B** Solenidion *ω* of tarsus II **C** Bothridial seta *sc1* **D** lateral view of the setae *d*, *e* and *f* **E** posterior view of the setae *d*, *e* and *f* **F** detail of the tegula.

Legs (Fig. 5): lengths (measured from femur to tarsus): leg I 40 (39–42), leg II 37 (35–40), leg III 79 (78–80). Number of setae (solenidia in parentheses) on femur, genu, tibia and tarsus, respectively: leg I: 3-4-5(2)-7(1), leg II: 3-3-4-4(1), leg III: 1+2-4-4. Claws medium-sized (not reduced) and hooked. Empodia of the legs I, II and III about the same size or slightly smaller compared to the respective basal stalks. Tarsal solenidion *ω* of tibiotarsus I 6 (5–7), stout, wider medially. Sensory cluster of tibia I complete (Fig. 7A), solenidion *φ1* 3 (3–4), slender,

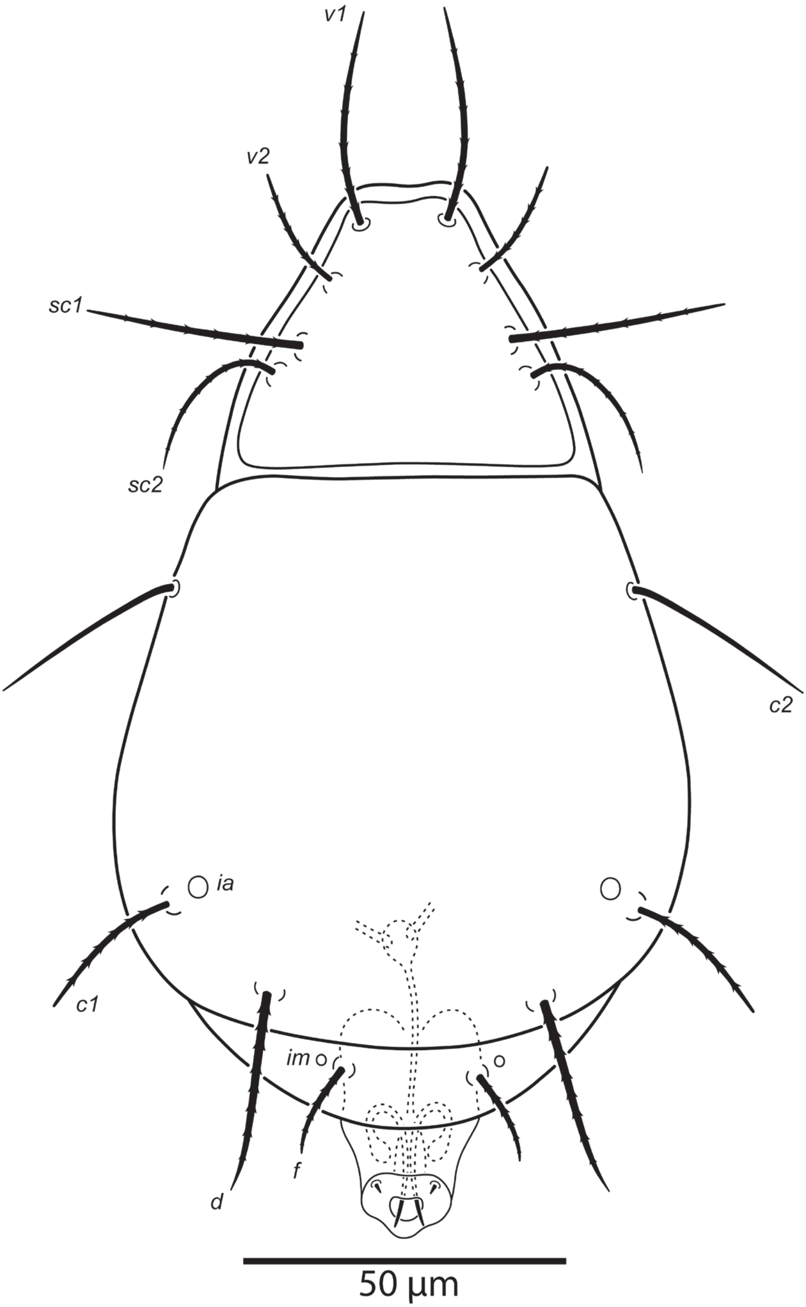

Figure 8. *Daidalotarsonemus oliveirai* sp. n. (male). Dorsal surface.

capitate; solenidion *φ2* 4, robust, slightly capitate; famulus *k* 6; all inserted at approximately the same level. Seta *d* of tibia I 18 (18–19), serrate. Solenidion *ω* of tarsus II proximally inserted, 4 long, stout, wider medially (Fig. 7B). Seta *d* of

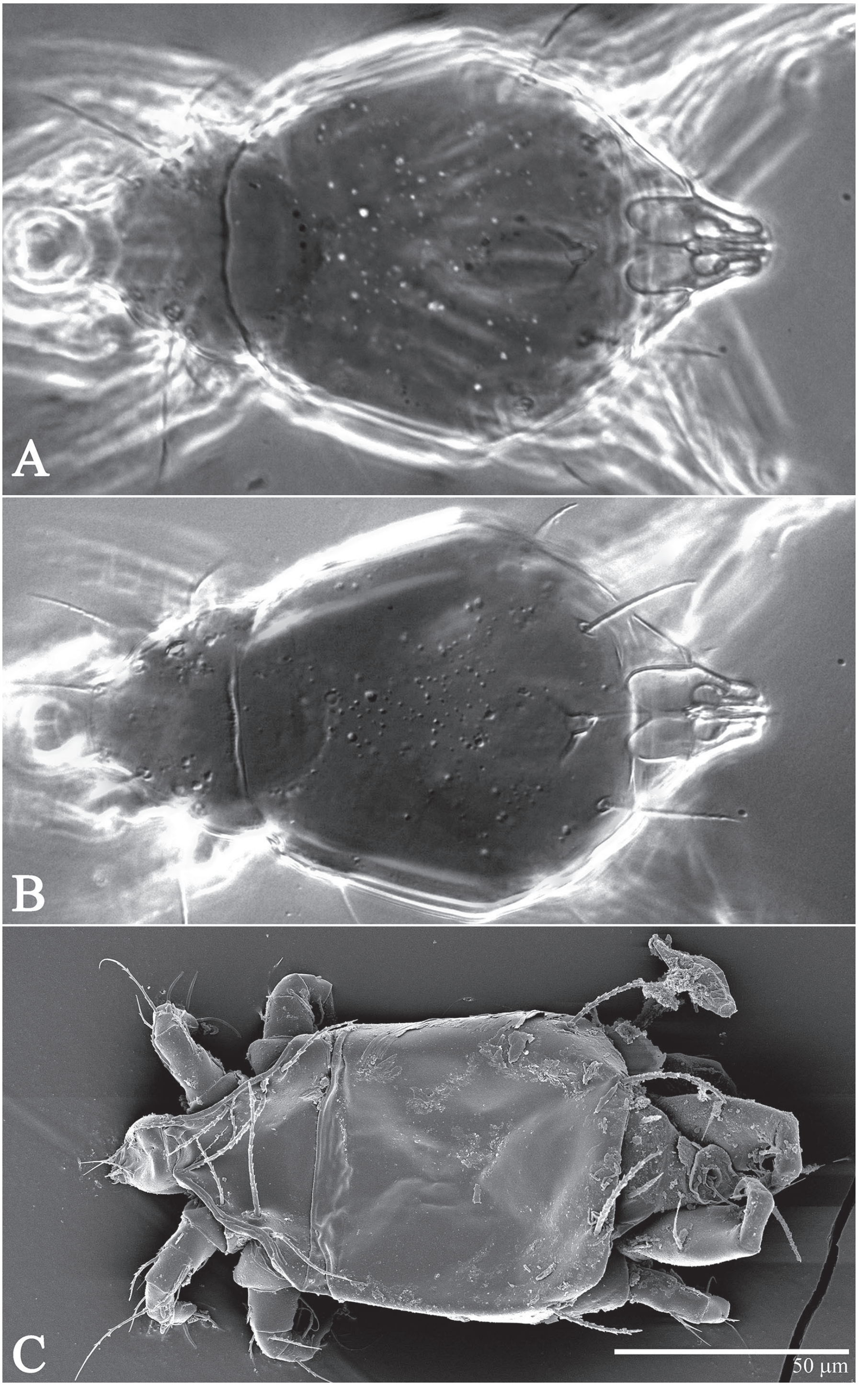

Figure 9. *Daidalotarsonemus oliveirai* sp. n. (male). Dorsal micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

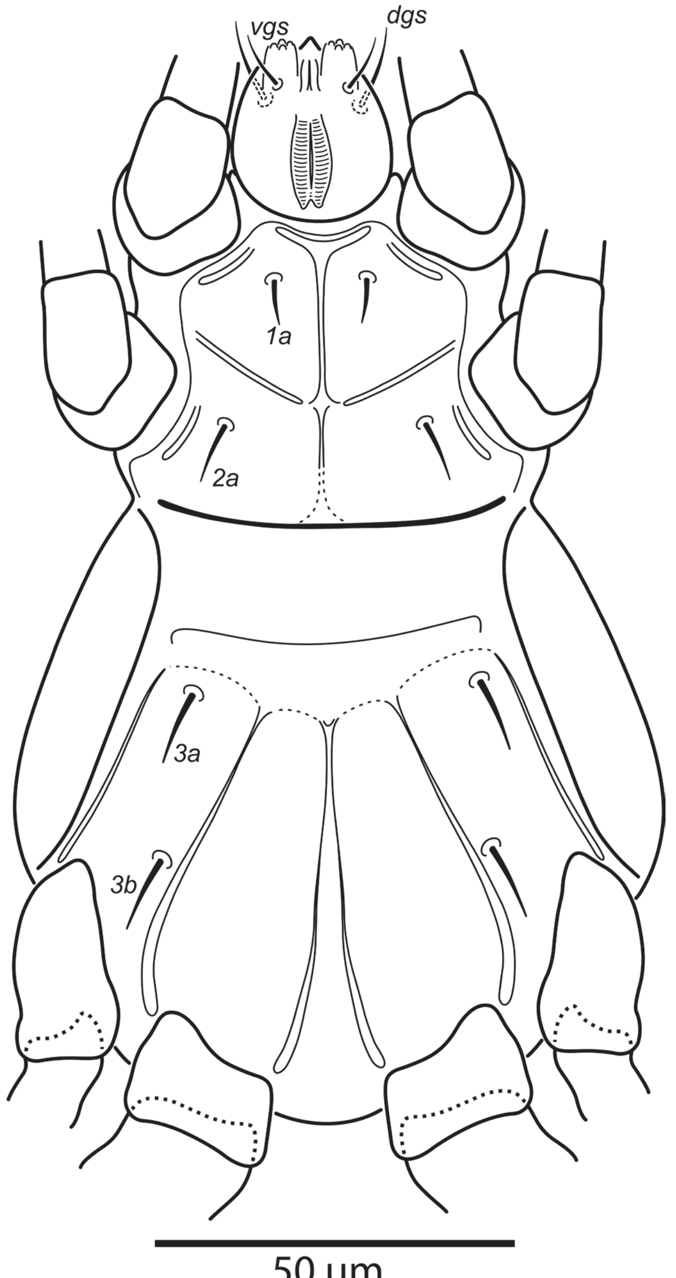

Figure 10. *Daidalotarsonemus oliveirai* sp. n. (male). Ventral surface.

tibia II 13 (13–14), serrate. Femorogenu IV 11 (14–15); tibiotarsus IV 8. Length of leg IV setae: *v'* F 9, *v'* G 11, *v´* Ti 19 and *tc"* 24 (23–27); setae *v'* Ti and *tc"* serrate; *v'* Ti falcate.

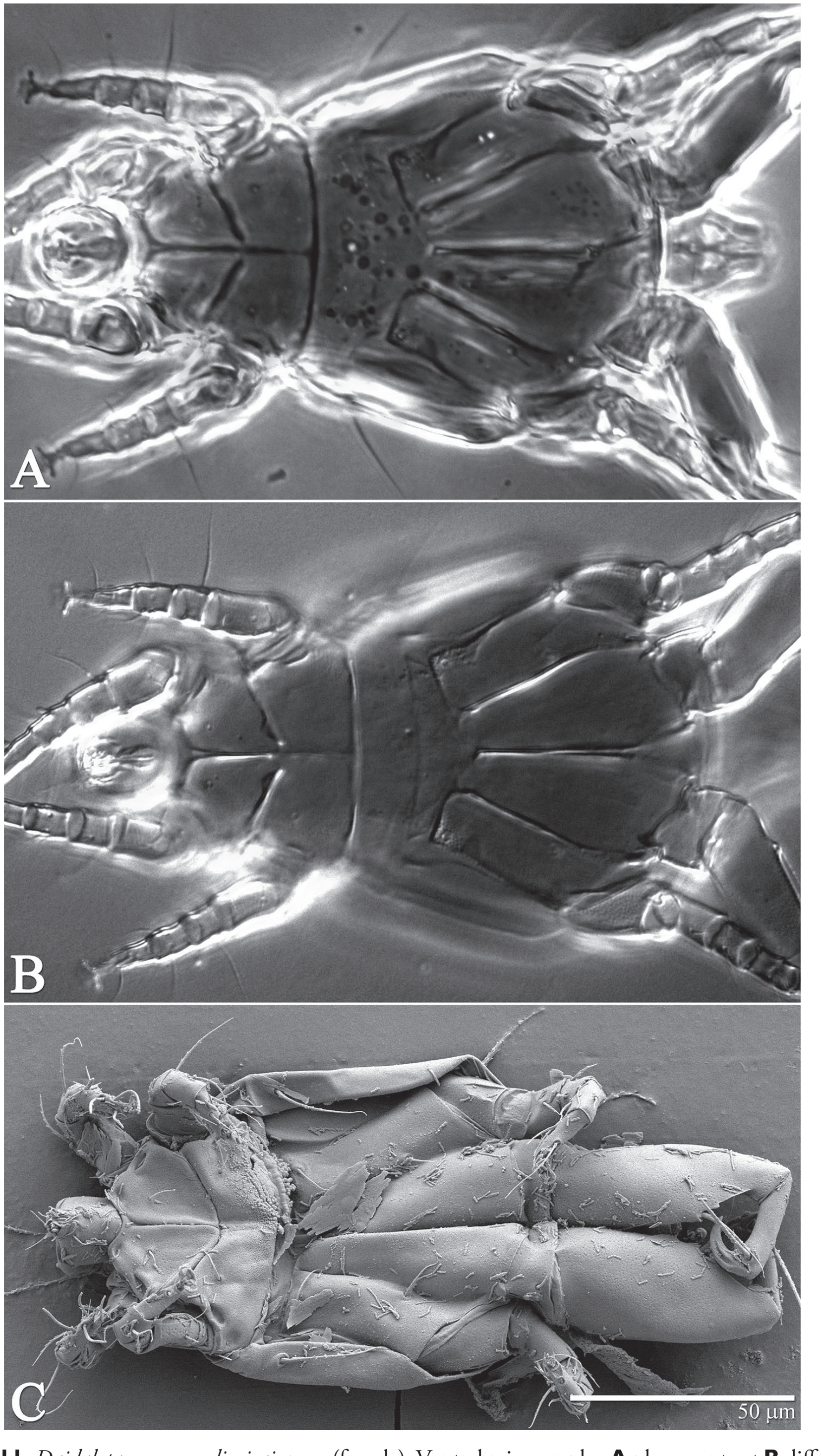

Figure 11. *Daidalotarsonemus oliveirai* sp. n. (female). Ventral micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

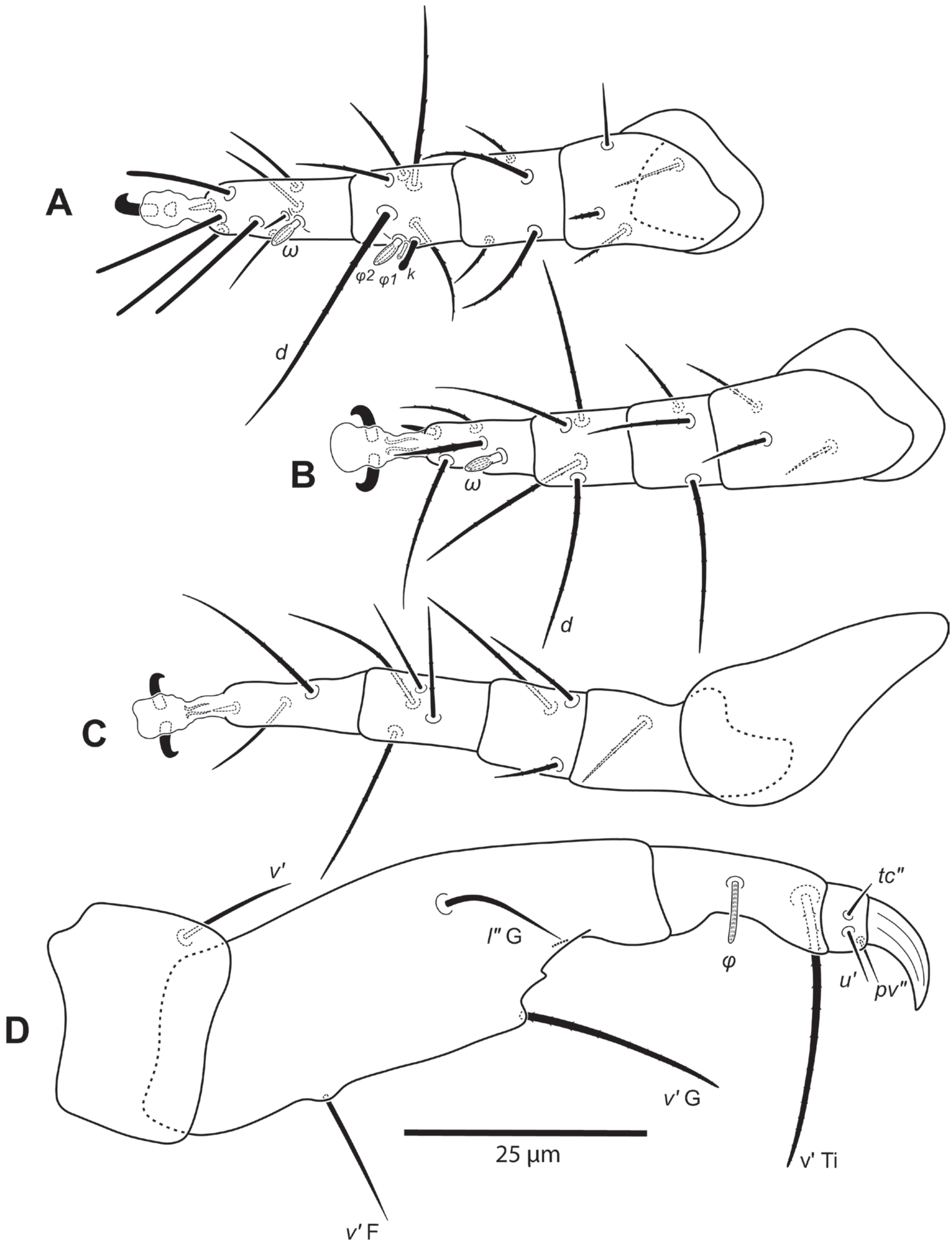

Figure 12. *Daidalotarsonemus oliveirai* sp. n. (male). **A** leg I **B** leg II **C** leg III **D** leg IV.

Adult male (3 specimens measured). Gnathosoma (Figs 10, 13 and 14A): subtriangular in ventral view, length 22 (21–23), maximum width 20 (19–20); dorsal apodeme distinct. Setae *dgs* 11 (10–12) and *vgs* 7 (7) smooth; Palps moderately long 9 (8–10), with 2 small subterminal setae and terminal projections. Pharynx fusiform,

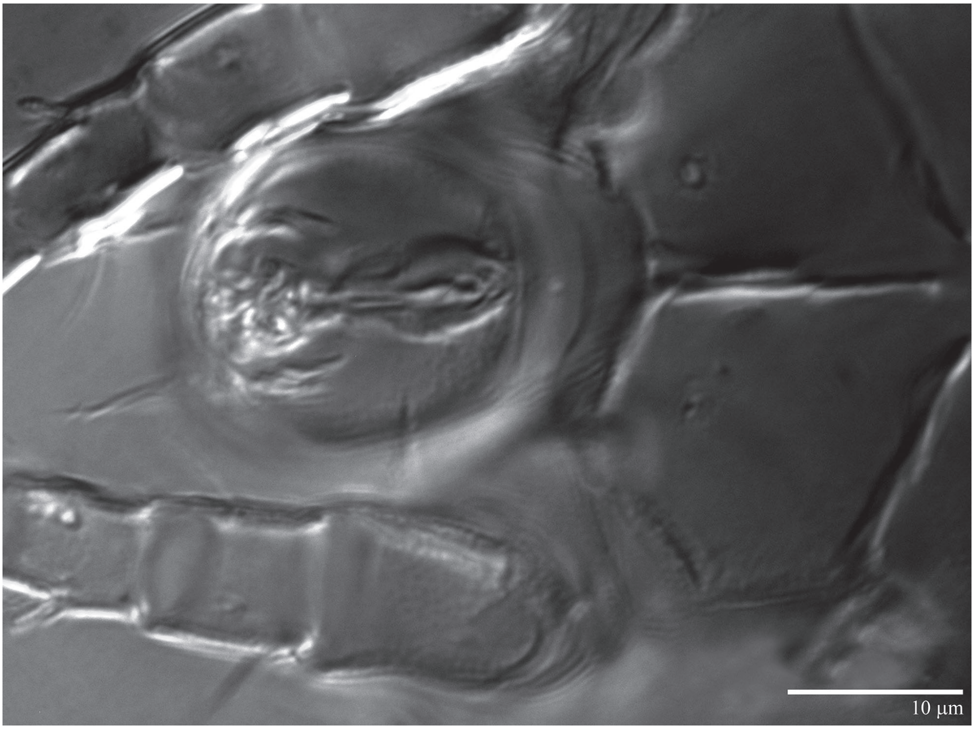

Figure 13. *Daidalotarsonemus oliveirai* sp. n. (male). Detail of the gnathosoma.

15 (14–17) long and 7 (6–8) wide at widest region. Gnathosoma, idiosoma and legs covered with tiny dimples, each 0.3 (0.2–0.5) in diameter.

Idiosoma – dorsum (Figs 8-9): length 174 (170–178), maximum width 82 (80–84). Prodorsal shield trapezoidal. Length of dorsal setae: *v1* 30 (29–31), *v2* 24 (22–25), *sc1* 38 (37–40), *sc2* 24 (22–25), *c1* 21 (20–22), *c2* 26 (24–29), *d* 32 (30–34), *f* 14 (13–16). All setae setiform and serrate. Distances between dorsal setae: *v1–v1* 13 (12–14), *sc1–sc1* 34 (32–35), *sc2–sc2* 44 (43–46), *v1–sc2* 26 (25–27), *c1–c1* 75 (74–77), *c2–c2* 78 (76–80), *c1–c2* 44 (43–47), *d–d* 45 (44–47), *f–f* 22 (20–23). Seta *sc2* laterad and slightly posterior to *sc1*; seta *c1* closer to *d* than to *c2*, anterolateral to the latter.

Idiosoma – venter (Figs 10-11): setae *1a* 6 (5–6) posteriad of apodemes 1; setae *2a* 7 (7–8) located in the center of coxisternal plate 2; seta *3a* 12 (11–13) located near anterior end of apodeme 3; and seta *3b* 12 (10–14) located near middle of apodeme 4. Apodeme 1 fused to anterior end of prosternal apodeme; apodeme 2 not fused to prosternal apodeme. Prosternal apodeme conspicuous between coxisternal plates I but thin between coxisternal plates II, extending close to sejugal apodeme. Sejugal apodeme conspicuous. Lines of fusion between coxae III and IV with venter of idiosoma mostly conspicuous (apodemes 3 and 4, poststernal apodeme and connecting apodeme between apodemes 3 and 4); connecting apodemes between apodemes 4 and poststernal diffuse.

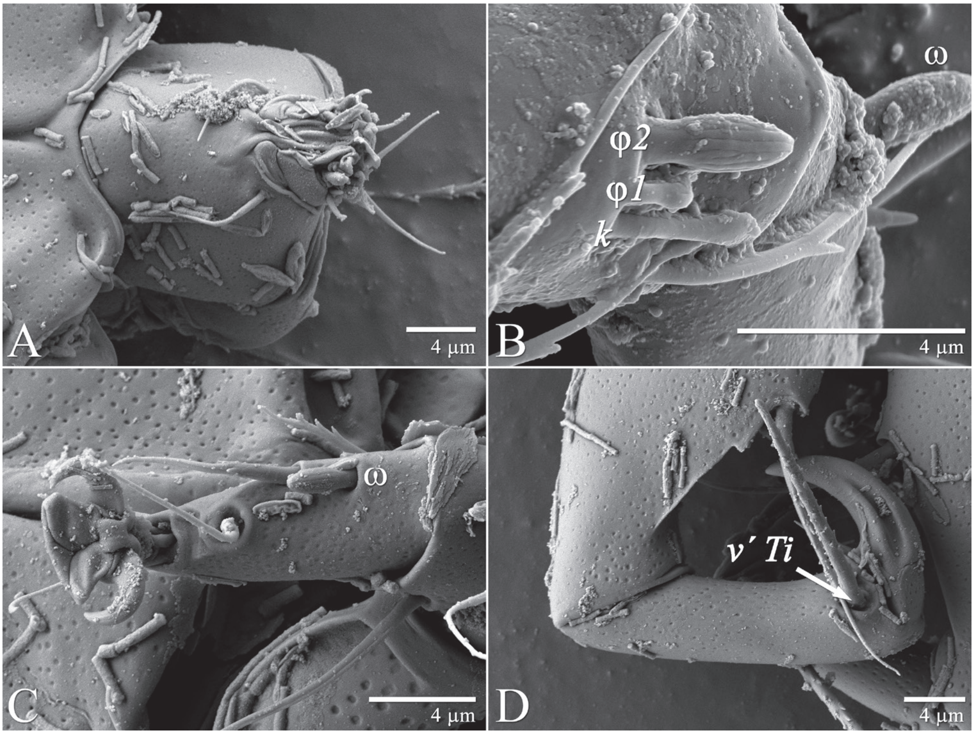

Figure 14. *Daidalotarsonemus oliveirai* sp. n. (male). **A** gnatosoma **B** sensorial cluster of tibia I **C** tarsus II **D** part of tibia and tarsus IV.

Legs (Fig. 12): lengths (measured from femur to tarsus): leg I 63 (62–65), leg II 59 (57–61), leg III 81 (79–83), leg IV 83 (81–84). Number of the setae (solenidia in parentheses) on femur, genu, tibia and tarsus, respectively: leg I: 4-4-6(2)-9(1), leg II: 3-3-4-4(1), leg III: 1-3-4-3. Claws medium-sized (not reduced) and hooked. Empodia of the legs I, II and III about the same size or slightly smaller compared to the respective basal stalks. Solenidion *ω* of tarsus I 4 (3–5), stout, wider medially. Sensory cluster of tibia I composed of *φ1* 3 (3), *φ2* 4 (4–5) and famulus *k* 4 (4), all inserted at approximately same level (Fig. 14B). Seta *d* of tibia I 27 (26–30), serrate. Solenidion *ω* of tarsus II proximally inserted 4 (4–5) long, stout, wider medially (Fig. 14C). Seta *d* of tibia II 23 (21–24), serrate. Trochanter IV slightly wider than long, seta *v'* 13 (12–14), smooth. Femorogenu IV 41 (40–43) long and 17 (16–19) wide at *v'* F level; anterior margin convex, posterior margin slightly convex at proximal third, with a serrate-like projection between these margins. Seta *v'* F 9 (8–10), serrate. Setae *v'* G 17 (16–18) and *l"* G 12 (11–13), smooth. Tibia IV 24 (22–26) long; solenidion *φ* 7 (6–8); seta *v'* Ti 28 (27–31), serrate. Tarsus IV short, bearing 3 smooth setae of the following length: *tc"* 4 (4–5), *pv"* 6 (5–7) and *u'* 5 (4–6). Claw well developed (Fig. 14D).

Type material. Holotype female, allotype male, 6 paratype females and 2 paratype males from *Theobroma cacao* L., 1 paratype female from *Annona muricata* L. and 2 paratype females from *Spondias purpurea* L., 14°47'45"S; 39°10'18"W, Ilhéus, State of Bahia, Brazil, 10/IX/2012, A.C. Lofego and J.M. Rezende. Holotype, allotype, 7 paratype females and 2 paratype males are deposited at DZSJRP and 2 paratype females are deposited at USNM.

Etymology. The species name *oliveirai* is in honor of Dr. Anibal Ramadan Oliveira (UESC - Universidade Estadual Santa Cruz from Ilhéus-BA) for his contribution to study of mites and for all his support during the samplings in the region.

Excelsotarsonemus caravelis Rezende, Lofego & Ochoa, sp. n.

http://zoobank.org/101417BE-223C-4746-9107-05528AD1A7F8

Figs 15–21

Diagnosis. Females of this species resemble those of *Excelsotarsonemus kimhansenae* Ochoa & OConnor because of the shape of dorsal setae *v1*, *sc2*, *c1* and *c2*, and the ornamentation pattern on the prodorsum; but they are distinguished by the asymmetric shape of setae *e* and the U-shaped cerotegument accumulation between prodorsum and tergite C in *Excelsotarsonemus caravelis* sp. n., whereas setae *e* are orbicular and smooth and tergite C surface is smoother in *E. kimhansenae*. The accumulation of the cerotegument between the tergites was easily noticed in all microscopy techniques used (Fig. 16), and it is being considered a taxonomic feature, useful for distinguishing these species.

Adult female (5 specimens measured). Gnathosoma (Figs 17, 20, 21A-B): completely covered by prodorsum. Subtriangular in ventral view, length 22 (21–24), maximum width 17 (16–19); dorsal apodeme distinct. Setae *dgs* 7 (7–8) and *vgs* 5 (5–6) smooth; palps moderately short 6–8 (7), with 2 small subterminal setae and terminal projections. Pharynx fusiform, 15 (15–16) long and 6 (6) wide at maximum width. Gnathosoma, idiosoma and legs covered with tiny dimples, each 0.3 (0.2–0.5) in diameter.

Idiosoma – dorsum (Figs 15-16): length 167 (166–168), width at level of *c1* 86 (84–90); prodorsal shield normally covering entire gnathosoma, with three external humps, broader proximally, central area with an inverted Y-shaped pattern. Stigma near lateral notch of the prodorsal shield, equidistant to the *v1* and *sc2* setal bases. Entire dorsum covered with cerotegument with a U-shaped cerotegument accumulating between the prodorsum and tergite C (Fig. 16). Tergite D with irregular bumps near setae *d*. Lengths of the setae: *v1* 29 (27–31), *sc1* 16 (14–18) (Fig. 21C), *sc2* 47 (45–49), *c1* 40 (40–41) (Fig. 21E), *c2* 9 (8–10), *d* 30 (28–32) (Fig. 21F), *e* 16 (16–17), *f* 36 (35–38) and *h* 13 (11–16). Maximum width of expanded setae: *sc2* 3 (3–4), *c1* 11 (11–12), *d* 22 (21–23), *e* 32 (31–33) and *f* 12 (11–13). All setae serrate, except for *c2* which is smooth. Bothridial setae *sc1* capitate with tiny spines; *sc2* linear with a strong central furrow; setae *c1* lanceolate, *d* ovate and *f* oblanceolate with serrate central veins; *e* each totally asymmetric (Figs 21G-H). Distances between dorsal setae: *v1–v1* 26 (24–29), *sc2–sc2* 46 (45–48), *v1–sc2* 15 (14–16), *c1–c1* 43 (41–45), *c2–c2* 89 (85–96), *c1–c2* 36 (34–38), *d–d* 27 (27–28), *f–f* 11 (9–13), *e–f* 12 and *h–h* 5 (4–7). Seta *sc2* located anteriorly to *sc1*. Dorsal cupules not easily seen.

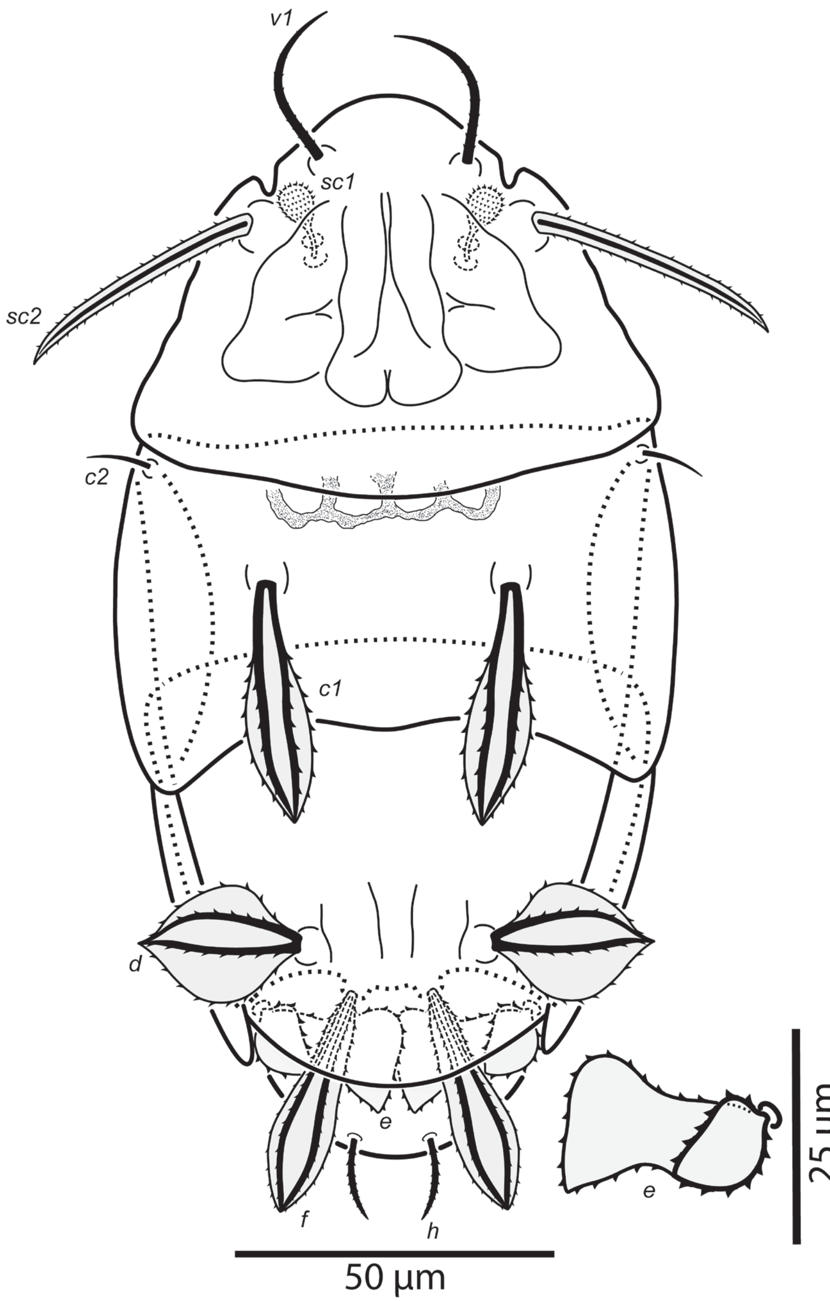

Figure 15. *Excelsotarsonemus caravelis* sp. n. (female). Dorsal surface.

Idiosoma – venter (Figs 17-18): seta *1a* 6 (6–7), posteriad of apodemes 1; *2a* 9 (9–10), posterolaterad of apodemes 2; *3a* 11 near anteriomedial margins of apodemes 3; *3b* 8 (8–9) on posterior margins of apodemes 4. Apodeme 1 conspicuous and fused

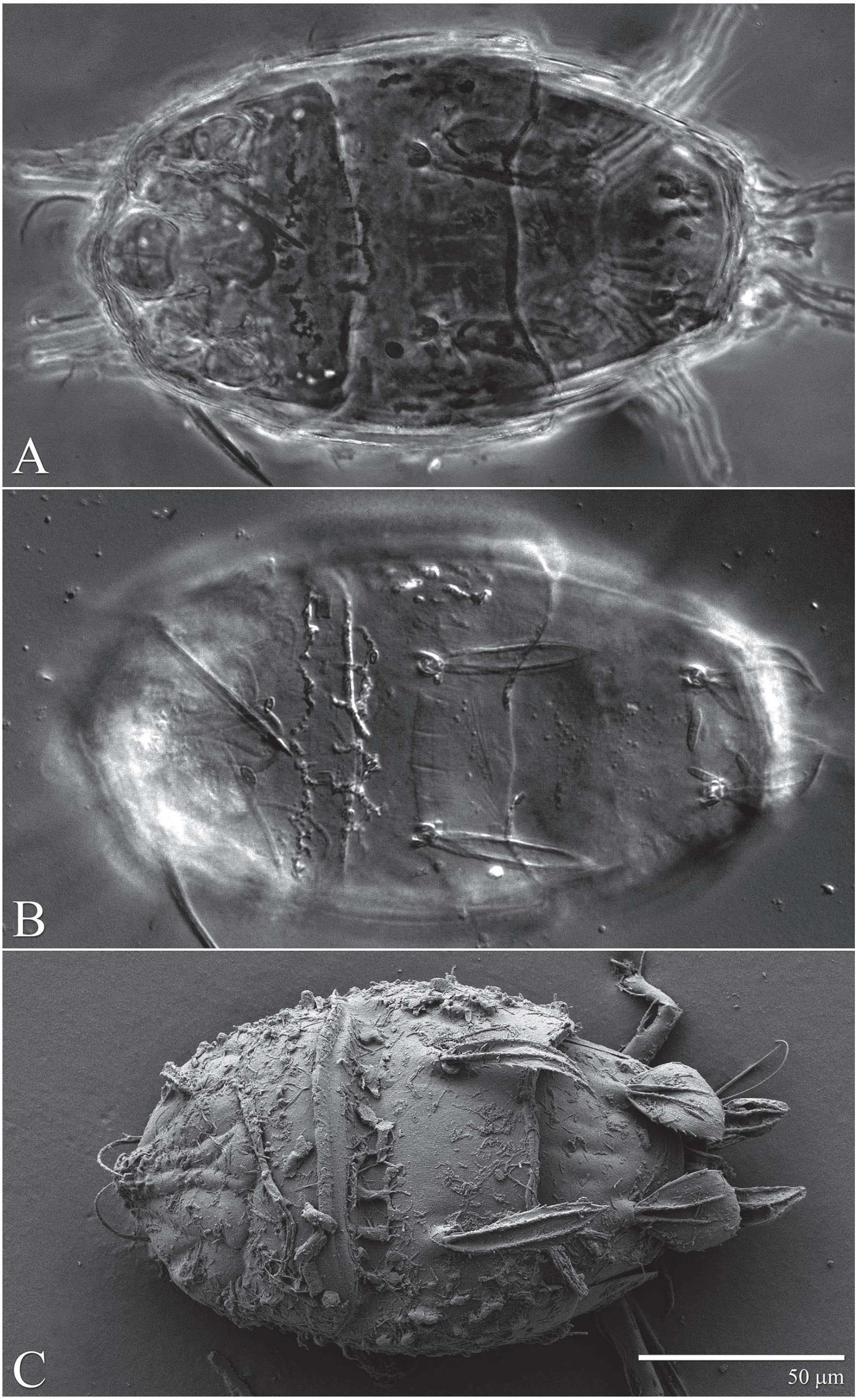

Figure 16. *Excelsotarsonemus caravelis* sp. n. (female). Dorsal micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

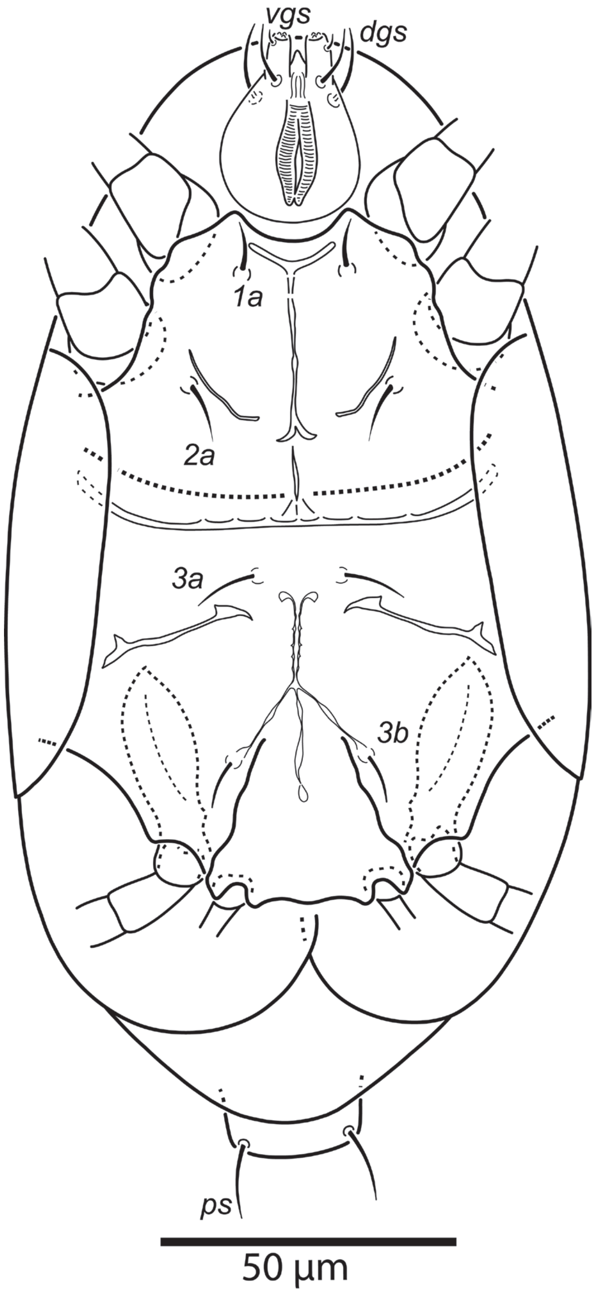

Figure 17. *Excelsotarsonemus caravelis* sp. n. (female). Ventral surface.

to anterior end of prosternal apodeme. Apodeme 2 short and not fused to prosternal apodeme. Prosternal apodeme conspicuous from junction with apodeme 1 near middle of sejugal apodeme portion. Sejugal apodeme uninterrupted with several small

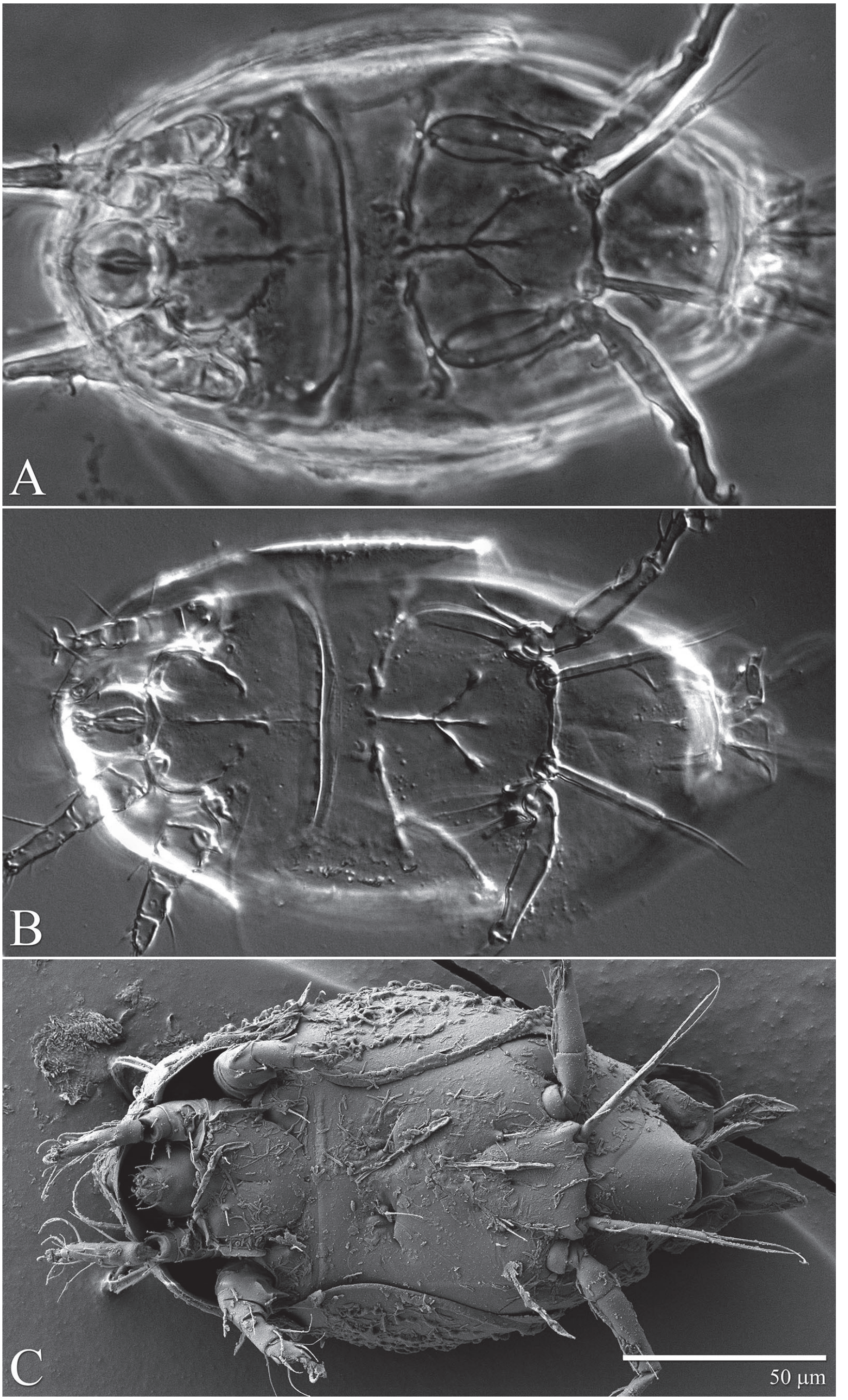

Figure 18. *Excelsotarsonemus caravelis* sp. n. (female). Ventral micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

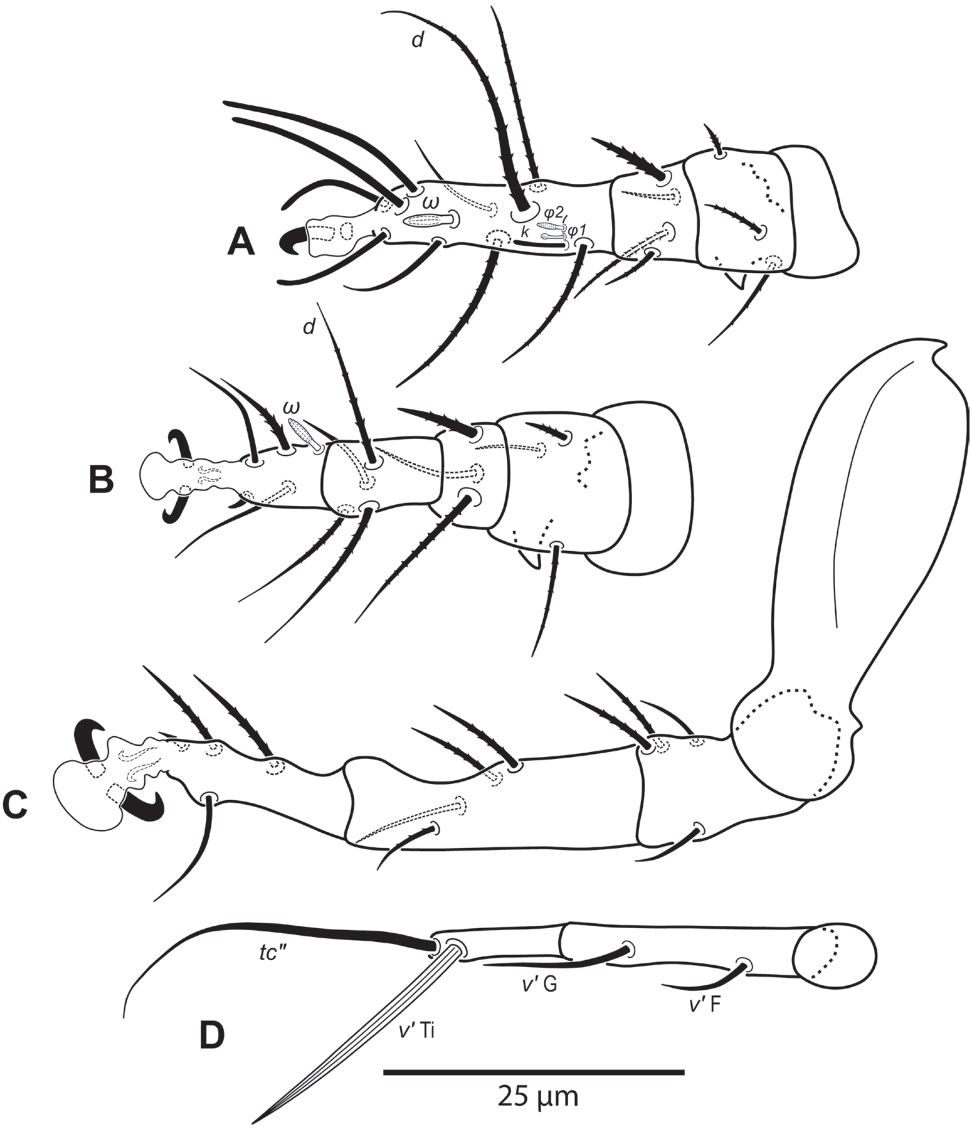

Figure 19. *Excelsotarsonemus caravelis* sp. n. (female). **A** leg I **B** leg II **C** leg III **D** leg IV.

indentations. Apodeme 3 with a constriction near anterior end, extending diagonally from proximity of base of seta *3a* to anterior margin of trochanter III; apodeme 4 extending diagonally from the middle of the poststernal apodeme to base of seta *3b*. Poststernal apodeme bifurcated anteriorly. Tegula wide 16 (15–17) and very short, 4 (4–5) (Fig. 21I), posterior margin slightly arched. Setae *ps* 17 (16–19) smooth.

Legs (Fig. 19): lengths (measured from femur to tarsus): leg I 42 (42–43), leg II 40 (39–41), leg III 92 (89–95), leg IV 32 (31–35). Number of setae (solenidia in parentheses) on femur, genu, tibia and tarsus, respectively: leg I: leg I: 3-4-5(2)-7(1),

Figure 20. *Excelsotarsonemus caravelis* sp. n. (female). Detail of the gnathosoma.

leg II: 3-3-4-4(1), leg III: 2+2-4-4. Claws medium-sized (not reduced) and hooked. Empodia of the legs I, II and III about the same size or slightly smaller compared to the respective basal stalks. Tarsal solenidion *ω* of tibiotarsus I 4 (4–5), stout, wider medially. Sensory cluster of tibia I complete (Fig. 21D), solenidion *φ1* 4 (4–5), slender, capitate; solenidion *φ2* 3, robust, slightly capitate; famulus *k* 6; all those inserted at approximately in the same level. Seta *d* of tibia I 23 (22–24), serrate. Solenidion *ω* of tarsus II proximally inserted, 4 long, stout, wider medially. Seta *d* of tibia II 17 (17–18), serrate. Femorogenu IV 18 (16–20); tibiotarsus IV 9 (9–10). Length of leg IV setae: *v'* F 8 (8–9), *v'*G 10 (10–11), *v'* Ti 23 (22–24) and *tc"* 31 (29–33); setae *v'* Ti and *tc"* smooth; *v'* Ti falcate.

Adult male. Unknown.

Type material. Holotype female and 4 paratype females on *Theobroma cacao* L., 14°47'45"S; 39°10'18"W, Ilhéus, State of Bahia, Brazil, 10/IX/2012, A.C. Lofego and J.M. Rezende. Holotype and 3 paratypes are deposited in the DZSJRP and 1 paratype is deposited in the USNM.

Etymology. The region where this mite was found is the same place as the first Portuguese explorers arrived in Brazil, at the end of 15th century. On their trip, they used caravels, which had big sails. The name *caravelis* is used because several dorsal setae of this mite species are held in the upright position resembling those sails.

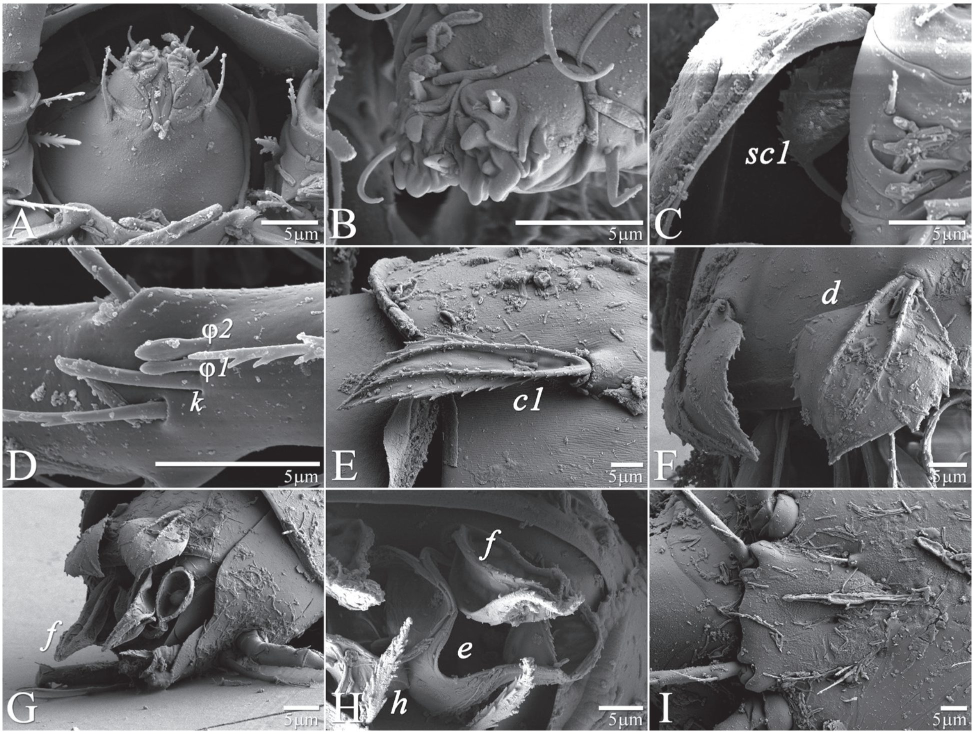

Figure 21. *Excelsotarsonemus caravelis* sp. n. (female). **A** gnatosoma **B** detail of the palps **C** Bothridial seta *sc1* **D** sensorial cluster of tibia I **E** seta *c1* **F** seta *d* **G** tergites **D, E, F, H** and posterior setae **H** setae *e*, *f* and *h* **I** tegula.

Note. Setae *f* has a unique modification as it is oblanceolate dorsal view, with four faces attached by the main vein, giving a deep concavity at either site, with a central furrow dorsally shoe-like; all margins serrate (Fig. 21H). Similar setal complex modification has been observed in *E. mariposa* (setae *d*, *f* and *e*) and other *Excelsotarsonemus* and *Daidalotarsonemus* species under DIC. However, it is under the LT-SEM that we can understand their complexity.

Excelsotarsonemus tupi Rezende, Lofego & Ochoa, sp. n.

http://zoobank.org/B37CCDE2-2748-47BD-B46B-801AD0F22D6F
Figs 22–28

Diagnosis. Females of this species resemble those of *Excelsotarsonemus kaliszewskii* Ochoa & Naskręcki (Ochoa et al. 1995) because of the similar shape of setae *sc2*, *c1* and *d*. However, setae *c2* and *e* of *Excelsotarsonemus tupi* sp. n. are setiform-like, while in *E. kaliszewskii* these setae are falcate and elongate. In addition, the humps on the prodorsum and the muscle attachments of tergite D are very different in shape between these two species, being more ornate and prominent in *E. kaliszewskii*.

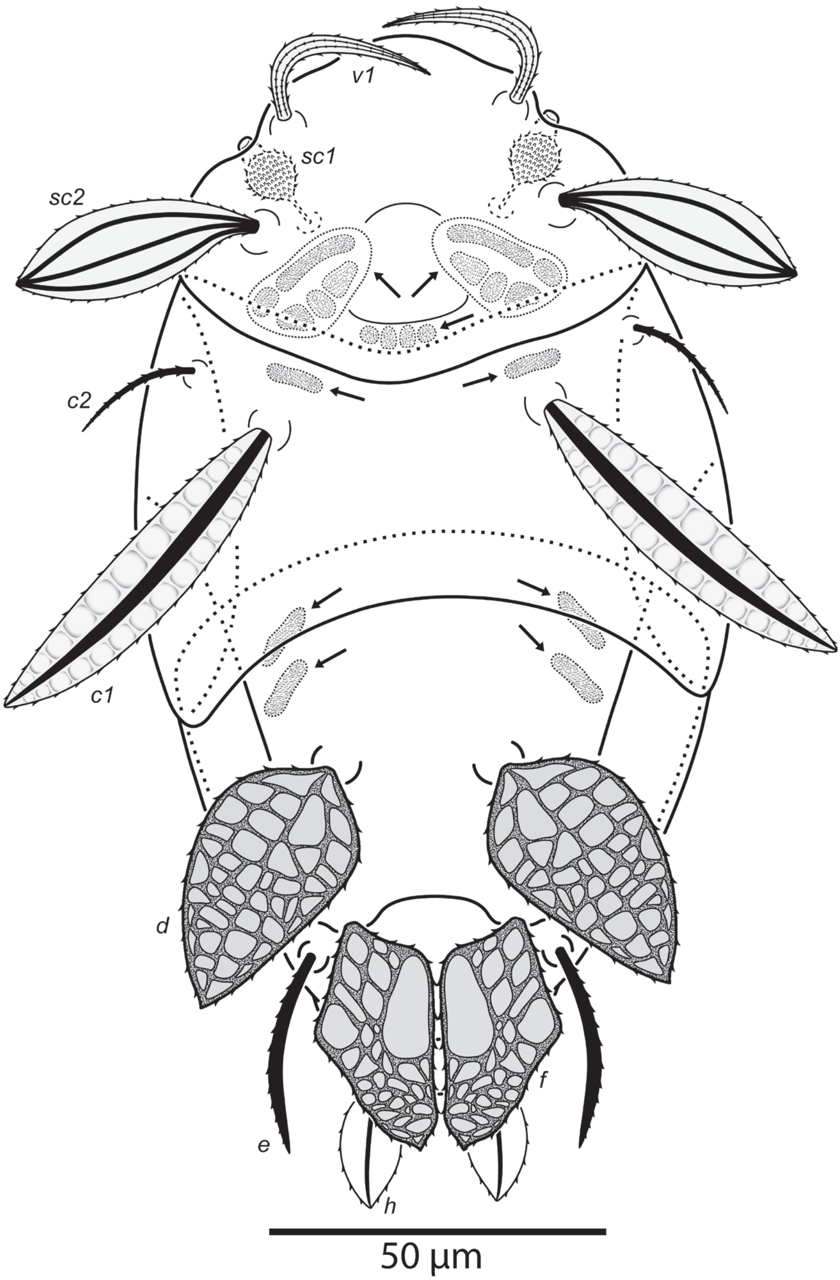

Figure 22. *Excelsotarsonemus tupi* sp. n. (female). Dorsal surface (arrows indicate muscle attachments present over the body).

Adult female (3 specimens measured). Gnathosoma (Figs 24 and 27): completely covered by the prodorsum. Subtriangular in ventral view, length 21 (21–22), maximum width 17 (16–19); dorsal apodeme distinct. Setae *dgs* 8 (7–9) and *vgs* 4 (4–5)

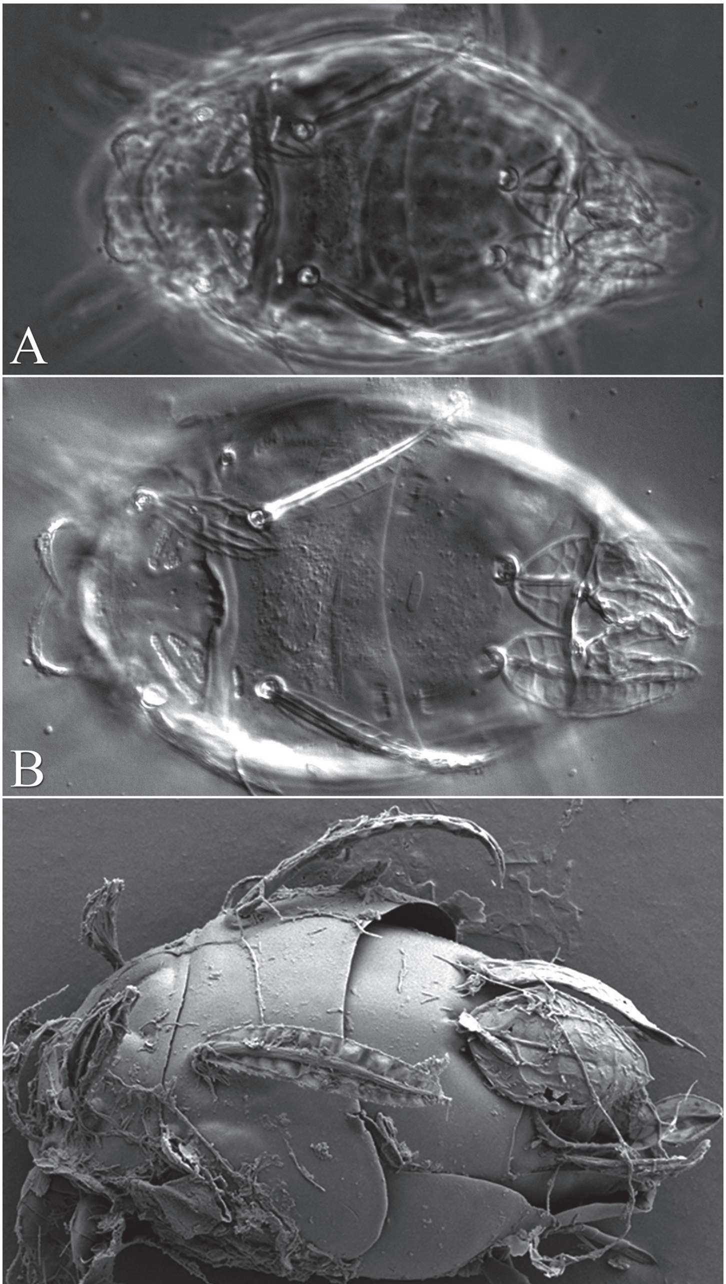

Figure 23. *Excelsotarsonemus tupi* sp. n. (female). Dorsal micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

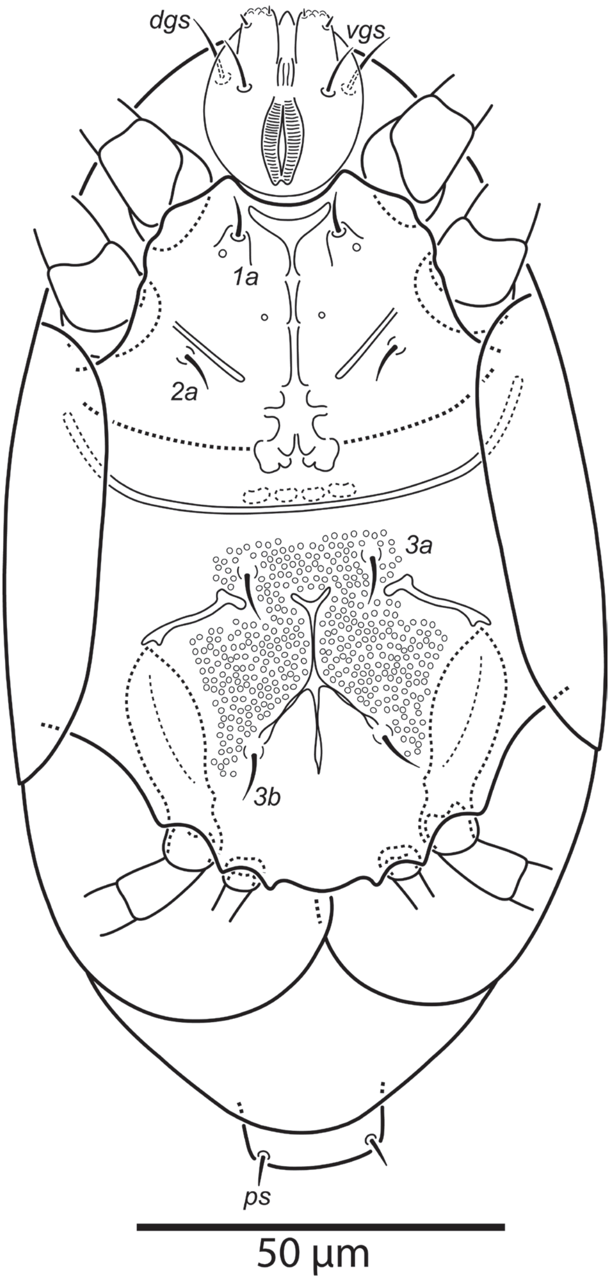

Figure 24. *Excelsotarsonemus tupi* sp. n. (female). Ventral surface.

smooth; Palps moderately short 6–8 (7), with 2 small subterminal setae and terminal projections. Pharynx fusiform, 15 (14–16) long and 8 (7–9) wide at maximum width region. Gnathosoma, idiosoma and legs covered with tiny dimples, each around 0.3 (0.2–0.5) in diameter.

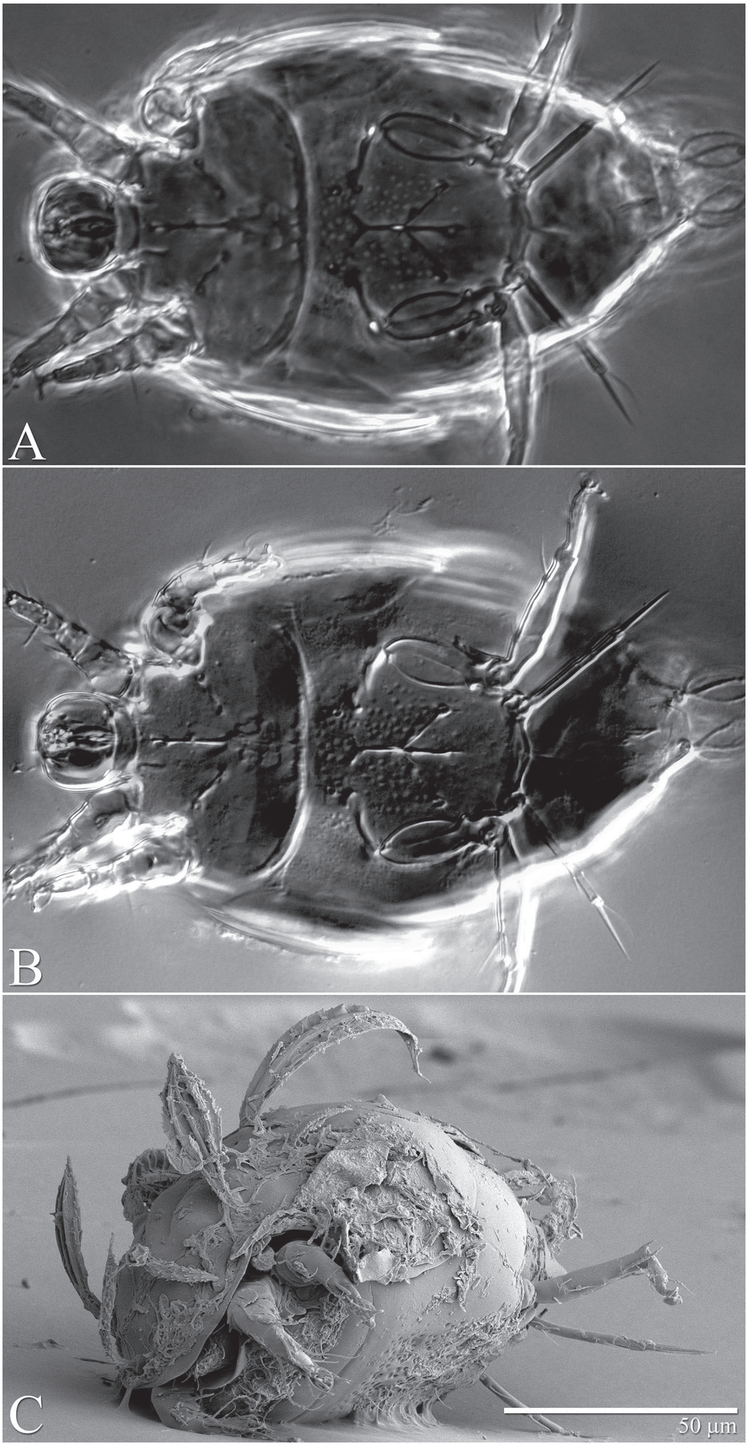

Figure 25. *Excelsotarsonemus tupi* sp. n. (female). Ventral micrographs. **A** phase contrast **B** differential interference contrast **C** low temperature scanning electron microscopy.

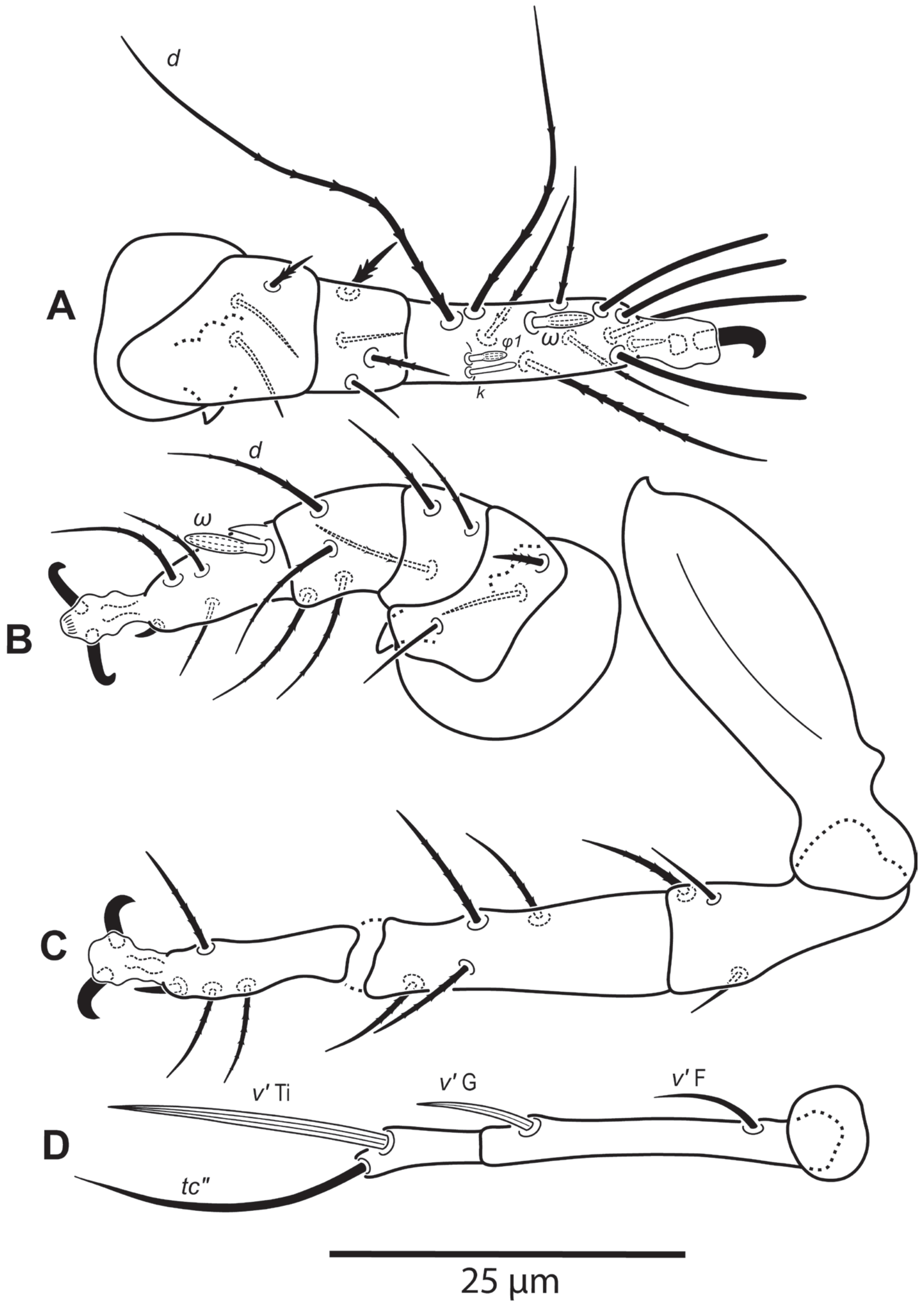

Figure 26. *Excelsotarsonemus tupi* sp. n. (female). **A** leg I **B** leg II **C** leg III **D** leg IV.

Idiosoma – dorsum (Figs 22-23): length 175 (171–179), width at level of *c1* 94 (93–95); prodorsal shield covering gnathosoma. Entire dorsum covered with cerotegument. Stigma inserted proximally at the lateral notch of the prodorsal shield, near the

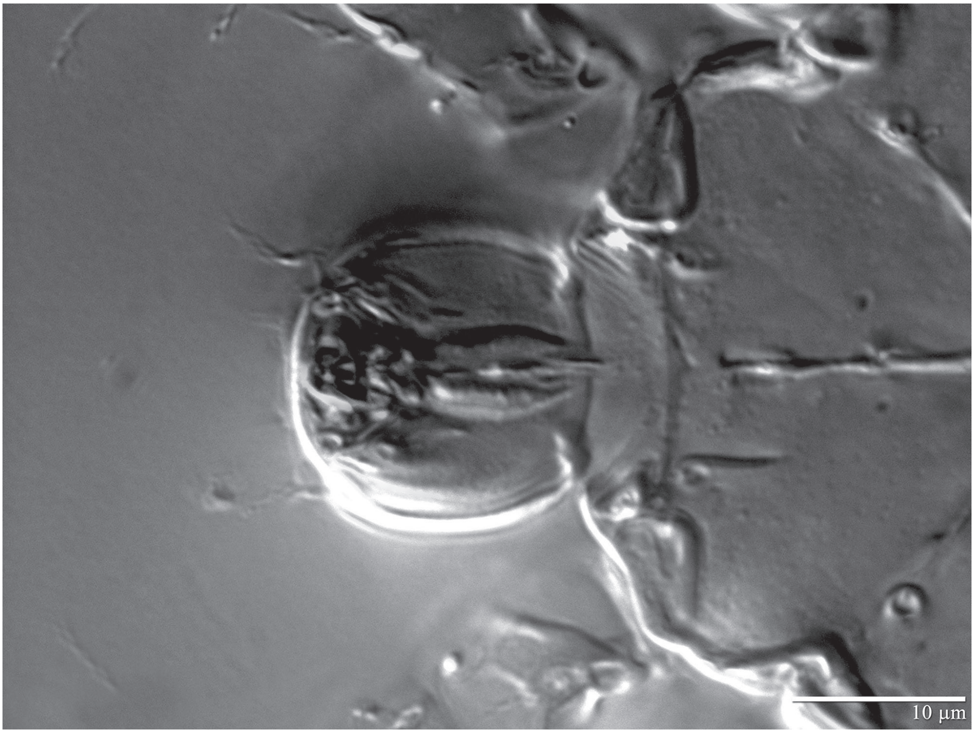

Figure 27. *Excelsotarsonemus tupi* sp. n. (female). Detail of the gnathosoma.

base of setae *v1*. Prodorsum, tergites C and D with distinct muscle attachments, visible with DIC and PC optic microscopes. Lengths of the setae: *v1* 23 (22–25) (Fig. 28C), *sc1* 15 (15–16) (Fig. 28B), *sc2* 44 (43–47) (Fig. 28D), *c1* 46 (44–49) (Fig. 28E), *c2* 14 (11–17), *d* 32 (31–34), *e* 26 (25–29), *f* 36 (35–37) and *h* 19 (19–20). Maximum width of expanded setae: *sc2* 12 (11–13), *c1* 8 (8–9), *d* 22 (21–23), *e* 3 (3–4) and *f* 22 (21–23). All dorsal setae serrated. Bothridia *sc1* capitate with tiny spines. Setae *v1* linear; *c2* setiform; *c1* oblong very elongated; *sc2* lanceolate with three heavy dorsal veins; *d* ovate and *f* asymmetrical, both with internal cells; *e* linear, heavily serrate (Figs 28F-H); *h* elliptical, serrate with one dorsal vein. Distances between dorsal setae: *v1–v1* 37 (37–38), *sc2–sc2* 48 (47–49), *v1–sc2* 16 (15–18), *c1–c1* 45 (44–46), *c2–c2* 76 (74–80), *c1–c2* 17 (16–19), *d–d* 25 (23–28), *f–f* 11 (9–15), *e–f* 13 (11–16) and *h–h* 10 (9–14). Seta *sc2* located lateral to *sc1*. Dorsal cupules not easily seen.

Idiosoma – venter (Figs 24-25): setae *1a* 5 (4–7), inserted on tubercles posteriad of apodemes 1; *2a* 7 (6–10), posterolaterad of apodemes 2; *3a* 8 (7–11) near anteriomedial margins of apodemes 3; *3b* 6 (5–9) on posterior margins of apodemes 4. Apodeme 1 conspicuous, fused to anterior end of prosternal apodeme. Apodeme 2 short and not fused to prosternal apodeme. Prosternal apodeme not clearly united with sejugal apodeme, continuous along length to level of apodemes 2, ending in a diffuse area that reaches to sejugal apodeme. Sejugal apodeme uninterrupted. Apodeme 3 with a constriction near

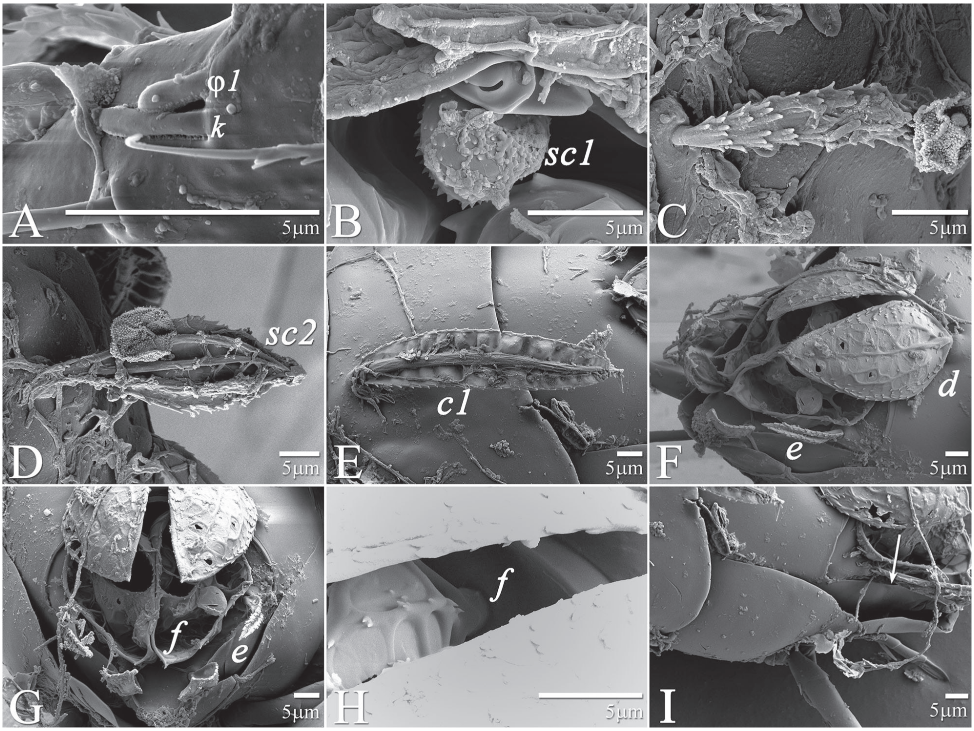

Figure 28. *Excelsotarsonemus tupi* sp. n. (female). **A** sensorial cluster of tibia I **B** Bothridial seta *sc1* and stigma opening **C** seta *v1* **D** seta *sc2* **E** seta *c1* **F** lateral view of the setae *d*, *e*, *f* and *h* **G** posterior view of the setae *d*, *e*, *f* and *h* **H** insertion of seta *f* **I** posterior view of tergites **E, F** and **H** (which is indicated by an arrow).

anterior end, extending diagonally from proximity of base of seta *3a* to anterior margin of trochanter III; apodeme 4 extending diagonally from the middle of the poststernal apodeme to base of seta *3b*. Poststernal apodeme bifurcated anteriorly. Externally, apodemes 3 and 4 surrounded by a distinct punctation. Tegula wide 16 (15–17) and very short 4 (4–5) with posterior margin slightly arched. Seta *ps* 6 (15–6) smooth.

Legs (Fig. 26): lengths (measured from femur to tarsus): leg I 44 (43–48), leg II 40 (39–41), leg III 90 (88–93), leg IV 33 (31–35). Number of setae (solenidia in parentheses) on femur, genu, tibia and tarsus, respectively: leg I: 3-4-4(2)-7(1), leg II: 3-3-4-4(1), leg III: 0+3-4-4. Claws medium-sized (not reduced) and hooked. Empodia of the legs I, II and III about the same size or slightly smaller compared to the respective basal stalks. Tarsal solenidion *ω* of tibiotarsus I 4 (4–5), stout, wider medially. Sensory cluster of tibia I incomplete, solenidion *φ1* 4, slender, capitate; famulus *k* 6 (6–7); both inserted at approximately the same level (Fig. 28A). Seta *d* of tibia I 21 (20–22), serrate. Solenidion *ω* of tarsus II proximally inserted, 4 long, stout, wider medially. Seta *d* of tibia II 18 (17–21), serrate. Femorogenu IV 19 (19–20); tibiotarsus IV 8 (7–9). Length of leg IV setae: *v'* F 7 (7–8), *v'* G 10 (9–11), *v´* Ti 18 (19–23) and *tc"* 25 (23–28); setae *v'* Ti and *tc"* smooth; *v'* Ti falcate.

Adult male. Unknown.

Type material. Holotype female and 2 paratype females on *Theobroma cacao* L., 14°47'45"S; 39°10'18"W, Ilhéus, State of Bahia, Brazil, 10/IX/2012, A. C. Lofego and J.M. Rezende. Holotype and 2 paratype females are deposited in the DZSJRP.

Etymology. The species name *tupi* is in honor of a Tupi people, one of the most important native indigenous tribes in Brazil which used to live in all coastal region where this mite species was found.

Discussion

Some characters of *Daidalotarsonemus*, *Excelsotarsonemus* and other tarsonemids in general have been misunderstood or have not been clearly interpreted, certainly because of the reliance on only light microscopy technology. This becomes clear by comparing LT-SEM micrographs with the drawings of species described previously. The use of LT-SEM and other SEM techniques by acarologists is useful to truly understanding morphological details of the mites, and contributing to more accurate and reliable taxonomic and systematic studies.

The extension of the prodorsum over the gnathosoma in the genera *Daidalotarsonemus* and *Excelsotarsonemus* is a feature mentioned by Lindquist (1986) and Ochoa et al. (1995), respectively. Using the LT-SEM, it was observed the gnathosoma has the ability to protract and retract, being covered by the prodorsum and the coxisternal plates I (Figs 4, 18 and 25).This is a difficult character to discern using light microscopy, mainly because slide mounting distorts it by the flattening of the specimen between the slide and the coverslip, often pushing the gnathosoma forward. In the *Daidalotarsonemus* species studied, it was observed these mites are able to partially retract the gnathosoma under the propodosoma, leaving the distal part, including the palps exposed. The two species of *Excelsotarsonemus* are able to retract the entire gnathosoma, similar to turtles, under the propodosoma and over the apodemes 1.

Both genera studied, especially *Excelsotarsonemus*, have some dorsal setae (especially *sc2, c1*, *d*, *e* and *f*) with very broad and intricate folding patterns. It is not clear the function of these setae yet. Each one has strong veins that probably help it raise up and maintain itself perpendicular to the body. These sail-like setae might allow them to become airborne, gliding within the canopies and colonizing new trees (Ochoa and OConnor 1998). Setae *e* and *f,* because of their position and the way they lay above tergite H, seem to have different functions, perhaps related to protection, entrapping fungal spores and/or improving the aerodynamic characteristics of the mites. Some setae have even more complicated patterns, e.g. the setae *e* of *Excelsotarsonemus caravelis* (clearly asymmetric) and setae *f* of *Excelsotarsonemus tupi* (asymmetrical and with internal cells). Furthermore, setae *d* in both species apparently sits on the modified setae *e* or *f* like a lid (Fig. 21G, 21H, 28F, 28H). Tergite EF and its setae are supported by plate H, which is concave; both plates are partially covered by the posterior projection of tergite D (Fig. 28I).

It was noticed the production of cerotegument (Krantz 2009) over the body of both genera. Using LT-SEM, the cerotegument was captured extending over the body with fungi, lichens and bacteria accumulating on it. The cerotegument along with its attached material are shed at the edge of the tergites, especially on the propodosoma and tergites C and D (Figs 2C, 4C, 9C, 16C, 18C, 23C and 25C), indicating a way these mites might disseminate microorganisms and even plant pathogens. Although these mites were preserved in 70% alcohol for about eight months, the cerotegument still contained fungi and bacteria. The primary purpose of this substance appears to be water retention, but it also may allow the mite to cover itself in another layer of particles if the substance is sticky (Walter and Proctor 2013). This fact has important biological and agricultural implications. First, this substance allows them to carry debris over their body when they disperse between the canopies. Also, the cerotegument could protect the mite against harmful fungi, being a barrier between them and the soft cuticle. Lastly, by carrying fungi and bacteria, they may act as reservoirs of microorganisms (including plant pathogens) to their host plants, and spreading them throughout the forests and surrounding crops. More studies on the biology and feeding parameters of these genera are necessary to better understand their role and impact.

The discovery of three new mite species in such a small sampling area is remarkable. Although South America has five of the biodiversity hotspots biomes of the world (Myers et al. 2000), just 10 tarsonemid species have been described based on specimens found in this region (Lofego et al. 2005, Lofego and Gondim Jr. 2006, Lofego and Feres 2006, Lofego et al. 2007, Moraes et al. 2002). In addition, two species of *Daidalotarsonemus* and three of *Excelsotarsonemus* were found in very similar rainforest areas in Costa Rica (Ochoa et al. 1991; Ochoa et al. 1995, Ochoa and OConnor 1998). Most of these mite species in Costa Rica and Brazil were collected on cocoa trees. This tropical crop has broad leaves which are often covered with fungi and lichens, making it a perfect collecting trap of falling insects and mites from the surrounding tree canopy. Undoubtedly, there is much more to be learned of the species composition, biology and ecology of tarsonemid species present in this rainforest. It is also alarming to think about how much biological information is probably being lost even before it becomes known to the scientific community due to deforestation. For this reason, it is imperative to conduct more surveys to increase the knowledge of the fauna of Tarsonemidae and other mite families in forest canopies around the world.

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RESEARCH ARTICLE

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The Blattodea *s.s.* (Insecta, Dictyoptera) of the Guiana Shield

Dominic A. Evangelista[1], Kimberly Chan[1], Kayla L. Kaplan[1], Megan M. Wilson[1], Jessica L. Ware[1]

1 *Department of Biology, Rutgers University, 195University Ave, Newark, NJ, 07102, USA*

Corresponding author: *Dominic A. Evangelista* (dominicev@gmail.com)

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Abstract

Here we provide a checklist of cockroach species known from areas within the Guiana Shield based on literature records and new field collection. We give records of sixteen species collected in Guyana, eight of which are new records for Guyana and one of which is a new generic record for the entire Guiana Shield. We also provide a description for a geographically disparate species of *Calhypnorna* Stal, and the new species *Xestoblatta berenbaumae*. The complete checklist contains 234 species of Blattodea *s.s.* currently known in the shield. This checklist shows particularly low richness in Guianan Venezuela, Roraima and Amapa Brazil, but this is likely an artifact due to under–sampling. Indeed, based on previously published data and current fieldwork, we believe that most regions of the Guiana Shield are under–sampled for cockroaches. Despite this, French Guiana (151 spp.) and Suriname (136 spp.) rank as the second and sixth most species dense faunas of cockroaches in the neotropics.

Keywords

Cockroach, species richness, *Calhypnorna*, *Xestoblatta*, Guyana

Introduction

The Guiana Shield is known for a high diversity of both plant and animal life (Alexander et al. 2005). Blattodea (Insecta: Dictyoptera), or cockroaches and termites, as well as most other insects, remain under-sampled relative to their biodiversity in the region. Developing more complete lists of fauna improves our ability to infer biogeographical patterns and make predictions about biodiversity loss. Additionally, keeping current records of regional faunas can assist in documenting introduced and invasive species, something particularly relevant to the study of cockroaches (Evangelista et al. 2013; Nickle 1984; Peterson and Cobb 2009).

The cockroach fauna of the entire Guiana Shield has previously been addressed by three works (i.e. Bonfils 1975; Bruijning 1959; Princis 1963). Princis' catalogue (1963) of global cockroach distributions is an important resource to consult for this fauna. However, there were cases (although very few) where Princis was incomplete in his records (pers. obs.; Pellens and Grandcolas 2008). Bruijning's (1959) and Bonfils' (1975) checklists are more manageable than Princis's global catalog given their focused geographic scope, but they are also an incomplete record of the fauna. Regardless, Bonfils' (1975), Bruijning's (1959) and Princis' (1963) work are all now 40 years or more out of date.

The cockroach fauna of sections of the Guiana Shield have been addressed directly by a few sources (e.g., Bonfils 1987; Bruijning 1959; Hebard 1926; Perez 1988; Rehn 1906; Rocha E Silva Albuquerque and Gurney 1962) as well as peripherally by others (e.g., Evangelista et al. 2014; Hebard 1921b; 1929; Pellens and Grandcolas 2008; Rehn 1928; Velez 2008). A few manuscripts have addressed the Blattodean faunas of French Guiana (Hebard 1926) and Suriname (Bruijning 1959) respectively. The Guianan fauna of relevant parts of Brazil and Venezuela are available from checklists for these respective countries (Bonfils 1987; Pellens and Grandcolas 2008; Perez 1988). However, there is no singular source to be consulted for the Blattodean fauna of Guyana (formerly known as British Guyana).

Lastly, the most current phylogenies of Blattodea all show that termites (Termitoidae) are nested within Blattodea (Djernaes et al. 2012, 2014; Inward et al. 2007; Ware et al. 2008). Given that this has only been recently adopted by systematists, there are few taxonomic treatments considering both termites and cockroaches simultaneously. Since each insect group requires very different morphological and organismal expertise this is understandable. In following, we present the most recent summative list of the non-termite Blattodea fauna of the Guiana Shield as well as for the country of Guyana.

Methods

Checklist

The checklist was initially compiled by synthesizing range data from the published literature. Searches for taxonomic records included some combination of the following locality names: British Guiana, Suriname, French Guiana, Guyane, Guiana or Guyana. Five additional sources were consulted (Bonfils 1987; Lopez-Osorio and Miranda-Esquivel 2010; Pellens and Grandcolas 2008; Perez 1988) for the taxa of the following states: Amazonas Venezuela, Bolivar Venezuela, Delta Amacuro Venezuela, Roraima Brazil and Amapa Brazil. The states of Para and Amazonas in Brazil were omitted because the majority of these states do not fall within the borders of the Guiana Shield. The recently published checklist of the cockroaches of Brazil (Pellens and Grandcolas 2008) sufficiently covered the fauna of these states. We treated ranges specified by

Princis (1963) as circumtropical, neotropical, or cosmopolitan as a presence for each region, even without a specific record for that region. Additional records were added based on specimens collected by the Ware lab in the field.

The validity of all taxonomic names was verified on the Cockroach Species File (CSF) online database (Beccaloni 2014). All synonymous names were changed to their valid name in the final checklist. All invalid higher taxa were given proper names in accordance with the most current taxonomy (Beccaloni and Eggleton 2011, 2013).

Specimen collection

We collected cockroaches from the field on four occasions from 2011 to 2013. All specimens were collected in Guyana. Specific collection information (locality and GPS, collection date, collectors and ecological information) is given with each record.

New records and descriptions

Species that were collected and could be identified are presented here. We report all collection information and some morphological information for each specimen as well as currently known geographic distribution as described on the Cockroach Species File database (Beccaloni 2014). All morphological measurements were done using Infinity software (INFINITY Camera Software 2013). For new species, we provide descriptions of gross morphology and male genitalia. The genitalia were dissected in accordance with the method of Roth (1969), whereby the genitalia are removed from the specimen by making a lateral incision along the subgenital plate, separating the genitalia from the remainder of the body and placing them in a KOH (10% by mass) solution until cleared (approx. 8 hours). Cleared genitalia were kept in a micro-vial with 70% ethanol after examination. We also include some notes on potential evolutionary relationships of some genera by referencing the cytochrome oxidase I (COI) gene tree published by the first and last author (Evangelista et al. 2014).

We imported the checklist data into Mathematica 9.1 (Wolfram Research 2012) to calculate the endemism rates of the faunas of each region. We calculated this as the proportion of species in a given region not present in any other region of the shield. We also calculated faunal similarity rates (inverse of endemism) among each region.

Results

Records and descriptions of cockroaches from Guyana

Here we report information on some of the specimens from our field collection. Those species listed here that are new records for Guyana are denoted by a "+" in the checklist (Table 1). Morphological measurements for all specimens are given in Table 2.

Table 1. Checklist of species from 8 regions of the Guiana Shield. ? = Record with a non-specific locality, and thus unconfirmed in this region. o = Presence record from published literature. + = new record from this paper. Amaz VEN = Amazonas Venezuela, Bolivar VEN = Bolivar Venezuela, Del Ama VEN = Delta Amacuro Venezuela, Rora BRA = Roraima Brazil, GUY = Guyana, SUR = Suriname, FG = French Guiana, Amapa BRA = Amapa Brazil.

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
Blaberidae									
Blaberinae									
Blaberus atropos (Stoll, 1813)	?	?	?		o				(Bruijning 1959; Hebard 1929; Perez 1988; Princis 1963; Princis and Kevan 1955; Walker 1868)
B. colosseus (Illiger, 1801)					o		o		(Bonfils 1987; Princis 1963; Hebard 1916)
B. craniifer Burmeister, 1838					o		o		(Princis 1963; Gutierrez and Perez-Gelabert 2000)
B. discoidalis Serville, 1838		o							(Princis 1963; Perez 1988; Princis and Kevan 1955; Gutierrez and Perez-Gelabert 2000)
B. giganteus (Linnaeus, 1758)					o	o	o	o	(Bonfils 1975; Bruijning 1959; Gutierrez and Perez-Gelabert 2000; Hebard 1926, 1921b; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Princis and Kevan 1955; Rocha e Silva Albuquerque and Gurney 1962; Walker 1868)
B. latissimus (Herbst, 1786)						o			(Princis 1963)
B. parabolicus Walker, 1868						o			(Bruijning 1959; Princis 1963)
Eublaberus distanti (Kirby, 1903)					o	o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963)
E. posticus (Erichson, 1848)					o	o	o		(Bruijning 1959; Hebard 1926, 1929; Princis 1963; Princis and Kevan 1955; Rehn 1906)
E. sulzeri (Guerin-Meneville, 1857)						o			(Princis 1963)
Hormetica laevigata Burmeister, 1838	o								(Perez 1988)
H. marmorata (Saussure, 1869)	?	?	?						(Bonfils 1987; Perez 1988; Princis 1963)
Lucihormetica verrucosa (Brunner von Wattenwyl, 1865)	?	?	?						(Perez 1988; Hebard 1929; Princis 1963)
Neorhicnoda maronensis (Hebard, 1921)					+	o	o		(Bonfils 1975; Bruijning 1959; Grandcolas 1992b; Hebard 1921b, 1926; Princis 1963)
Paradicta rotunda Grandcolas, 1992							o		(Grandcolas 1992b)
P. circumvagans (Burmeister, 1838)	o	o	o	o	o	o	o	o	(Princis 1963)
Phoetalia pallida (Brunner von Wattenwyl, 1865)	o	o	o	o	o	o	o	o	(Baaren et al. 2002; Bruijning 1959; Princis 1963; Princis and Kevan 1955)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
Sibylloblatta pustulata (Hebard, 1929)	?	?	?						(Bonfils 1987; Perez 1988)
Epilamprinae									
Colapteroblatta bordoni Bonfils, 1987		o							(Bonfils 1987)
C. surinama (Saussure, 1868)					o	o			(Princis 1963; Roth Gutierrez 1998)
Dryadoblatta mira Rehn, 1937	o								(Bonfils 1987; Perez 1988; Princis 1963; Rehn 1937a)
Epilampra abdomennigrum (De Geer, 1773)					o	o	o		(Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926, 1929; Princis 1963; Princis and Kevan 1955; Rehn 1903; Shelford 1910)
E. amapae Rocha e Silva Albuquerque & Gurney, 1962								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. azteca Saussure, 1868	o					o	o		(Bonfils 1975 1987; Bruijning 1959; Hebard 1921b, 1926; Perez 1988; Princis 1963; Princis and Kevan 1955)
E. bromeliacea Princis, 1965					o				(Princis 1963)
E. carsevennae Bonfils, 1975							o		(Bonfils 1975)
E. colorata Rocha e Silva Albuquerque & Gurney, 1962								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. conferta Walker, 1868								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. conspersa Burmeister, 1868						o	o	o	(Bruijning 1959; Hebard 1921b, 1926; Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. crossea Saussure, 1864						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
E. egregia Hebard, 1926						o	o		(Bonfils 1975; Bruijning 1959; Princis 1963)
E. fusca Brunner von Wattenwyl, 1865	?	?	?		o	o			(Bruijning 1959; Perez 1988; Princis 1963; Rehn 1906)
E. grisea (De Geer, 1773)					o	o	o	o	(Baaren et al. 2002; Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rehn 1903, 1906; Rocha e Silva Albuquerque and Gurney 1962; Shelford 1910; Walker 1868)
E. guianae Hebard, 1926					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
E. maculicollis (Serville, 1838)					o		o		(Hebard 1921b; Rehn 1906)
E.opaca Walker, 1868	?				o	o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926, 1929; Pellens and Grandcolas 2008; Perez 1988; Rocha e Silva Albuquerque and Gurney 1962; Roth 1970; Walker 1868)
E.sagitta Hebard, 1929								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. sodalis Walker, 1868	o				+	o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
E. substrigata Walker, 1868	o							o	(Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Roth 1970; Rocha e Silva Albuquerque and Gurney 1962; Shelford 1910)
E. taira Hebard, 1926						o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963)
Galiblatta cribrosa Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926)
Notolampra punctata Saussure, 1862						o	o	o	(Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Phoraspis pellucens (Thunberg, 1826)						o			(Princis 1963; Shelford 1910)
Oxyhaloinae									
Nauphoeta cinerea (Olivier, 1789)	o	o	o	o	o	o	o	o	(Princis 1963)
Rhyparobia maderae (Fabricius, 1781)	o	o	o	o	o	o	o	o	(Bonfils 1987; Bruijning 1959; Hebard 1926; Perez 1988; Princis and Kevan 1955)
Panchlorinae									
Achroblatta luteola (Blanchard, 1843)					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
Panchlora aurora Hebard, 1926					o	o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963)
P. bidentula Hebard, 1916	o					o	o		(Bonfils 1975; Bonfils 1987; Bruijning 1959; Hebard 1926; Perez 1988; Princis 1963; Princis and Kevan 1955)
P. dumicola Rocha e Silva Albuquerque & Gurney, 1962								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
P. exoleta Burmeister, 1838	?	?	?					o	(Pellens and Grandcolas 2008; Perez 1988; Rocha e Silva Albuquerque and Gurney 1962)
P. fraterna Saussure & Zehntner, 1893					o	o			(Bruijning 1959; Hebard 1929; Princis 1963)
P. hebardi Princis, 1951					o	o	o		(Bonfils 1975; Princis 1963)
P. maracaensis Lopes & Oliveira, 2000				o					(Pellens and Grandcolas 2008)
P. nivea (Linnaeus, 1758)	o	o	o	o	o	o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926, 1929; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Princis and Kevan 1955; Walker 1868)
P. peruana Saussure, 1864					o				(Rehn 1906)
P. regalis Hebard, 1926						o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
P. thalassina Saussure & Zehntner, 1893	o	o						o	(Bonfils 1987; Pellens and Grandcolas 2008; Perez 1988)
P. viridis (Fabricius, 1775)					o				(Gutierrez and Perez-Gelabert 2000; Rehn 1906)
Pycnoscelinae									
Proscratea complanata (Perty, 1832)						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
Pycnoscelus surinamensis (Linnaeus, 1758)	o	o	o	o	o	o	o	o	(Bonfils 1987; Bruijning 1959; Hebard 1926; Perez 1988; Princis 1963; Princis and Kevan 1955; Rehn 1906)
Zetoborinae									
Lanxoblatta emarginata (Burmeister, 1931)					o	o	o		(Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
Phortioeca nimbata (Burmeister, 1838)						o	o		(Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
Schizopilia fissicollis (Serville, 1838)						o	o		(Bruijning 1959; Hebard 1921b, 1926; Princis 1963; Rehn and Hebard 1927; Shelford 1910)
S. neblinensis Lindemann, 1971	o								(Beccaloni 2007; Bonfils 1987)
S. nitor Grandcolas, 1991							o		(Baaren et al. 2002; Grandcolas 1990)
Thanatophyllum akinetum Grandcolas, 1991					+		o		(Grandcolas 1990)
Tribonium guyanense Grandcolas, 1993							o		(Grandcolas 1993b)
Zetoborella gemmicula Hebard, 1921						o	o		(Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
Blattidae									
Blattinae									
Blatta orientalis Linnaeus, 1758	o	o	o	o	o	o	o	o	(Princis 1963)
Neostylopyga rhombifolia (Stoll, 1813)	o	o	o	o	o	o	o	o	(Perez 1988; Princis 1963)
Pelmatosilpha guianae Hebard, 1926						o	o	o	(Baaren et al. 2002; Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Rehn 1930)
P. lata Hebard, 1929					o	o			(Bruijning 1959; Hebard 1929; Princis 1963; Rehn 1930)
P. macu Rehn, 1930								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
P. miranha Rehn, 1930								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
Periplaneta americana (Linnaeus, 1758)	o	o	o	o	o	o	o	o	(Bruijning 1959; Hebard 1926; Princis 1963; Perez 1988; Princis and Kevan 1955)
P. australiasiae (Fabricius, 1775)	o	o	o	o	o	o	o	o	(Bruijning 1959; Hebard 1926; Princis 1963; Perez 1988; Princis and Kevan 1955; Rocha e Silva Albuquerque and Gurney 1962)
P. brunnea Burmeister, 1838	o	o	o	o	o	o	o	o	(Bruijning 1959; Hebard 1921b, 1926; Perez 1988; Princis 1963; Princis and Kevan 1955)
Polyzosteriinae									
Eurycotis blattoides Hebard, 1926					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
Corydiidae									
Corydiinae									
Eulissosoma stygia Hebard, 1926						o	o		(Hebard 1926)
Holocompsinae									
Holocompsa nitidula (Fabricius, 1781)	o	o	o	o	o	o	o	o	(Bruijning 1959; Hebard 1921b, 1926; Princis 1963; Princis and Kevan 1955; Rehn 1906)
Latindiinae									
Buboblatta geijskesi Bruijning, 1959						o			(Bruijning 1959; Princis 1963)
Latindia dohrniana Saussure & Zehntner, 1894	?	?	?	?	?	o	o	?	(Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
Tiviinae									
Melestora fusca Rocha e Silva Albuquerque, 1964	o								(Bonfils 1987; Perez 1988)
Oulopteryx dascilloides Hebard, 1921						o	o		(Bruijning 1959; Hebard 1921b, 1926; Princis 1963)
Sphecophila polybiarum Shelford, 1907							o		(Bruijning 1959; Hebard 1921b, 1926)
Ectobiidae									
Anaplectinae									
Anaplecta analisignata Rehn, 1916								o	(Pellens and Grandcolas 2008)
A. balachowskyi Bonfils, 1975							o		(Bonfils 1975)
A. bivittata Brunner von Wattenwyl, 1865	o							o	(Bonfils 1987; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
A. guianae Bruijning, 1959						o			(Bruijning 1959)
A. hemiscotia Hebard, 1920								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
A. jari Rocha e Silva Albuquerque, 1966								o	(Pellens and Grandcolas 2008)
A. lateralis Burmeister, 1838	o								(Bonfils 1987; Perez 1988; Princis 1963)
A. maronensis Hebard, 1921						o	o	o	(Bruijning 1959; Hebard 1921b; Pellens and Grandcolas 2008)
A. minutissima (De Geer, 1773)						o	o		(Bruijning 1959; Hebard 1926)
A. parviceps (Walker, 1868)					o	o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008)
A. pluto Hebard, 1926						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963)
A. poecila Hebard, 1926	o				o	o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
A. pulchella Rehn, 1906					o	o	o	o	(Bruijning 1959; Hebard 1921b; Pellens and Grandcolas 2008; Rehn 1906)
A. pygmaea Bruijning, 1959						o			(Bruijning 1959; Princis 1963)
A. subsignata Hebard, 1926	o					o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
A. suffusa Hebard, 1926					o	o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Maraca fossata Hebard, 1926	o					o	o		(Bruijning 1959; Hebard 1926; Perez 1988; Princis 1963)
Attaphilinae									
Attaphila aptera Bolivar, 1905						o			(Bruijning 1959; Princis 1963)
Blattellinae									
Anisopygia decora Hebard, 1926					+		o		(Bruijning 1959; Hebard 1926)
Blattella germanica (Linnaeus, 1767)	o	o	o	o	o	o	o	o	(Bonfils 1987; Perez 1988; Princis 1963; Princis and Kevan 1955)
Cahita insignis (Hebard, 1926)							o		(Bruijning 1959; Hebard 1926; Rehn 1937a)
Chromatonotus coloratus Rocha e Silva Albuquerque, 1964	o								(Perez 1988)
C. infuscatus (Bruner, 1906)	o								(Bonfils 1987; Princis 1963; Princis and Kevan 1955)
C. notatus (Brunner von Wattenwyl, 1893)						o	o		(Bonfils 1975 1987; Bruijning 1959; Hebard 1926; Princis 1963)
Dasyblatta charpentierae Bonfils, 1975							o		(Bonfils 1975)
D. maldonadoi Rocha e Silva Albuquerque, 1964	o								(Bonfils 1987; Perez 1988; Princis 1963)
D. stylata Bonfils, 1975							o		(Bonfils 1975)
D. thaumasia Hebard, 1921						o			(Bonfils 1975; Bruijning 1959; Princis 1963)
Eudromiella bequaerti Rehn, 1932	o								(Bonfils 1987; Perez 1988; Princis 1963)
E. chopardi Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
E. inexpectata (Rehn, 1906)					o		o		(Bruijning 1959; Hebard 1926, 1929; Princis 1963; Rehn 1906)
E. maroni Hebard, 1926							o		(Bruijning 1959; Hebard 1926)
Ischnoptera atrata Hebard, 1916					o				(Princis 1963; Hebard 1916)
Ischnoptera castanea Saussure, 1869	o							o	(Bonfils 1987; Pellens and Grandcolas 2008; Perez 1988; Rocha e Silva Albuquerque and Gurney 1962)
I. clavator Rehn, 1918								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
I. galibi Hebard, 1926						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926)
I. hercules Rehn, 1928					o	o			(Bruijning 1959; Princis 1963; Rehn 1928)
I. neoclavator Rocha e Silva Albuquerque, 1964	o								(Bonfils 1987; Perez 1988; Princis 1963)
I. ocularis Saussure, 1873							o		(Beccaloni 2007)
I. paramacca Hebard, 1926					o	o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963)
I. rehni Hebard, 1926					o	o	o	o	(Bonfils 1975, 1987; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
I. rufa (De Geer, 1773)					o	o			(Bruijning 1959; Gutierrez and Perez-Gelabert 2000; Princis and Kevan 1955; Rehn 1903)
I. stygia Hebard, 1926	o				o	o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Pseudomops affinis (Burmeister, 1838)					o	o	o	o	(Bruijning 1959; Hebard 1926, 1929; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962; Walker 1868)
P. angustus Walker, 1868	o								(Bonfils 1987; Perez 1988; Princis 1963)
P. brunneri (Saussure, 1869)					o	o			(Bruijning 1959; Hebard 1929; Princis 1963)
P. crinicornis (Burmeister, 1838)					o				(Rehn 1906)
P. luctuosus (Saussure, 1868)					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
P. oblongatus (Linnaeus, 1758)					?	o	o		(Bonfils 1975; Bruijning 1959; Princis 1963; Walker 1868)
Xestoblatta agautierae Grandcolas, 1992					+		o		(Grandcolas 1992a)
X. amaparica Rocha e Silva Albuquerque & Gurney, 1962	o							o	(Bonfils 1987; Pellens and Grandcolas 2008; Perez 1988; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
X. carbuncula Grandcolas, 1992							o		(Grandcolas 1992a)
X. castanea Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
X. cavicola Grandcolas, 1992							o		(Grandcolas 1992a)
X. jygautieri Grandcolas, 1992							o		(Grandcolas 1992a)
X. micra Hebard, 1921					o				(Princis 1963)
X. nourragui Grandcolas, 1992							o		(Grandcolas 1992a)
X. nyctiboroides (Rehn, 1906)					o		o		(Bruijning 1959; Hebard 1926; Princis 1963; Rehn 1906)
X. berenbaumae sp. n.					+				New record
X. surinamensis Bruijning, 1959						o	o		(Bonfils 1975; Bruijning 1959; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
Nyctiborinae									
Megaloblatta insignis (Serville, 1838)						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
Nyctibora brunnea (Thunberg, 1826)	o						o		(Bonfils 1975; Perez 1988; Hebard 1921b)
N. dichropoda Hebard, 1926					+	o	o		(Hebard 1926; Princis 1963)
N. latipennis Burmeister, 1838					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963; Rehn 1906; Walker 1868)
N. tenebrosa Walker, 1868					o	o	o	o	(Bonfils 1975 1987; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Walker 1868)
Paramuzoa alsopi Grandcolas, 1993							o		(Grandcolas 1993a)
Paratropes elegans (Burmeister, 1838)					o	o	o	o	(Bruijning 1959; Hebard 1921b; Pellens and Grandcolas 2008; Princis 1963; Rehn 1906; Rocha e Silva Albuquerque and Gurney 1962; Walker 1868)
P. phalerata (Erichson, 1848)					o	o	o		(Bruijning 1959; Hebard 1929; Princis 1963; Princis and Kevan 1955)
Pseudischnoptera lineata (Olivier, 1789)						o	o		(Princis 1963; Hebard 1921b, 1926; Rehn and Hebard 1927)
Pseudophyllodromiinae									
Amazonina conspersa (Brunner von Wattenwyl, 1865)	o				o	o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Perez 1988; Princis 1963)
A. impuctata Rocha e Silva Albuquerque, 1995	o								(Bonfils 1987; Perez 1988; Princis 1963)
A. lanei Rocha e Silva Albuquerque, 1962	o							o	(Pellens and Grandcolas 2008; Perez 1988; Rocha e Silva Albuquerque and Gurney 1962)
A. platystylata (Hebard, 1921)					o	o	o		(Bruijning 1959; Perez 1988; Hebard 1921b, 1929)
Arawakina frontalis Hebard, 1926					o		o		(Bruijning 1959; Hebard 1926; Princis 1963)
Calhypnorna sp. Saussure & Zehntner, 1893					+				New record
Cariblatta personata Rehn, 1916							o		(Bruijning 1959; Hebard 1926)
Cariblattoides gruneri Bonfils, 1975							o		(Bonfils 1975)
C. guyanensis Bonfils, 1975							o		(Bonfils 1975)
C. sinnamariensis Bonfils, 1975							o		(Bonfils 1975)
Ceratinoptera picta Brunner von Wattenwyl, 1865						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963; Princis and Kevan 1955)
C. albonervosa Rehn, 1916						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926; Princis 1963)
C. barticae Hebard, 1921					o	o	o		(Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
C. cistelina (Walker, 1868)						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926)
C. elegantula Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
C. fuscipennis Hebard, 1920						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
C. galibi Hebard, 1926						o	o		(Bonfils 1975; Bruijning 1959)
C. gatunae Hebard, 1921						o	o		(Bruijning 1959; Hebard 1926; Perez 1988; Princis 1963)
C. gracilis (Saussure, 1862)					o	o			(Bruijning 1959; Princis 1963; Rehn 1906)
C. guianae Hebard, 1921					o	o	o		(Bruijning 1959; Hebard 1921b, 1926)
C. heydei Bruijning, 1959						o			(Bruijning 1959; Princis 1963)
C. inversa Hebard, 1926					o	o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963)
C. lata Rehn, 1916						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1921b, 1926)
Chorisoneura multivenosa Saussure, 1869							o		(Beccaloni 2007)
C. parishi Rehn, 1918					o	o	o		(Bruijning 1959; Hebard 1926; Perez 1988; Princis 1963)
C. splendida Hebard, 1926					o	o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926 1929; Princis 1963)
C. strigifrons Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
C. stylata Hebard, 1926					o	o			(Bruijning 1959; Hebard 1926; Princis 1963)
C. surinama Saussure, 1868						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
C. vitrifera (Walker, 1868)					o	o	o		(Bruijning 1959; Hebard 1926, 1929)
C. vivida Rocha e Silva Albuquerque & Gurney, 1962								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
Dendroblatta callizona Rehn, 1928					o	o			(Princis 1963; Princis and Kevan 1955; Bruijning 1959; Rehn 1928)
D. cnephaia Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
D. insignis Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
D. coppenamensis Bruijning, 1959						o			(Bruijning 1959; Princis 1963)
Euphyllodromia atropos Rehn, 1928					o	o	o		(Bonfils 1975; Bruijning 1959; Princis 1963; Rehn 1928)
E. aurora Rehn, 1932							o	o	(Bonfils 1975; Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
E. chopardi Hebard, 1921				o	o		o	o	(Bruijning 1959; Hebard 1921b; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
E. elegans (Shelford, 1907)							o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Rehn 1928; Rocha e Silva Albuquerque and Gurney 1962)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
E. fasciatella (Saussure, 1868)					o	o			(Bruijning 1959; Hebard 1929; Princis 1963; Rehn 1906)
E. hystrix (Saussure, 1869)	?	?	?						(Bonfils 1987; Perez 1988; Princis 1963; Hebard 1929)
E. literata (Burmeister, 1838)					o	o	o	o	(Bruijning 1959; Hebard 1921b, 1926; Pellens and Grandcolas 2008; Princis 1963; Walker 1868)
E. marowijnensis Bruijning, 1959						o			(Bruijning 1959; Princis 1963)
E. obscura (Saussure, 1873)					o				(Rehn 1906)
E. pavonacea (Rehn, 1903)					o	o	o	o	(Bonfils 1975; Bruijning 1959; Pellens and Grandcolas 2008; Princis 1963; Rehn 1903, 1906; Rocha e Silva Albuquerque and Gurney 1962)
E. prona (Rehn, 1906)					o				(Bruijning 1959; Princis 1963; Rehn 1906)
E. variegata (Walker, 1868)						o	o	o	(Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Imblattella litosoma (Hebard, 1926)						o	o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Leuropeltis atopa Hebard, 1921							o		(Bruijning 1959; Hebard 1921b 1926)
Leuropeltis gurneyi Rocha e Silva Albuquerque, 1964	o								(Bonfils 1987; Perez 1988; Princis 1963)
Lophoblatta arawaka Hebard, 1929					o	o			(Bonfils 1975, 1987; Bruijning 1959; Perez 1988; Princis 1963; Princis and Kevan 1955; Hebard 1929)
L. brevis Rehn, 1937	o				o	o			(Bruijning 1959; Perez 1988; Princis 1963; Rehn 1937b)
L. pellucida (Burmeister, 1838)						o	o	o	(Pellens and Grandcolas 2008; Princis 1963)
Macrophyllodromia nigrigena Hebard, 1926					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
Nahublattella aristonice Hebard, 1926						o	o		(Bonfils 1975; Hebard 1926; Princis 1963)
N. incompta (Hebard, 1926)							o		(Bonfils 1975; Bruijning 1959; Hebard 1926)
Neoblattella adspersicollis (Stål, 1860)								o	(Bruijning 1959; Hebard 1921b; Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
N. binodosa Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
N. elegantula Rocha e Silva Albuquerque, 1964	o								(Perez 1988; Princis 1963; Lopes and de Oliveira 2004)
N. guianae Hebard, 1929					o		o	o	(Bonfils 1975; Hebard 1929; Lopes and de Oliveira 2004; Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
N. longior Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Lopes and de Oliveira 2004; Princis 1963)

Taxon	*Amaz VEN*	*Bolivar VEN*	*Del Ama VEN*	*Rora BRA*	*GUY*	*SUR*	*FG*	*Amapa BRA*	Source
N. nodipennis Hebard						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
N. picta Rocha e Silva Albuquerque & Gurney, 1962								o	(Pellens and Grandcolas 2008; Rocha e Silva Albuquerque and Gurney 1962)
N. poecilops Hebard, 1926						o	o		(Bruijning 1959; Hebard 1926; Lopes and de Oliveira 2004; Princis 1963)
N. titania (Rehn, 1903)					o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963; Rehn 1903)
N. unifascia Hebard, 1926							o		(Bruijning 1959; Hebard 1926; Lopes and de Oliveira 2004; Princis 1963)
Plectoptera pulicaria Saussure & Zehntner, 1893						o	o		(Bruijning 1959; Hebard 1926; Princis 1963)
Riatia distincta (Hebard, 1926)						o	o		(Bruijning 1959; Hebard 1926)
R. fulgida (Saussure, 1862)					o	o			(Bruijning 1959; Rehn 1906; Princis 1963)
R. orientis (Hebard, 1926)	o				o	o	o		(Bruijning 1959; Hebard 1926; Princis 1963; Perez 1988; Princis and Kevan 1955)
R. stylata (Hebard, 1926)						o	o		(Bonfils 1975; Bruijning 1959; Hebard 1926)
R. variegata Rocha e Silva Albuquerque & Aguiar, 1976	o								(Perez 1988)
R. venezuelana Rocha e Silva Albuquerque, 1964	o								(Perez 1988; Princis 1963)
Sciablatta galibi Hebard, 1926							o		(Bruijning 1959; Hebard 1926)
S. poecila Hebard, 1921					o		o		(Bruijning 1959; Hebard 1921b; Princis 1963)
Supella longipalpa (Fabricius, 1798)	o	o	o	o	o	o	o	o	(Bonfils 1987; Bruijning 1959; Hebard 1929; Perez 1988; Princis 1963; Princis and Kevan 1955)
Tairella carinatifrons Hebard, 1926						o	o		(Hebard 1926; Princis 1963)
Trioblattella callosoma (Hebard, 1926)					o		o	o	(Bonfils 1975; Bruijning 1959; Hebard 1926; Pellens and Grandcolas 2008; Princis 1963; Rocha e Silva Albuquerque and Gurney 1962)
Lamproblattidae									
Lamproblattinae									
Lamproblatta albipalpus Hebard, 1919	?	?	?					o	(Hebard 1931; Pellens and Grandcolas 2008; Princis and Kevan 1955; Rehn 1930; Rocha e Silva Albuquerque and Gurney 1962)
L. ancistroides Rehn, 1930	?	?	?						(Perez 1988; Princis 1963)

Table 2. Allometry of new records of cockroaches from Guyana reported in the text. All values are lengths reported in millimeters. NA – refers to specimens which are damaged and therefore cannot be measured or refer to specimens for which the listed measurement does not apply. Specimens with asymmetrical styli have lengths of both right (R.) and left (L.) styli given. When possible, broken specimens had relevant measurements estimated (est.) by piecing together damaged parts or extrapolating visually.

Morphological feature			*Eublaberus distanti*	*Eublaberus* sp.		*Neorhicnoda maronensis*	*Colapteroblatta surinama*		*Epilampra opaca*		*Epilampra sodalis*	*Thanatophyllum akinetum*
			Adult ♂	Adult ♂	Adult ♂	Adult ♂	Adult ♂	Adult ♀	Adult ♂	Adult ♀	Adult ♀	Adult ♂
			DEKBO0843	DEKBO0842	DEKBO0844	DECBA0615	DECBA0703	DECBA1810	DECBA1845	DECBA1847	DECBA0401	DECBA0611
Head	Greatest width		6.5	6.5	6.8	4.5	3.0	3.4	3.3	3.8	5.0	3.8
	Medial length		7.5	7.0	7.1	5.4	3.1	3.4	3.1	4.5	5.5	3.8
Pronotum	Greatest width		17.5	15.5	15.0	12.9	6.0	6.5	6.0	8.0	10.0	10.0
	Medial length		11.0	10.5	10.0	8.8	4.7	4.5	4.6	6.5	7.8	7.0
Leg	Front	Femur	6.0	6.0	5.7	5.0	2.2	2.2	3.0	3.5	4.8	4.0
		Tibia	2.8	4.5	3.9	2.2	1.4	1.6	2.0	2.5	2.5	2.2
	Middle	Femur	9.5	8.3	8.0	6.3	2.3	2.7	4.5	5.5	5.6	5.0
		Tibia	7.0	7.0	6.0	4.5	1.8	1.9	4.0	4.0	5.5	4.9
	Hind	Femur	10.0	9.0	8.0	6.7	3.1	2.7	5.8	6.0	7.0	5.8
		Tibia	13.0	11.0	10.0	8.5	3.7	3.4	7.9	9.2	10.0	8.0
Cerci length			3.0	3.3	2.8	1.5	0.6	0.5	3.0	2.2	3.3	1.2
Styli length			0.8	0.8	1.0	0.5	0.3	NA	0.5	NA	NA	NA
Tegminal length			39.5	NA	NA	NA	10.0	2.0	20.0	24.5	28.0 (est.)	22.0
Total body length			43.5	44.0	46.0	34.0	15.7	19.3	20.5	25.0	31.0	26.0

Table 2. Continue.

Morphological feature			*Anaplecta parviceps*	*Anisopygia decora*	*Ischnoptera atrata*		*Xestoblatta agautierae*		*Nyctibora dichropoda*	*Chorisoneura inversa*	*Dendroblatta callizona*	*Calhypnorna* sp.
			Adult ♂	Adult ♀	Adult ♂	Adult ♂	Adult ♂	Adult ♀	Adult ♂	Adult ♂	Adult ♀	Juvenile
			DECBA1843	DEKBO0504	DECBA2153	DEKBO0594	DEKBO0827	DEKBO0826	DECBA0302	DECBA1782	DECBA0805	DECBA1802
Head	Greatest width		1.0	1.8	3.1	3.5	2.6	2.4	4.9	1.6	2.4	1.5
	Medial length		1.1	1.9	3.8	4.2	3.3	3.0	6.0	1.5	2.8	1.3
Pronotum	Greatest width		1.6	3.9	5.9	6.7	5.0	5.3	11.0	2.9	4.9	1.7
	Medial length		1.1	2.4	4.0	4.8	3.4	3.8	6.0	1.8	3.0	1.6
Leg	Front	Femur	1.0	1.8	3.1	3.0	2.8	3.1	6.0	1.5	2.8	1.1
		Tibia	0.7	1.0	2.2	2.0	1.7	2.0	4.0	1.0	1.9	0.7
	Mid-dle	Femur	1.4	2.2	4.0	3.8	3.5	4.0	7.6	?	3.4	1.4
		Tibia	1.2	1.8	4.1	3.6	3.4	3.5	7.0	?	2.8	1.0
	Hind	Femur	NA	2.5	5.2	4.3	4.0	4.6	9.0	2.3	4.3	1.4
		Tibia	NA	2.9	6.0	6.1	6.0	5.1	12.0	2.7	4.6	1.3
Cerci length			NA	1.6	3.6	3.0	2.3	2.3	7.0	1.6	3.3	0.6
Styli length			0.1	NA	0.6 (L.) 0.9 (R.)	0.5 (L.) 0.7 (R.)	NA	NA	2.0 (L.) 1.2 (R.)	0.6	NA	0.2
Tegminal length			3.7	1.3	22.0	21.8	10.0	10.0	36.0	7.4	9.8	NA
Total body length			4.7	8.9	21.8	21.3	17.0 (est.)	15.0	37.0	7.8	13.8	7.3

Subfamily: Blaberinae

***Eublaberus distanti* (Kirby, 1903)**

Materials. *Adult* ♂.

Voucher number: DEKBO0843.

Collection locale. Karanambu Ranch, Rupununi, Guyana.

GPS: 3°45'2.2"N, 59°18'31.2"W.

Date: 7 – June – 2013.

Collectors. Dominic A. Evangelista, Oswin Ambrose, Susan George, and Megan M. Wilson.

Collection/ecological information. This specimen was collected in the bathroom of one of the cabins at the camp of Karanambu Ranch.

Known geographic distribution. Guatemala, Costa Rica, Panama, Colombia, Trinidad and Tobago, French Guiana, Suriname, Guyana and Brazil

***Neorhicnoda maronensis* (Hebard, 1921)**

Materials. *Adult* ♂ Figure 1.

Voucher number: DECBA0615.

GenBank accession number: KF155090.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Date: 02 – January – 2012.

Collectors. Dominic A. Evangelista, Ian Biazzo, Joseph A. Evangelista, Paul Frandsen, William R. Kuhn, and Jessica L. Ware.

Collection/ecological information. This specimen was caught in a pitfall trap baited with beer in an uplands secondary forest.

Morphological identification. This specimen agrees with the description of the male genitalia in Grandcolas (1992b).

Known geographic distribution. Guyana (new record), Suriname, and French Guiana.

Subfamily: Epilamprinae

***Colapteroblatta surinama* (Saussure, 1868)**

Materials. *Adult* ♂ Figure 2E.

Voucher number: DECBA0703.

GenBank accession number: KF155029.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

Figure 1. *Neorhicnoda maronensis* adult male (DECBA0615).

GPS: 6°29'N, 58°13'W.

Date: 05 – August – 2011.

Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski, and Jessica L. Ware.

Collection/ecological information. This specimen was collected in an uplands secondary forest from within a rotting vine.

Morphological identification. This specimen was identified using Roth and Gutierrez (1998).

Adult ♀ Figure 2D.

Voucher number: DECBA1810.

GenBank accession number: KF155126.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Date: 20 – August – 2011.

Collectors. Dominic Evangelista and William R. Kuhn.

Collection/ecological information. This specimen was collected in an uplands secondary forest from within an arboreal bromeliad.

Morphological identification. This specimen was identified using Roth and Gutierrez (1998).

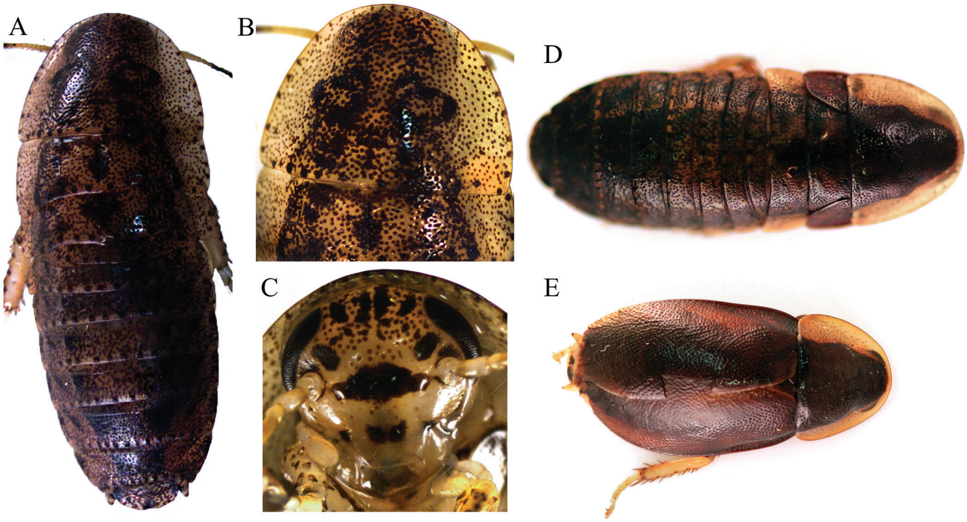

Figure 2. *Colapteroblatta surinama.* **A–C** Juvenile (dorsal aspect, pronotum, ventral aspect of head) **D** Adult female, dorsal aspect **E** Adult male, dorsal aspect. Photos not to scale.

Juvenile Figure 2A–C.
Voucher number: DECBA1811.
GenBank accession number: KF155112.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'N, 58°13'W.
Date: 17 – August – 2013.
Collectors. Dominic Evangelista and William R. Kuhn.

Collection/ecological information. This specimen was collected on vegetation in an uplands secondary forest.

Morphological identification. This specimen was associated to its adult morph using barcodes in Evangelista et al. (2014). The overall coloration of the juvenile specimens of this species is more similar to that of *C. darlingtoni* Roth & Gutiérrez, 1998 and *C. rehni* Roth & Gutiérrez, 1998 than to that of the adults of its own species (see Figure 2).

Genetic information and evolutionary placement. All three specimens have nearly identical cytochrome oxidase I (COI) haplotypes but their position could not be determined relative to other cockroach species with the data evaluated by Evangelista et al. (2014).

Known geographic distribution. Guyana, Suriname.

Epilampra opaca Walker, 1868

Materials. *Adult* ♂ Figure 3B.

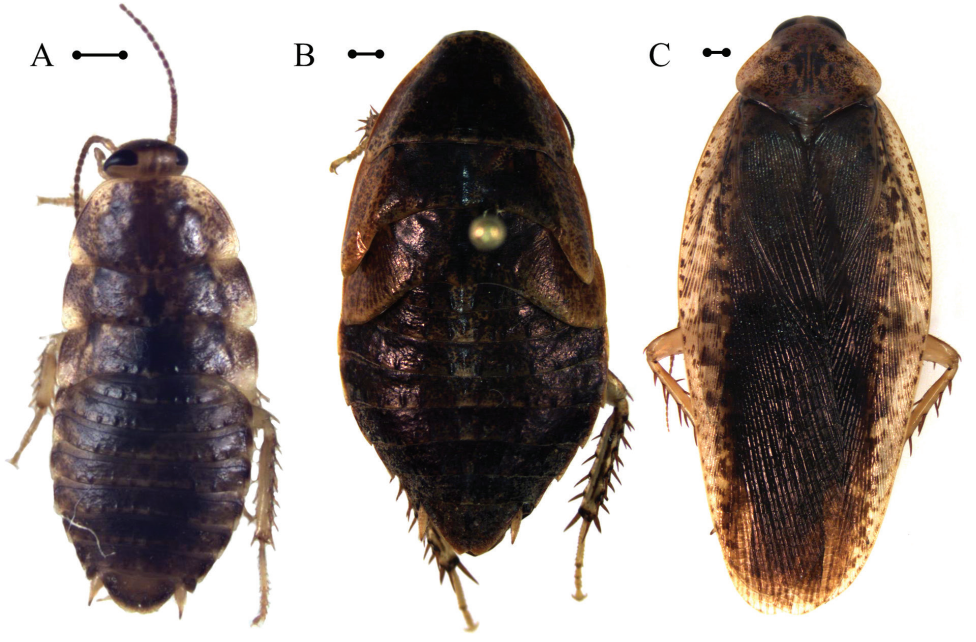

Figure 3. *Epilampra opaca.* **A** Early juvenile instar (DEDSM0141) **B** Late juvenile instar (DECBA1706) **C** Adult (DECBA1845). Scale bars approximate 1 mm.

Voucher number: DECBA1845.
GenBank accession number: KF155125.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'N, 58°13'W.
Date: 18 – August – 2012.
Collectors. Dominic A. Evangelista and William R. Kuhn.

Adult ♀
Voucher number: DECBA1847.
GenBank accession number: KF155124.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29"N, 58°13"W.
Date: 5 – August – 2011.
Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski and Jessica L. Ware.

Collection/ecological information. The adult male (DECBA1845) was collected at a light trap. Adult female (DECBA1847) was collected by hand in the leaf litter by a small pond. Most late instar individuals of this species were also collected at the edge of this pond and some were collected in pitfall traps baited with beer. Early instar individuals of this species were collected from within bromeliads.

Genetic information. The two adult specimens reported here, as well as three juvenile individuals (Voucher and accession numbers: DEDSM0141 – KF155097, DECBA1706 – KF155089, DECBA0205 – KF155088) have identical COI barcodes and are sister to each other on the tree. However, other individuals (similar to *E. opaca*) included in the analysis (Voucher and accession numbers: DECBA0214 – KF155018, DECBA0216 – KF155017, DECBA0606 – KF155013, DECBA1101 – KF155016, DECBA0605 – KF155012, DECBA0608 – KF155015) are more genetically diverse and are only supported as monophyletic by 63% bootstrap support.

Morphological identification. There is a great deal of intraspecific variation in the morphology of this species. Early instar nymphs are difficult to associate to later instar nymphs, all of which are entirely unrecognizable from the adults (Figure 3A–C). Furthermore, there is variation within instars, where some later instar nymphs will appear to have a medially divided subgenital plate and others do not. This trait was not found to correlate with genetic differences (Evangelista et al. 2014).

The external morphology of this species provides little assistance in its identification, as most descriptions of it emphasize coloration that is both subtle and variable. However, the allometry of our specimens (Table 2) agree with those of Bruijning (1959). A definitive identification was made by comparison of genital morphology using Roth (1970b), particularly in the shape of the prepuce.

Known geographic distribution. Venezuela (unverified), Guyana, Suriname, French Guiana and Brazil

History and synonymy. Walker (1868) first described both *E. opaca* Walker, 1868 and *E. substrigata* Walker, 1868. Hebard (1926) noted that *E. opaca* Walker, 1868 has a highly variable morphology and may be synonymous with a few other *Epilampra* (e.g. *E. conferta* Walker, 1868 syn. *stigmosa* Giglio-Tos, 1898*, E. maculicollis* (Serville, 1838)). This variability is evident in the work published by Roth (1970b), which shows a great deal of variation in the genital morphology, in particular for L2d. Although it is not clear if anyone before Roth (1970b) examined the genitalia of these two species, both Shelford (1910) and Princis (1963) considered them to be synonyms. Roth's (1970b) photos show that, although each species is intraspecifically variable, both are distinct and separable by the shape of L2d and the prepuce. Roth himself acknowledged this and considered the species as being separate. Although we have not examined any *E. substrigata* Walker, 1868*,* we agree with Roth's interpretation of the morphology and follow from his precedence in considering these separate (see Roth 1970b for the opinions of Princis and Gurney on the status of these two species).

Epilampra sodalis Walker, 1868

Materials. *Adult* ♂ Figure 4A.

Voucher number: DECBA0401.

GenBank accession number: KF155063.

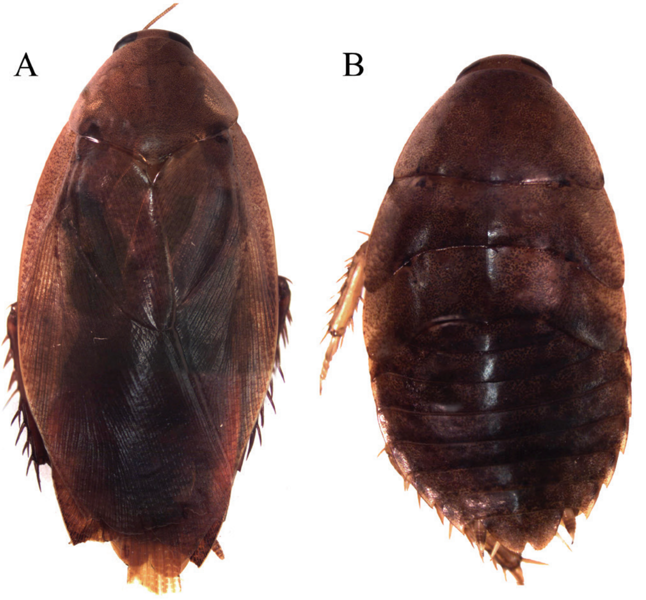

Figure 4. *Epilampra sodali.* **A** Adult male dorsal view (DECBA0401) **B** Juvenile dorsal view (DECBA2163). Add scale bar.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Date: 31 – July to 6 – August – 2011.

Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski, and Jessica L. Ware.

Collection/ecological information. This specimen was collected at a light trap.

Morphological identification. This specimen agrees with the description the synonym *E. cinnamomea* (Hebard 1926).

Juvenile

Voucher number: DECBA1702.

GenBank accession number: KF155068.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Date: 27 – December – 2011.

Collectors. Dominic A. Evangelista, Ian Biazzo, Joseph A. Evangelista, Paul Frandsen, William R. Kuhn and Jessica L. Ware.

Juvenile

Voucher number: DECBA1701.

GenBank accession number: KF155069.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.
Date: 10 – January – 2012.
Collectors. Dominic A. Evangelista, Ian Biazzo, Joseph A. Evangelista, Paul Frandsen, William R. Kuhn and Jessica L. Ware.

Collection/ecological information. Both of these juvenile specimens were collected at the edge of a small pond.

Genetic information and evolutionary placement. These three specimens (previous reported as "Blaberidae sp. 04") were placed in the same clade with 90% bootstrap support.

Known geographic distribution. Venezuela, Guyana (new record), Suriname, French Guiana and Brazil

Subfamily: Zetoborinae

Thanatophyllum akinetum Grandcolas, 1991

Materials. *Adult* ♂ Figure 5.
Voucher number: DECBA0611.
GenBank accession number: KF155066.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'N, 58°13'W.
Date: 28 – December – 2011.
Collectors. Dominic A. Evangelista, Ian Biazzo, Joseph A. Evangelista, Paul Frandsen, William R. Kuhn and Jessica L. Ware.

Collection/ecological information. This specimen was collected by hand on vegetation in an uplands secondary forest.

Morphological identification. This specimen agrees with the description of the head and male genitalia of Grandcolas (1990).

Known geographic distribution. Guyana (new record) and French Guiana.

Family: "Ectobiidae"
Subfamily: Anaplectinae

Anaplecta parviceps (Walker, 1868)

Materials. *Adult* ♂ Figure 6.
Voucher number: DECBA1843.
GenBank accession number: KF155137.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'N, 58°13'W.
Date: 16 – August – 2012.

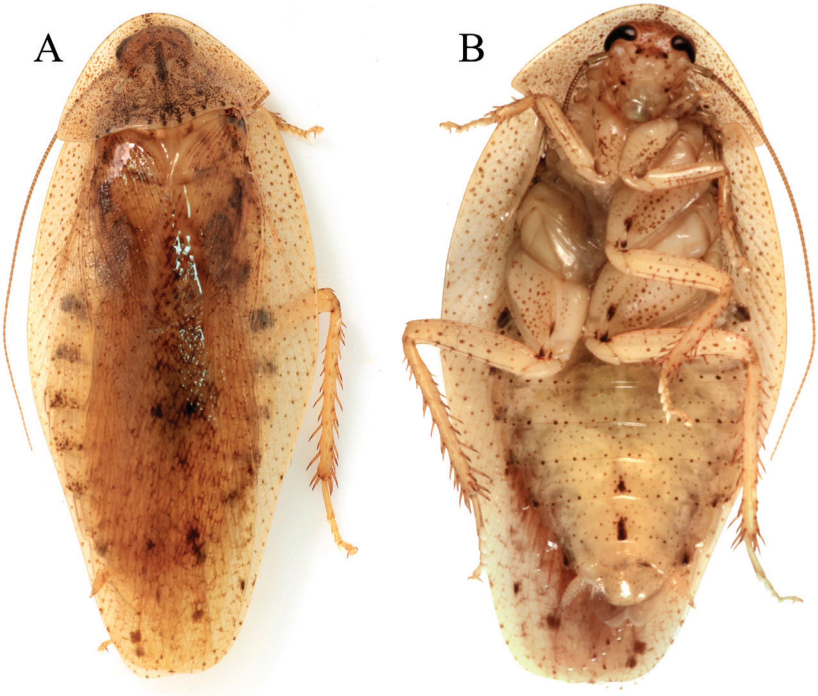

Figure 5. *Thanatophyllum akinetum* adult male (DECBA0611). **A** Dorsal view **B** Ventral view.

Figure 6. *Anaplecta parviceps* adult male (DECBA1843).

Collectors. Dominic A. Evangelista and William R. Kuhn.

Collection/ecological information. This specimen and another adult male (Voucher number: DECBA1841) were collected at a light trap near the camp of CEIBA Biological Station on the date noted above. A juvenile of this species was also collected at the same locale, found crawling through a benab between 21 and 24 of August 2012 (Voucher number: DECBA1842).

Morphological identification. The specimen agrees with the description of the synonym *A. insignis* of Hebard (1926). Other specimens were identified by comparison with specimen DECBA1843.

Genetic information and evolutionary placement. The COI barcodes of this specimen (previously reported as "Blattodea sp. 18") falls sister to another specimen identified as *Anaplecta* sp. (previously reported as "Ectobiidae sp. 04"; Voucher number: DEDSM0111; GenBank accession number: KF155041) but with 25% bootstrap support. This other species is not reported in this paper due to an uncertainty in specific identification.

Known geographic distribution. Guyana, Suriname, French Guiana, Brazil (Rio de Janeiro), Brazil (Pará), and Brazil (Amapá).

Subfamily: Blattellinae

Anisopygia decora Hebard, 1926

Materials. *Adult* ♀ Figure 7.

Voucher number: DEKBO0504.

Collection locale. Capuchin Trail, Karanambo Ranch, Rupununi, Guyana.

GPS: 3°44'43.70"N, 59°18'51.88"W.

Date: 10 – June – 2013.

Collectors. Dominic A. Evangelista, Oswin Ambrose, Susan George, and Megan M. Wilson.

Collection/ecological information. This specimen was collected by hand in an undisturbed forested area. This is the first record of this specimen from Guyana.

Morphological identification. This specimen was identified by comparison with Hebard's description (1926).

Known geographic distribution. Guyana (new record) and French Guiana.

Ischnoptera atrata Hebard, 1916

Materials. *Adult* ♂.

Voucher number: DECBA2153.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Figure 7. *Anisopygia decora* adult female (DEKBO0504).

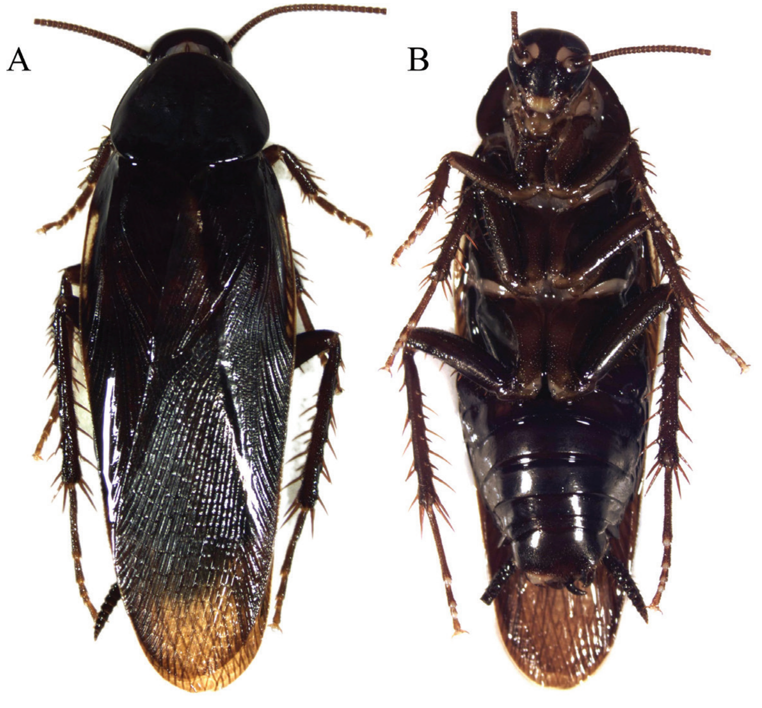

Figure 8. *Ischnoptera atrata* adult male (DEKBO0594). **A** Dorsal view **B** Ventral view.

Collection date: December – 2011.

Collectors. Dominic Evangelista, Ian Biazzo, Joseph A. Evangelista, Paul Frandsen, William R. Kuhn, and Jessica L. Ware.

Collection/ecological information. This specimen was collected in a pitfall trap baited with beer in an uplands secondary forest area.

Adult ♂ Figure 8.

Voucher number: DEKBO0594.

Collection locale. Karanamabu Ranch, Rupununi, Guyana.

GPS: 3°45'0.1"N, 59°18'53.7"W.

Collection date: 10 – June – 2013.

Collectors. Dominic A. Evangelista, Oswin Ambrose, Susan George, and Megan M. Wilson.

Collection/ecological information. This specimen was collected in a pitfall trap baited with beer in a forest proximal to the Rupununi River.

Morphological identification. Both specimens mostly agree with the description and figures of Hebard (1916). However, there are slight differences in the supra-anal plate when compared to Hebard's illustration. The white region on the SA plate of our specimen is slightly larger than in Hebard's illustration. It is possible that this is a different species than that described by Hebard, but this cannot be fully determined without a full phylogenetic treatment of sexual morphology and genetic information of individuals from both Trinidad and Guyana.

Known geographic distribution. Trinidad and Tobago, and Guyana

***Xestoblatta berenbaumae* Evangelista, Kaplan, & Ware, sp. n.**

http://zoobank.org/0DCFF043-F783-49E4-8576-4A2AD402AF82

Authors of description. Evangelista, Kaplan, & Ware.

Holotype. *Adult* ♂ Figure 9B–E, G.

Voucher number: DECBA2109.

Type locality. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Collection date: 17 to 18 – August – 2012.

Collectors. Dominic A. Evangelista and William R. Kuhn.

Type information. The holotype specimen is stored in ethanol with genitalia in a separate ethanol vial and is deposited at the Center for Biodiversity at the University of Guyana.

Collection/ecological information. This specimen was collected in a pitfall trap baited with beer and fruit in an uplands secondary forest in CEIBA Biological Station.

Morphological identification. This specimen was identified as *Xestoblatta* Hebard, 1916 by the position of the hooked phallomere (left), the presence of the external modification of the tergum as part of the dorsal tergal gland (Figure 9A), incomplete

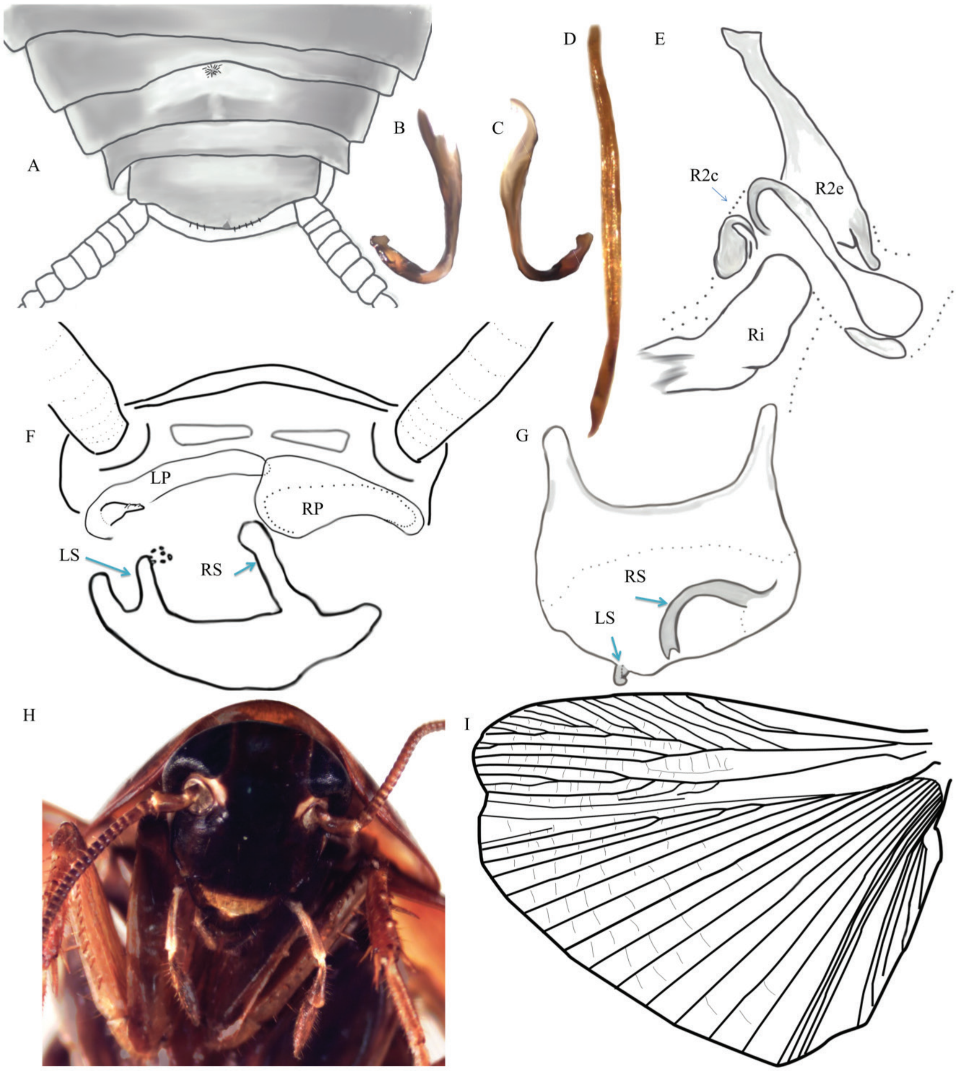

Figure 9. *Xestoblatta berenbaumae* sp. n. **A** Dorsal view of abdomen showing the simple tergal gland (DECBA2023) **B, C** Hooked left phallomere **D** Ventral medial phallomere (L2vm) **E** Right phallomere. R2e – external sclerite, R2i – internal sclerite, R2c – cleft sclerite **F** Posterior view of abdomen showing paraprocts and subgenital plate. RS-right stylus, LS-left stylus with small translucent ball at tip, LP-left paraproct reduced and specialized with polydentate spine, RP-unspecialized right paraproct. Illustration is a composite of multiple individuals **G** Dorsal view of sub-genital plate (DECBA1967) **H** Head of adult male **I** Hindwing (DECBA0801). Photos and illustrations contributed by Kayla Kaplan and Dominic A. Evangelista.

rami on the ulnar vein of the hind wing (Figure 9I) and the spination (type A) on the ventro-anterior margin of the fore-femur.

Holotype morphological description. Head uniformly colored a deep mahogany. Clypeus pale buffy. Ocellar spots easily distinguishable, smaller than antennal pits and white. Head otherwise without distinguishing features. Ocellar spots slightly closer together than eyes. Facial grooves on lateral most edge. See Figure 9H for a representative photo of the head.

Pronotum a uniformly reddish mahogany color (Figure 10A). Medial expansion on posterior margin of pronotum is barely noticeable. Ventral margin of pronotum not lined with hairs. Anterior margin of pronotum significantly conformed around the head. Leg coloration deep orange amber. Coxae with some diffuse black regions. Ventro-anterior margin of fore-femur with 14 (left) or 13 (right) spines decreasing in size from basal to apical, one slightly larger pre-apical spine and one large apical spine (16 total left, 15 total right). Ventro-posterior margin of forelimbs with 4 large spines and 1 apical spine. Ventro-anterior margin of middle leg has seven large spines and one apical spine. Middle leg also with one large genicular spine. Hind leg ventro-anterior margin has six spines, one apical spine, and one genicular spine. Pulvilli present on all tarsomeres. Arolia present but not surpassing the tips of the pretarsal claws. Claws symmetrical and unspecialized.

Ulnar vein with three incomplete rami and three complete rami (Figure 9I). Tegmina reddish mahogany with small patch of white under the base of the subcostal vein.

Supra-anal plate subtriangular with a blunt tip from dorsal view. Left paraproct modified into a tri-dentate spine (Figure 9F; bi-dentate in some other specimens). Sub-genital plate has both styli highly modified (Figure 9F, G). The right stylus is projecting dorso-medially from posterior margin, curving back posteriorly and terminating in a shape reminiscent of a bifurcated serpentine tongue. Left stylus projecting dorsally, shorter than right stylus and tipped with a small, translucent, irregularly shaped ball (Figure 9F, G).

Left phallomere (Figure 9B, C) hooked in apical third. (Hooked phallomere is about 1.5 mm long). Medial phallomere (Figure 9D) approximately three times the length of the left phallomere, roughly uniform width, and a slight slender curve in the posterior end. R2c (Figure 9E) divided into two sclerites that form dual concave cups that meet dorsally.

Dorsal modification of terga as part of the dorsal tergal gland. Modification represented by a small patch of hairs with a concave semi-circular modification of the margin of the segment anterior to the gland. See Figure 9A for an illustration of a representative dorsum.

Medium sized hairs (~ 2 mm) covering entire body roughly uniformly, yet sparsely.

Other adult male paratypes. Voucher numbers: DECBA1967, DECBA0801, DECBA1958, DECBA2182, DECBA2092, DECBA2039

Collection/ecological information. All additional male individuals reported here were collected in leaf litter pitfall traps baited with beer at various locations (dryer secondary uplands forest and wet primary lowlands forest) in CEIBA biological station.

Adult female paratype morphological description. Voucher number: DECBA2074.

Head slightly darker in color than male with a more reflective surface. Other features of head similar to male.

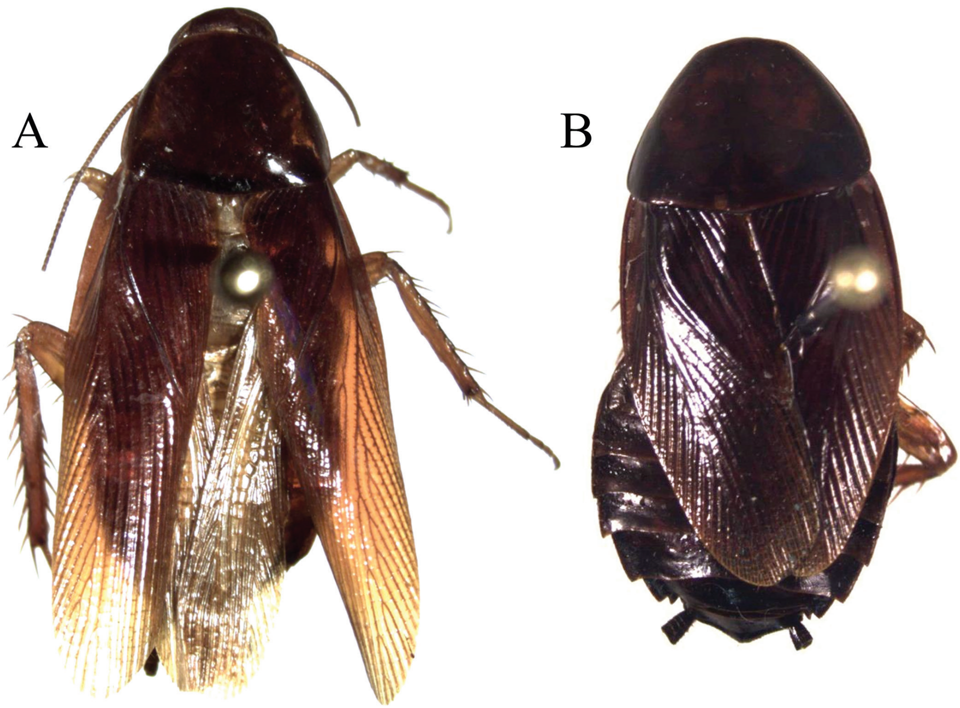

Figure 10. *Xestoblatta berenbaumae* sp. n. **A** Adult male dorsal view (DECBA2182) **B** Adult female dorsal view (DECBA2210).

Description of legs similar or identical to that of male with the following spination on the ventro-anterior margin of fore-femur: 13 (left) and 12 (right) spines decreasing in size from basal to apical, two larger preapical spines and one large apical spine (16 total left and 15 total right). Ventro-posterior margin of fore-femur four large spines and one apical spine. Ventro-anterior margin of mid-leg with seven large spines, one apical spine, and one genicular spine. Ventro-anterior margin of hind-leg with five large spines, one apical spine, and one genicular spine.

Tegmina and wings reduced and not reaching end of abdomen. Three incomplete and three complete rami on ulnar vein. Ulnar vein very faint in the reduced wings of the female (Figure 10B; Table 3).

Pronotum matches description of the male.

Subgenital plate slightly more abbreviated than in male. Paraprocts simple and unspecialized. Sub-genital plate simple and symmetrical.

Other adult female paratypes. Voucher numbers: DECBA1787, DECBA1791, DECBA1792, and DECBA1793

Collection/ecological information. All additional female individuals reported here were collected in leaf litter pitfall traps baited with beer in an uplands secondary forest at CEIBA biological station.

Table 3. Allometry of *Xestoblatta berenbaumae* sp. n. All values are lengths reported in millimeters.

Morphological feature			*Xestoblatta berenbaumae* sp. n.										
			Adult ♂ (HT)	Adult ♂	Adult ♂	Adult ♂	Adult ♂	Adult ♂	Adult ♂	Adult ♀	Adult ♀	Adult ♀	Adult ♀
			DECBA2109	DEC-BA1967	DEC-BA0801	DEC-BA1958	DEC-BA2182	DEC-BA2092	DEC-BA2039	DEC-BA1787	DEC-BA1974	DEC-BA1793	DEC-BA2074
Head	Greatest width		2.7	3.0	3.0	2.9	3.0	2.8	2.9	3.1	3.0	3.0	3.1
	Medial length		3.6	3.8	3.8	3.8	3.9	3.5	3.6	4.0	4.0	4.0	3.7
Pronotum	Greatest width		5.3	6.0	6.0	5.6	4.9	5.3	5.3	5.9	4.7	5.9	4.1
	Medial length		4.0	4.0	4.4	4.0	4.5	4.0	4.0	4.8	5.9	4.3	5.6
Leg	Front	Femur	3.0	3.5	4.0	4.0	3.3	3.2	4.0	3.0	3.6	3.5	3.0
		Tibia	2.0	2.0	2.5	2.0	2.5	2.0	2.4	2.0	2.6	2.3	2.0
	Middle	Femur	4.0	4.5	4.2	4.0	4.7	4.0	4.8	4.2	4.3	4.4	4.2
		Tibia	3.8	3.7	4.0	4.0	3.7	4.0	4.4	4.0	4.0	3.8	4.0
	Hind	Femur	4.9	5.0	5.0	4.5	5.0	4.8	5.4	5.7	5.0	4.9	5.0
		Tibia	6.0	6.1	6.0	5.6	6.0	6.1	6.0	6.2	6.1	6.0	6.3
Cerci length			2.8	3.0	NA	2.3	2.5	3.2	3.0	3.0	2.8	2.4	NA
Tegminal length			13.5	14.0	14.0	14.0	13.3	14.0	13.8	10.1	10.0	10.0	9.2
Total body length			NA	NA	NA	17.5	15.4	16.0	18.0	18.7	17.0	18.2 (est.)	NA

Summary of female morphology. All individuals match the description of the above female and have the following spination on the vento-anterior margin of the fore-limb: 13 spines decreasing in size from basal to apical, one or two slightly larger preapical spines and one large apical spine making a total of 15 or 16 spines.

Juvenile paratypes. Voucher numbers: DECBA1788, DECBA1789, DECBA1790, DECBA1796.

Collection/ecological information. All additional juvenile individuals reported here were collected in leaf litter pitfall traps baited with beer in an uplands secondary forest at CEIBA biological station.

Summary of juvenile morphology. Juveniles are apterous and largely match the morphology of adults except for in the following. Simple styli present on the subgenital plate in some individuals but are short and abbreviated. Spines on ventro-anterior margin of forelimb are as follows: 12 to 14 spines decreasing in size basally to apically, one or two slightly larger preapical spines and one large apical spine making a sum total of 15 or 16 total spines.

Molecular data and evolutionary placement. Vouchers numbers and GenBank accession numbers: DECBA1791 – KF155114, DECBA1789 – KF155105, DECBA0801 – CBA0801, DECBA1827 – KF155103, DECBA1826 – KF155107, DECBA1814 – KF155115. The clade containing the above haplotypes (formerly reported as "Blattodea sp.1") is supported by 96% bootstrap support and the haplotypes are nearly identical.

Diagnostic features of *X. berenbaumae*. The morphology of modified styles on the subgenital plate is the most useful trait for discerning this species with other *Xestoblatta* Hebard, 1916. The simple dorsal tergal gland, shape of the paraprocts (left modified into a tri-dentate or bi-dentate spine), and morphology of the internal genital sclerites of the male are also useful in identifying this species. Unfortunately the adult females and juveniles are largely lacking obvious identifying characteristics and there may be errors made in associating juveniles to the adults without the use of genetic information.

Etymology. We give this species the specific epithet "*berenbaumae*" in honor of the esteemed entomologist, Dr. May Berenbaum, who has made huge contributions to entomology through scientific products, service and public outreach.

Known geographic distribution. Guyana

Xestoblatta agautierae Grandcolas, 1992

Materials. *Adult ♂*.

Voucher number: DEKBO0827.

Collection locale. Wilson's pond trail (Honey pond trail), Karanambu Ranch, Rupununi, Guyana.

GPS: 3°44'42.36"N, 59°19'15.21"W.

Collection date: 10 – June – 2013.

Collectors. Dominic A. Evangelista, Oswin Ambrose, Susan George, and Megan M. Wilson.

Adult ♀.

Voucher number: DEKBO0826.

Collection locale. Forest Island “Darwin”, Karanambu Ranch, Rupununi, Guyana.

GPS: 3°47'47.62"N, 59°22'6.77"W.

Collection date: 14 – June – 2013.

Collectors. Dominic A. Evangelista, Oswin Ambrose, Susan George, and Megan M. Wilson.

Collection/ecological information. Both specimens above were collected in pitfall traps baited with beer in the forests of the Rupununi savannah.

Morphological identification. The left genital phallomere, right genital phallomere, absence of a dorsal tergal gland and body coloration match closely with the species description (Grandcolas 1992a). The styli differ slightly to the illustrations in the original description in that the left stylus of our specimen is shorter and originates more medially. The female was associated to the male by comparison of gross morphology and body coloration. See Figure 11 for photos of adult male and adult female.

Collection/ecological information for other specimens not reported here. We collected many individuals of this species from most forested areas surrounding Karanambu Ranch. We collected only one individual of this species in a similar trap at the edge of a forest, near open savannah. We found this species and *X. berenbaumae* sp. n. to be extremely abundant in their respective localities (>100 individuals of each collected). However, both are previously unreported for Guyana. We believe this can be attributed to the fact that we used beer and fermenting fruit to bait out pitfall traps. As Gurney (1939) reports, *Xestoblatta* Hebard, 1916 were rare in collections until the contributions of an entomologist trapping fruit flies in Panama. We can speculate that these fruit flies were also collected with some sort of aromatic bait (as this is common for fruit fly trapping) that attracted the *Xestoblatta* Hebard, 1916 as by-catch.

Known geographic distribution. Guyana (new record) and French Guiana.

Subfamily: Nyctiborinae

Nyctibora dichropoda Hebard, 1926

Materials. *Adult* ♂ Figure 12.

Voucher number: DECBA0302.

GenBank accession number: KF155061.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Collection date: 29 – July – 2011.

Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski and Jessica L. Ware.

Collection/ecological information. This specimen was collected in the leaf litter.

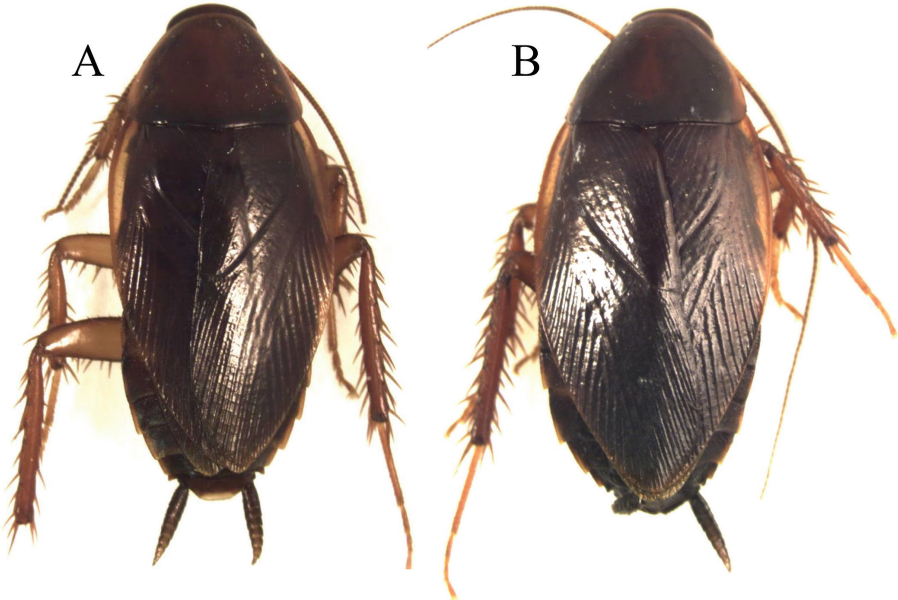

Figure 11. *Xestoblatta agautierae.* **A** Adult male dorsal view (DEKBO0442) **B** Adult female dorsal view (DEKBO0445).

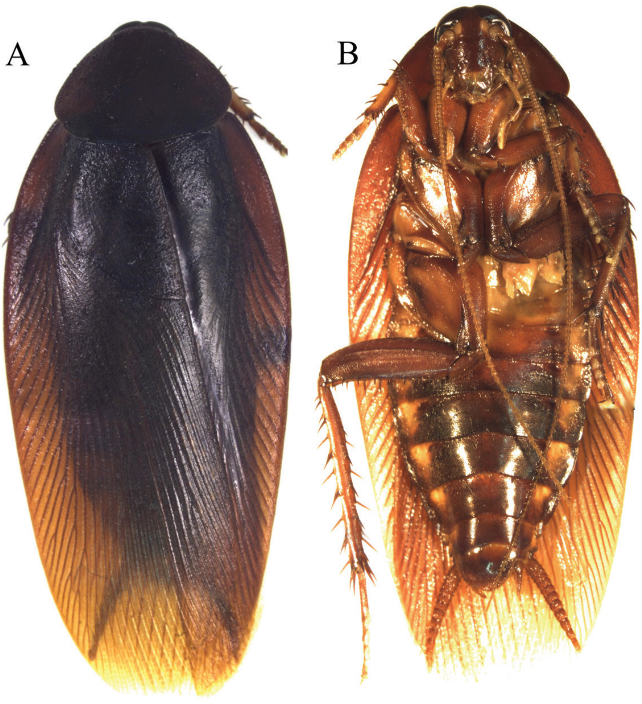

Figure 12. *Nyctibora dichropoda* adult male (DECBA0302). **A** Dorsal view **B** Ventral view.

Morphological identification. This specimen matches the illustration and description by Hebard (1926) in the "striking pale" coloration on the surfaces of the tibiae, the definitive character for this species. However, the male we have is much larger than that which he described. It is matching in all other ways.

Molecular identification. The COI barcodes of this specimen are close to an adult female (Voucher number: DECBA0235; GenBank accession number: KF155062) and juvenile specimen (Voucher number: DECBA0104; GenBank accession number: KF155024) of *Nyctibora*. Based on both genetic distance and morphological dissimilarity, these individuals are likely members of a separate species. We do not report them further here.

Known geographic distribution. Guyana (new record), Suriname and French Guiana.

Subfamily: Pseudophyllodromiinae

Chorisoneura inversa Hebard, 1926

Materials. *Adult* ♂ Figure 13.

Voucher number: DECBA1782.

GenBank accession number: KF155130.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'N, 58°13'W.

Date: 7 to 11 – August – 2013.

Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski and, Jessica L. Ware.

Morphological identification. This individual was recognizable when comparing to the description of Hebard (1926) and the presence of the anteriorly pointing "V" shape on pronotum.

Genetic information and evolutionary placement. As discussed below, this specimen was placed near *Calhypnorna* Saussure & Zehntner, 1893 with 75% bootstrap support.

Known geographic distribution. Guyana, Suriname, French Guiana and Brazil.

Dendroblatta callizona Rehn, 1928

Materials. *Adult* ♀ Figure 14.

Voucher number: DECBA0805.

Collection locale. CEIBA Biological Station, Madewini, Guyana.

GPS: 6°29'57.75"N, 58°13'7.28"W.

Date: 14 – August – 2011.

Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski, and Jessica L. Ware.

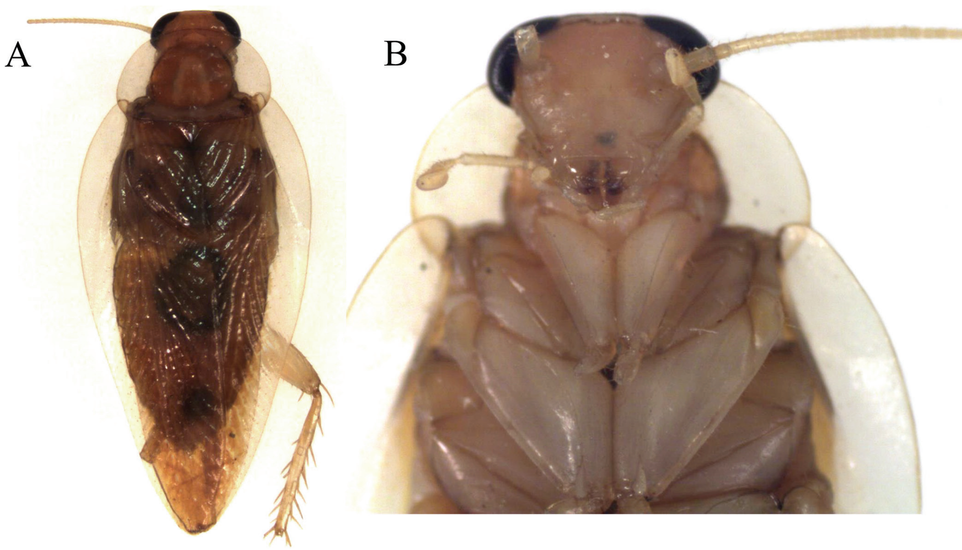

Figure 13. *Chorisoneura inversa* adult male (DECBA1782). **A** Dorsal view **B** Ventral view of head.

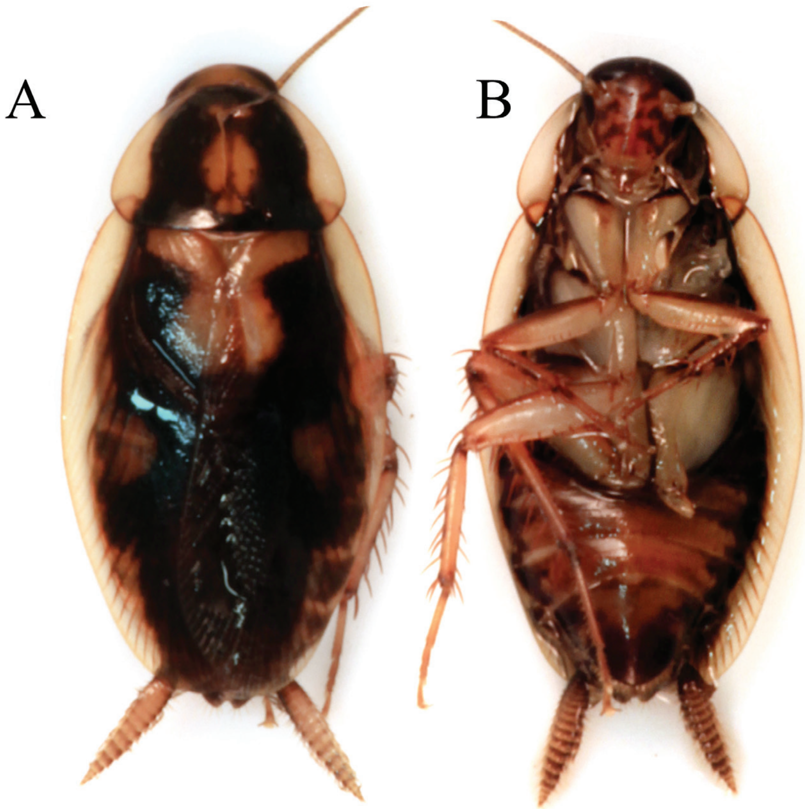

Figure 14. *Dendroblatta callizona* adult female (DECBA0805). **A** Dorsal view **B** Ventral view.

Juvenile
Voucher number. DECBA0901.
GenBank accession number: KF155067.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'57.75"N, 58°13'7.28"W.
Date: 13 – August – 2011.
Collectors. Dominic A. Evangelista, Ian Biazzo, Manpreet K. Kohli, Melissa Sanchez-Herrera, Nicole Sroczinski, and Jessica L. Ware.

Collection/ecological information. Both of these specimens were collected in a cup baited with beer placed in the canopy. The cup was tied to the trunk of a tree 13.8 meters above the ground. The tree chosen was close to a swampy primary forest area and on the edge of grassy hillside (most likely a plot that had been burned in the past). There were traps placed in the same tree at other heights but both individuals of this species were caught in this particular trap.

Morphological identification. Our female specimen of *D. callizona* Rehn, 1928 is within the variation described by Rehn (1928). The juvenile specimen was identified by comparison with the adult and using genetic data as well.

Genetic information. In the tree of Evangelista et al. (2014) this species is placed near two individuals reported as "Ectobiidae sp. 10". The morphology of these specimens is consistent with *Dendroblatta cnephaia* Hebard, 1926, although we do not report them here because of a lack of adults to confirm identification.

Known geographic distribution. Trinidad and Tobago, Guyana, and Suriname.

Calhypnorna sp. A

Authors of the description. Evangelista, Wilson, & Ware.

Materials. *Juvenile* Figure 15.
Voucher number: DECBA1802.
GenBank accession number: KF155118.
Collection locale. CEIBA Biological Station, Madewini, Guyana.
GPS: 6°29'N, 58°13'W.
Collection date: 15 – August – 2012.
Collectors. Dominic A. Evangelista and William R. Kuhn.

Specimen information. This specimen is stored in ethanol and is deposited in the Center for Biodiversity at the University of Guyana.

Identification and differential diagnosis. We identified this specimen as *Calhypnorna* based on the following comparisons. Our specimen is not lacking an interocular carina as in *Hypnornoides* (Rehn 1917). Our specimen also has a definitively truncate posterior margin of the pronotum (Figure 15B), which differentiates it from *Euhypnorna* (Hebard 1921). Our specimen is lacking the hairs covering most of the body as in *Hypnorna* (1893) and most closely matches the illustration of *Calhypnorna* by Saussure and Zehntner (1893).

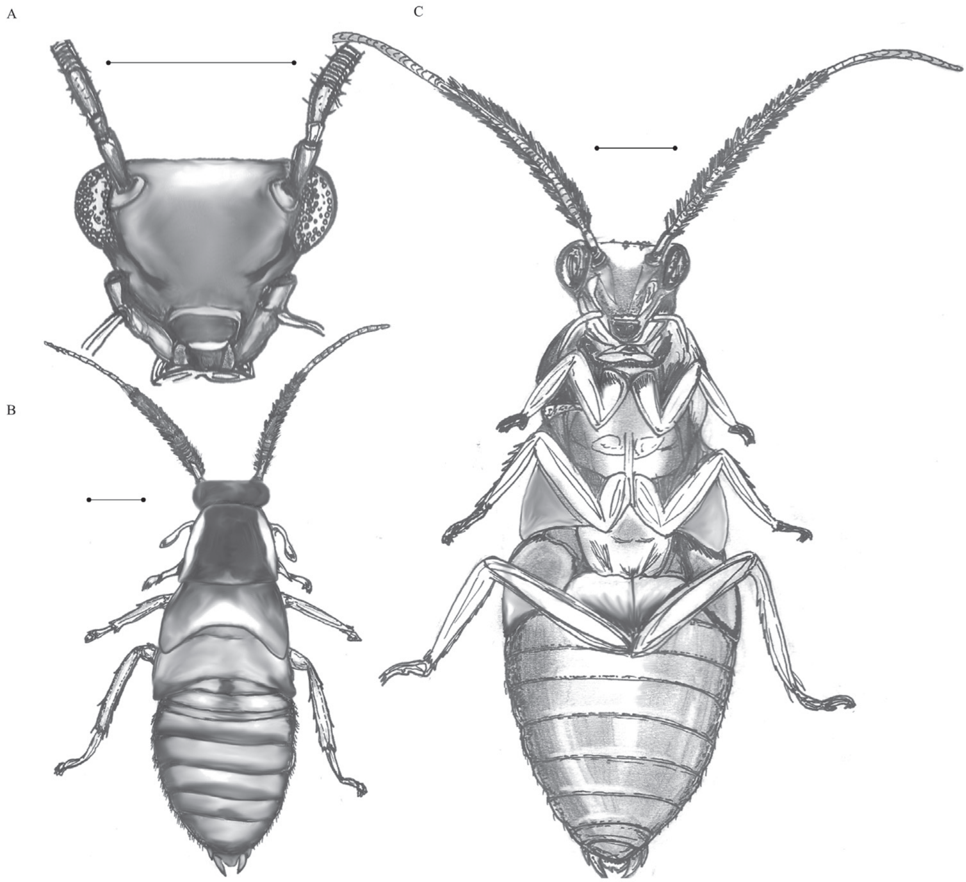

Figure 15. *Calhypnorna* sp. **A** Ventral view of head **B** Dorsal view of body **C** Ventral view of body. Scale bar = 1 mm. Illustrations contributed by Megan M. Wilson.

Description. The specimen is a juvenile that is likely in its penultimate instar. Overall, the body shape is elongated for a typical cockroach, and even for a typical Pseudophyllodromiinae. A large portion of the head is visible from a dorsal perspective, and reaches anteriorly past the pronotum significantly. The black coloration on the pronotum is the same width as the width of the head where it meets with the pronotal margin (Figure 15B).

Antennae are hirsute to nearly plumose. The antennae are slightly clubbed basally with the widest point occurring at first segment of the flagellum. There are two major color regions of the antennae: a dark basal region and a light distal region. The dark basal region begins as slightly lighter than the remainder but becomes a dark black color by the end of the dark region. The 25th segment of the antennae is the final dark segment. The 26th antennal segment begins the light region of the antennae. The 26th or 27th and subsequent segments are nearly white, becoming more brownish orange after the 7th white segment (33 total). The total number of antennal segments on the specimen is 38 (left) and 44 (right).

The head is very large in relation to the remainder of the body, triangular, and wider than typical for a Pseudophyllodromiinae (Figure 15A). Inter-ocular space is sharply angled creating a carina that begins where the compound eye meets the antennae. The antennal pits are closer together than the eyes. Eyes are prominent and appear to bulge the head laterally. Facial grooves spanning from the posterior portion of the eye towards the mouthparts are prominent. Coloration on head is brown-orange overall with a slightly lighter, less brown, patch above and below the carina. Ocellar spots are either absent or not readily visible.

The pronotum is colored with a dark black region taking up the major two fifths of the medial area. The black area is opaque and reaches forward to the anterior margin but just stops short of completion in the posterior eighth of the segment. The black region is nearly rectangular, slightly rounded anteriorly and widened posteriorly (Figure 15B). Bordering the black region laterally and posteriorly are translucent regions colored brown-orange similar to the remainder of the body.

Meta- and meso-thoracic segments are both strongly lobed, presumably due to the developing wings within. Color is orange-brown overall with small amounts of black on the tips of the posterior pair of wing pads. Legs are light in color with a slight orange tinge overall. Dark regions are present on the medial side of the base of the fore-coxae.

The ventro-anterior margin of the fore-femur have five (right) or eight (left) large piliform spines basally followed by 27 (right) and 20 (left) shorter piliform spines, which are then each followed by one larger piliform spine and finally one large distal spine that is not piliform. Arolia are large and extend beyond the tips of the pretarsal claws on all legs. Claws are symmetrical and unspecialized.

Both the venter and dorsum of the abdomen is the same orange-brown color as the remainder of the body, but with a slightly redder tinge. Soft black color borders the abdomen laterally and posteriorly.

The dorsal abdomen is mostly glabrous. Hairs that are present are most dense laterally and on segments five and six. Ventral abdomen is glabrous as well, with fewer hairs than on the dorsal side and no regions with any dense pubescence. Supra-anal plate is unspecialized and broadly subtrapezoidal or triangular. Subgenital plate is broadly subtrapezoidal with the posterior margin being broader than that of the subgenital plate. The posterior margin of the subgenital plate is not perfectly uniform and conforms around two large styli. Styli are equal in length to the entire subgenital plate. Their width is equal to half of the length of the visible portion of the styli.

Genetic information and evolutionary placement. Evangelista et al. (2014) recovers this sequence as being most closely related to a species reported as "Ectobiidae sp. 6" with 75% bootstrap support. This species is identified above as *Chorisonuera inversa* Hebard, 1926. Hebard hypothesized that these are closely related genera (Hebard 1921a) and we can now say that genetic data supports this hypothesis. We cannot definitively say, however, that they are sister taxa because of incomplete phylogenetic

Figure 16. Comparison of overall body coloration of three sympatric species (Left: Ichneumonidae, Middle: *Calhypnorna* sp. "Aguyana", Right: Reduviidae) from northern Guyana. *Calhypnorna* sp. shares the orange hind section and dark forward section with the other two insects. Additionally, the antennae of the cockroach composed of: a white band shared with the wasp; an orange band shared with the assassin bug; and a black base share among all. Photos are not to scale.

sampling in this tree. Thus, we follow Hebard (1921a) and not Beccaloni (Beccaloni 2007) and consider this to be in the Psuedophylodromiinae.

Known geographical distribution of Calhypnorna. Guyana (new record), Para Brazil, Bolivia and Panama.

Collection/ecological information. This specimen was found crawling through a benab. The only individual of this species observed in the field was the one collected and described here. Given that our overall collecting effort was significant (>1000 individuals of Blattodea *s.s.*) and we only found a single individual of *Calhypnorna* sp. A, we consider this species to be quite rare.

Previous work (Shelford 1912) has cited species of this genus as being beetle mimics. However, we observed no beetle model in the field that this species may have been mimicking. We did notice a similarity in body coloration of a wasp and Hemipteran sympatric with this conspicuously colored Blattodea (Figure 16).

Notes on historical records of this genus. The genus *Calhypnorna* Saussure & Zehntner, 1893 was originally established as a subgenus of *Hypnorna* Stål, 1860. It was then given generic status by Kirby (1904). The genera *Calhypnorna*, *Hypnorna*, *Hypnornoides* Rehn, 1917 and *Euhypnorna* Hebard, 1921 are thought to be closely related (Hebard 1921). These are known from a number of regions (Para and Rio de Janiero Brazil, Bolivia and Panama) but there are no records from the Guiana Shield. Therefore, a new record of this species from the coastal rainforests of Guyana is geographically disjointed from all other records of these taxa. On this basis alone, we might distinguish this specimen as a new species. However, since our lone specimen is a juvenile, we have limited morphological basis for differentiating this from known taxa. We refrain from establishing this as new species until adult specimens can be found but we still give a synopsis of the biological traits of this specimen. This new record extends the potential range of *Calhypnorna* Saussure & Zehntner, 1893 and it has now been recorded from Para Brazil (south of Amazon), Bolivia, Panama, and Guyana (new record).

Cockroach fauna of the Guyana Shield: Summary

The checklist (Table 1) contains 5 families, 18 subfamilies, 79 genera, and 234 species. French Guiana and Suriname contribute the most to this richness, with 151 and 136 species respectively (Figure 17). The surprisingly low number of records from Guianan Venezuela, Roraima and Amapa Brazil (Figure 17) are most definitely due to an historical under sampling in these regions.

When pooling and examining the range data for all the taxa (Figure 18) we see that, as expected, small ranges are most common among species. This is also true when pooling taxa together into genera, although these range sizes are larger overall. 85 species (36%) and 20 genera (25%) are limited to a single region while 36 species (15%) and 24 genera (30%) are represented in four or more regions. Small ranges (<4 regions) are no longer the majority when lumping species into subfamilies or families.

The highest rates of endemism are seen in Guianan Venezuela, Amapa Brazil and French Guiana (Figure 19). However, we believe these values to be inaccurate due to lack of sampling. Compared on a pairwise basis, Guyana, Suriname and French Guiana had a high proportion of shared fauna (Figure 20). These are each proximal to each other and centrally located, thus their faunal similarity is expected. Roraima showed a high number of its own species shared among each other region. However, most of the species recorded from Roraima are circumtropical taxa and the region is severely under sampled.

Most of the species in the checklist have neotropical distributions. There were few taxa listed with distributions that may be considered circumtropical or cosmopolitan: *Blatta orientalis* Linnaeus, *Neostylopygia rhombifolia* (Stoll) , *Periplaneta americana* (Linnaeus), *P. australasiae* (Fabricius), *P. brunnea* Burmeister, *Holocompsa nitidula* (Fabricius), *Phoetalia pallida* (Brunner von Wattenwyl), *P. circumvagans* (Burmeister),*Nauphoeta cinerea* (Olivier), *Rhyparobia maderae* (Fabricius), *Panchlora nivea* (Linnaeus), *Pycnoscelus surinamensis* (Linnaeus), *Blattella germanica* (Linnaeus), *Supella longipalpa* (Fabricius). Most of these may be considered non-native, or adventive.

Discussion

The majority of records used to compile the checklist were lacking in specific biological, geographic or ecological information. Most historical records we encountered only gave general collection locales within their respective country. GPS information was non-existent for nearly all records.

We present eight new species records for Guyana. This includes one genus new to the entire shield (*Calhypnorna* Saussure & Zehntner, 1893) and one new species (*Xestoblatta berenbaumae*). Given the somewhat high local richness of cockroaches (Evangelista et al. 2014) in one small plot compared to the richness of the entire country (Figure 17) we believe that much of this country's diversity has yet to be discovered.

Among the regions considered here, Guyana and Amapa are moderately well sampled. Guianan Venezuela, and Roraima Brazil are sampled especially poorly and our knowledge of the Blattodea of these regions is very much preliminary. In contrast, French Guiana and Suriname are some of the most well sampled cockroach faunas in all the neotropics, ranking as the 2nd and 6th most species dense regions respectively (Table 4). The most well sampled region in the neotropics, Rio de Janeiro, has a species density of 0.01 species per square mile (Table 4). If we consider this value as being typical of true species density, which is purely speculation, then no other neotropical region has been sampled thoroughly.

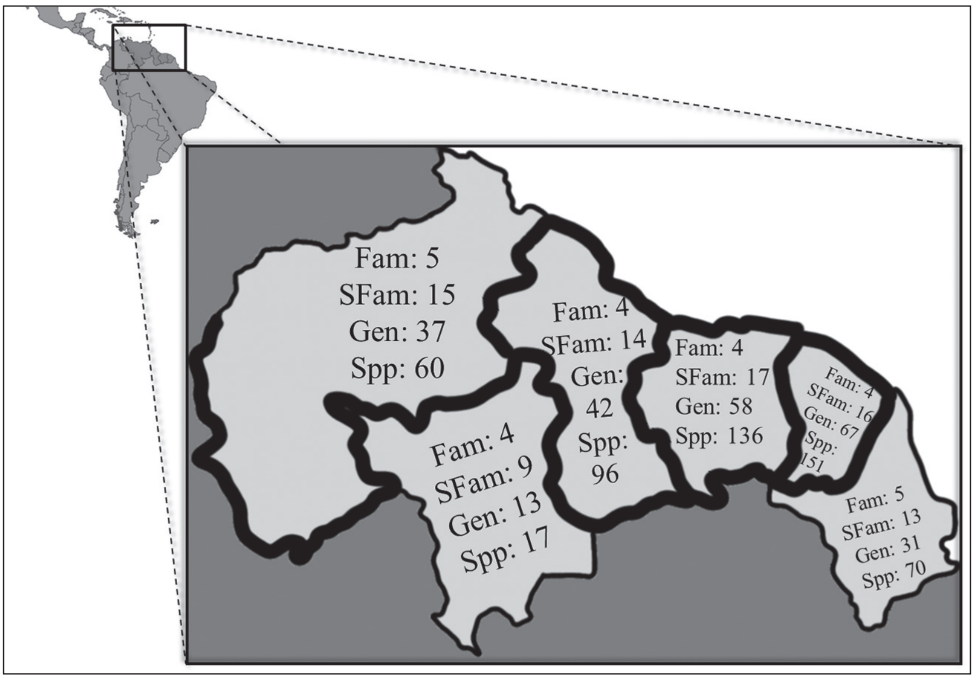

Figure 17. Known richness of cockroach fauna at different taxonomic levels for six regions of the Guiana Shield.

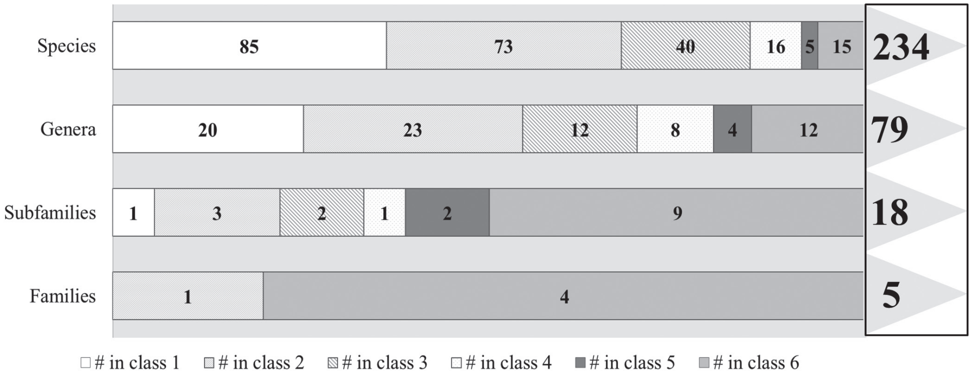

Figure 18. Extent of range for cockroach taxa. Classes represent the number of regions a taxon was present in: present in only one region – class one; present in all six regions – class 6; etc. Total number of taxa for each level shown on the right.

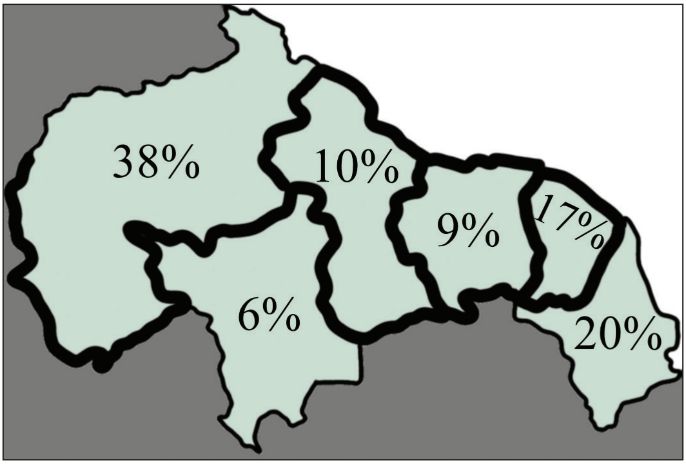

Figure 19. Proportion of cockroach fauna endemic to a region. Endemism is only referred to within the context of the shield.

The levels of endemism we see (Figure 19) are surprisingly low compared with other known rates of endemism for the Guiana Shield (Funk et al. 2007; Hollowell and Reynolds 2005; Kelloff and Funk 2004; Naka 2011). One possible explanation would simply be that cockroaches have low rates of tropical endemism. However, this is contradicted by other cockroach faunas showing much higher rates of endemism (e.g. ~60% of all taxa in Hispaniola; Gutierrez and Perez-Gelabert 2000). The alternate explanation is that there is a collection bias for taxa with broad ranges. This could be true if geographic sampling is very sparse, which may be the case. The levels of endemism we report (Figure 19) are actually higher than what they are in reality, since we only considered strictly Guianan regions. There are likely a few species that appear endemic when only considering these regions but by expanding the geographic scope

	Venezuela	Guyana	Suriname	French Guiana	Roraima, Bra.	Amapa, Bra.
Venezuela		0.4	0.45	0.43	0.25	0.48
Guyana	0.25		0.75	0.74	0.17	0.38
Suriname	0.2	0.53		0.81	0.11	0.32
French Guiana	0.17	0.47	0.73		0.11	0.32
Roraima, Bra.	0.88	0.94	0.88	0.94		0.94
Amapa, Bra.	0.41	0.51	0.61	0.69	0.23	

Figure 20. Proportion of fauna in a region (left) shared with each other region (top). Values greater than .5 are shaded by magnitude. The three central regions (Guyana, Suriname and French Guiana) have a high degree of similarity with each other.

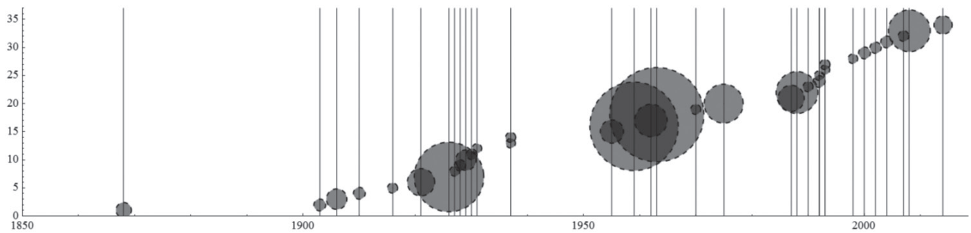

Figure 21. Studies contributing to the checklist of cockroaches of the Guiana Shield. The year of publication of each source plotted against the order in which they were published. The present study, the 34th, is the final circle in the top right. The radius of the circles represents the relative number of times that study is cited in the checklist.

we would find that they are actually not Guianan endemics (e.g. also being present in Trinidad, Colombia or other parts of Brazil).

If we didn't already know that under-sampling for cockroaches (Pellens and Grandcolas 2008; Roth 2003) and other insects (Erwin 1982; Stork 1993) was generally problematic, we could infer this based on a number of clues in our data. First, as mentioned previously, an estimate of total species richness of cockroaches for one small plot in northern Guyana nearly matches the recorded richness of the entire country

Table 4. The ten regions of the Neotropics with the highest known cockroach richness per unit area.

Region	Size (mi²)	# of spp.	spp/mi²	Source
Rio de Janeiro, Brazil	16,871	169	0.0100	(Pellens and Grandcolas 2008)
French Guiana	32,253	151	0.0047	-
Panama	29,118	118	0.0041	(Beccaloni 2007)
Costa Rica	19,730	72	0.0036	(Beccaloni 2007)
Hispaniola	29,530	86	0.0029	(Perez-Gelabert 2008)
Continental Ecuador	46,444	114	0.0025	(Vidlicka 2013)
Suriname	63,039	136	0.0022	-
Cuba	42,426	85	0.0020	(Gutierrez 1995)
Amapa, Brazil	55,141	70	0.0013	-
Guyana	83,000	96	0.0012	-

(Evangelista et al. 2014). Furthermore, there are 20 cases of species with unusual distributions (Table 5), where it is absent from a region but recorded from neighboring regions. Without evidence to the contrary, the simplest explanation for these distribution "holes" is inadequate sampling. Finally, although specific locality information is severely lacking for most records, those that are recorded do not represent effective spatial sampling, and most records are from coastal areas of major rivers. Finally, the number of species per region is significantly lower than that of better sampled but less diverse taxa such as Odonata (Checklist of Odonata of the Guiana Shield 2012; Garrison et al. 2006, 2010).

Although there is clearly a great under-sampling of cockroaches from this region, we cite 34 publications that contributed to this checklist, including the present (Figure 21). The earliest source was from 1868 (Walker 1868). Most of the publications contributing to the checklist were published between 1900 and 1940. Morgan Hebard, Isolda Rocha e Silva Albuquerque, Ashley Gurney and James Rehn contributed the most through primary taxonomic publications and species descriptions (in particular see Hebard 1926; Rehn 1930; Rocha E Silva Albuquerque and Gurney 1962). Karlis Princis, J. Bonfils and Conrad F.A. Bruijning were also important in these capacities but more-so through their own published checklists. Jaime Perez and J. Bonfils were also great contributors to the fauna of Venezuela and French Guiana. Similarly, Roseli Pellens was an important contributor to the knowledge of the two Brazilian regions through her checklist. Philippe Grandcolas was also an instrumental author through this same checklist, as well as other primary taxonomic publications. The three most cited papers in the checklist are Princis' "Orthopterum Catalogus" (148 citations), Bruijning's "The Blattidae of Surinam" (138 citations), and Hebard's "The Blattidae of French Guiana" (105 citations) (Figure 21). It is worth restating that, although they are invaluable authors, Princis' and Bruijning's contributions were mainly through synthesizing work done by others. The significance of Hebard's contribution to the knowledge of the Guianan fauna through "The Blattidae of French Guiana", in which he alone described 53 new species, cannot be understated.

Table 5. Recorded (o and +) and projected (p) presences of cockroaches from the Guiana Shield. VEN – Combined data from Amazonas, Bolivar and Delta Amacuro Venezuela; GUY – Guyana; SUR – Suriname; FG – French Guiana; Rora BRA – Roraima, Brazil. Amapa BRA – Amapa, Brazil. Projected occurrences are expectations of species presence based on confirmed presence in neighboring regions. Data used to determine this is taken from the checklist (Table 1) and other sources (see Table 1 for citations for these species).

	VEN	*GUY*	*SUR*	*FG*	*Rora BRA*	*Amapa BRA*
Blaberidae						
Blaberinae						
Blaberus colosseus	**p**	o	**p**	o		
Blaberus craniifer	**p**	o	**p**	o		
Epilamprinae						
Epilampra azteca	o	**p**	o	o		
Epilampra maculicollis		o	**p**	o		
Panchlorinae						
Panchlora bidentula	o	**p**	o	o		
Zetoborinae						
Thanatophyllum akinetum		+	**p**	o		
Ectobiidae						
Anaplectinae						
Anaplecta subsignata	o	**p**	o	o		o
Maraca fossata	o	**p**	o	o		
Blattellinae						
Cahita misella	**p**	**p**	**p**	o		
Chromatonotus notatus	**p**	**p**	o	o		
Eudromiella ineopectata		o	**p**	o		
Xestoblatta nyctiboroides		o	**p**	o		
Xestoblatta agautierae		+	**p**	o		
Pseudophyllodromiinae						
Anisopygia decora		o	**p**	o		
Arawakina frontalis		o	**p**	o		
Chorisoneura gatunae	**p**	**p**	o	o		
Euphyllodromia chopardi		o	**p**	o	o	o
Neoblattella guianae		o	**p**	o		o
Sciablatta poecila		o	**p**	o		
Trioblattella callosoma		o	**p**	o		o

Conclusions

This checklist of Blattodea s.s. of the Guiana Shield, showing 234 species, is the most comprehensive to date. It is also functions as the first true checklist of cockroaches of Guyana, as all previous sources severely fall short of listing even the modest number of species we record here. Given the large number of species found in the small country of French Guiana, we see that the Guiana Shield may be one of world's hotspots of biodiversity for cockroaches. However, sampling is still severely lacking. What little sampling has been done in the Guianas was mostly completed before 1960. There are huge gaps to fill in, and until they are we will be unable to adequately address most questions about the nature and origins of cockroach biodiversity.

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RESEARCH ARTICLE

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A new species of the genus *Sulawesifulvius* Gorczyca, Chérot, & Štys, 2004 (Insecta, Heteroptera, Miridae, Cylapinae) from India

H. M. Yeshwanth[1], Chérot Frédéric[2]

1 *Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bangalore 560 065, India* 2 *Département de l'Etude du Milieu Naturel et Agricole, Service Public de Wallonie, Gembloux, BE-5030, Belgium*

Corresponding author: *Chérot Frédéric* (frederic.cherot@spw.wallonie.be)

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Abstract
A new species, *Sulawesifulvius indicus* **sp. n.**, is described from Bangalore, India. It is easily separated from the type species *S. schuhi* Gorczyca et al., 2004, the only other species of the genus, by the small size, dorsal coloration, and the male genital structures. The discovery of a new species of *Sulawesifulvius* in southern India considerably extends the distribution of the genus, previously recorded only from Sulawesi, Indonesia.

Keywords
Sulawesifulvius indicus sp. n., Cylapinae, India, taxonomy

Introduction

The monotypic genus *Sulawesifulvius* was erected by Gorczyca et al. (2004) to accommodate the new plant bug species *Sulawesifulvius schuhi* Gorczyca, Chérot & Štys, 2004 from Nani Wartabone National Park, Sulawesi (Indonesia).

Recently, two specimens of an unknown cylapine were collected by the first author in Hessaraghatta, near Bangalore, South India. These Indian specimens conform to the original generic diagnosis of the genus *Sulawesifulvius*. However, the genital structures of the male holotype, especially the parameres, are different and much simpler than the male genitalia of *S. schuhi*. Consequently, we describe these specimens as a new species of *Sulawesifulvius*.

Material and methods

The specimens examined for the study are deposited in the collection of the Department of Entomology, University of Agricultural Sciences, Bangalore, India (UASB). The terminology adopted for male genitalia follows Gorczyca et al. (2004).

All measurements are given in millimeters. Photographs were taken using a Leica M205 C microscope. Multiple images were taken at different depths and were combined using a Combine ZM software. Illustrations of male genitalia were drawn using a Leica DM2000 compound microscope attached to a camera lucida.

Results

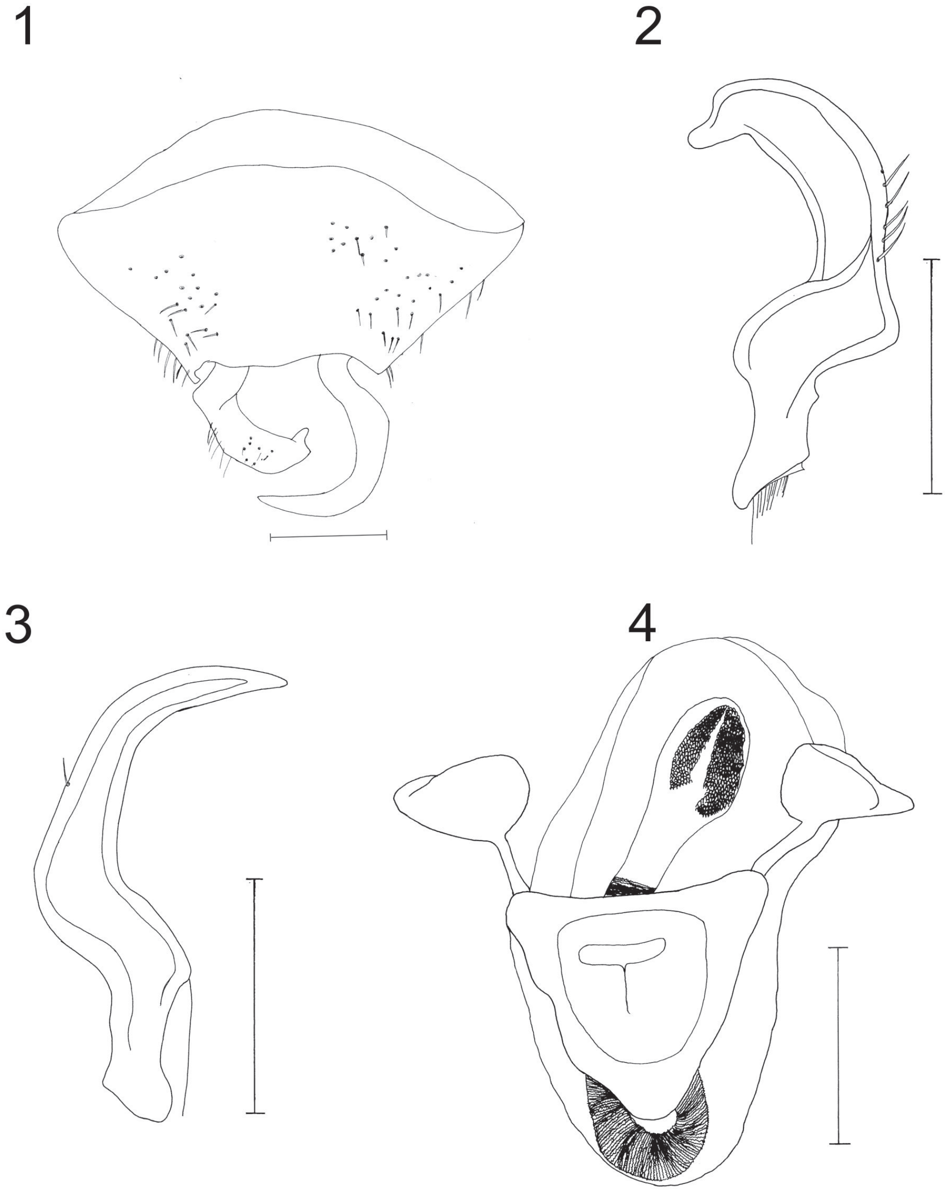
***Sulawesifulvius indicus* sp. n.**
http://zoobank.org/4D0C4992-1485-4F85-BDB0-3AE32B840CE6
Figs 1–9

Type material. Holotype ♂: India: Karnataka: Hessarghatta, near Bangalore (approx. 13°09'N, 77°29'E; altitude: 960 m), 20.vi.2011, at light, H.M. Yeshwanth leg. (UASB). Paratype ♀: India: Karnataka, Hessaraghatta, near Bangalore, 2.v.2010, at light, H.M. Yeshwanth leg. (UASB).

Diagnosis. Small species, length 2.70, width 1.50 (versus length 3.40 and width 1.80 in *S. schuhi*), dorsally yellowish brown, slightly tinged with dark red, with simple parameres (Figs 2–3), devoid of sharp processes (versus parameres with sharp processes in *S. schuhi*), and pygophore with a straight right side and a posterior margin not deeply curved (Fig. 1).

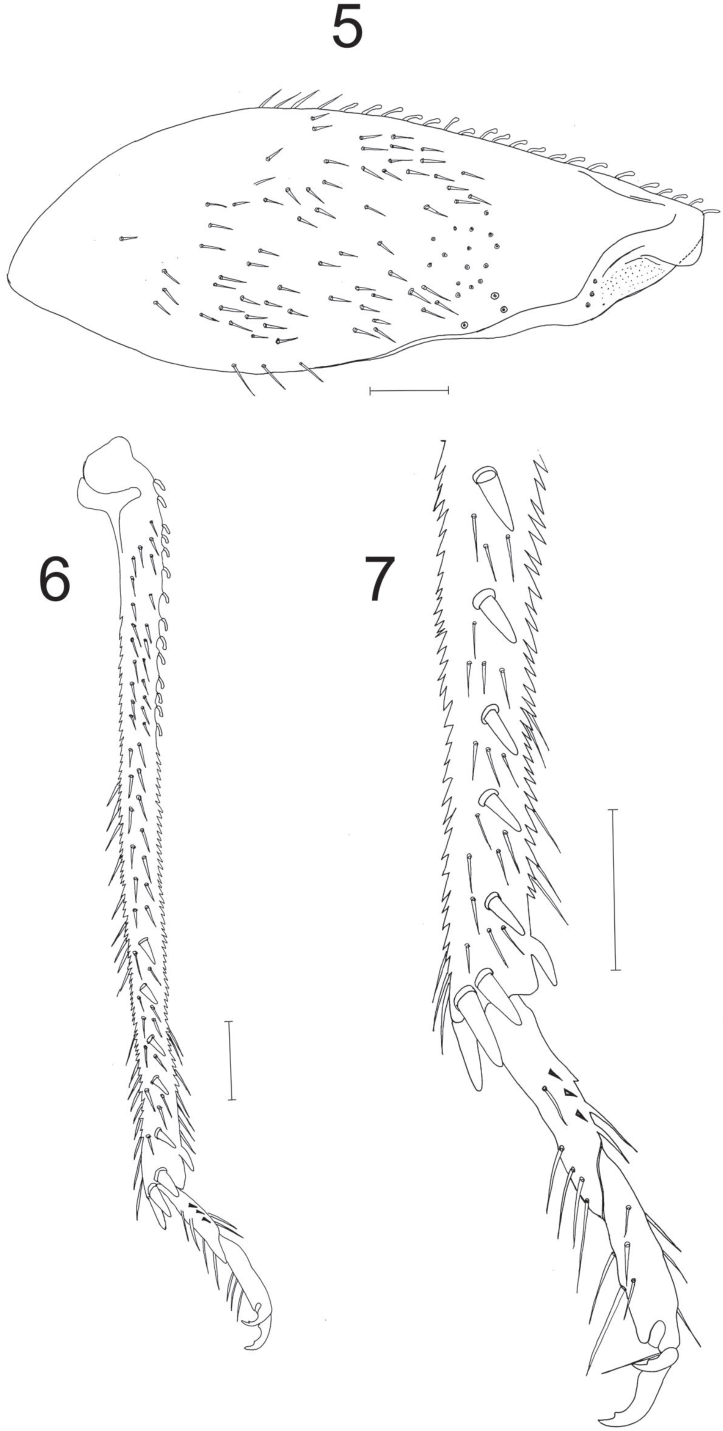
Description. ***Body of male*** pale yellow with pale red and brown markings; body length 2.70, width 1.50 (Fig. 9).

Head pale yellow, longer than width, clypeus prominent; vertex and frons with two pairs of tubercles; head length in dorsal view 0.40, intraocular width 0.27; first segment of antenna tubular, pale yellow, tinged with red and brown markings; second segment yellow with a brown band medially, covered with short, pale setae; third segment pale yellow, apex dark brown, with bright white setae; fourth segment dark brown, with bright white setae; length of antennal segments: 0.15: 0.30: 0.40: 0.15; rostrum brown, shiny, length of rostral segments: 0.22: 0.25: 0.22: 0.25.

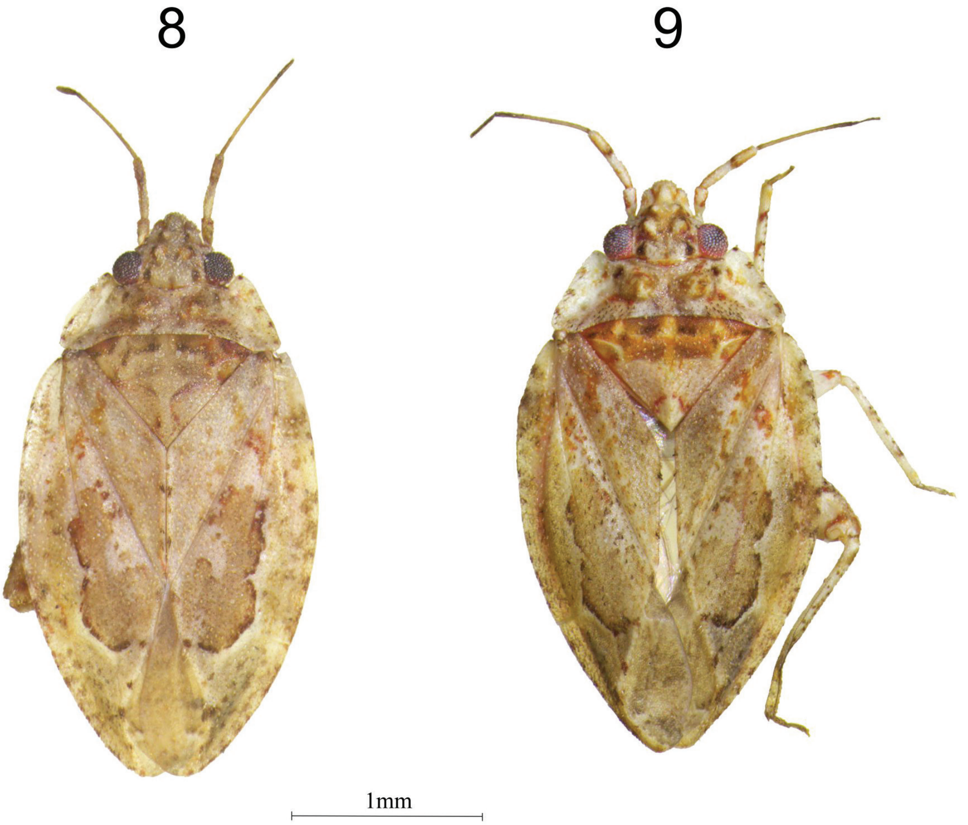


Figures 1–4. *Sulawesifulvius indicus* sp. n. male holotype, genital structures. **1** pygophore (dorsal view). Scale = 0.5 mm. **2** left paramere **3** right paramere **4** phallus Scales = 0.25 mm.

Pronotum pale yellow with red and brown markings, anterior margin of pronotum concave, with two brown spots; calli raised, large, tuberculate; lateral margins with brown spots on posterior region; anterolateral angle with scalelike setae; posterior margin arcuate. Length of pronotum 0.39, width of pronotum 1.18, length along lateral margin 0.50.



Figures 5–7. *Sulawesifulvius indicus* sp. n. male holotype, legs. **5** metafemur **6** metatibia and tarsus. Scales = 0.5 mm **7** apex of metatibia and tarsus. Scale = 0.25 mm.



Figures 8–9. *Sulawesifulvius indicus* sp. n. habitus in dorsal view. **8** female paratype **9** male holotype.

Legs (Figs 5–7) coxae, trochanters and femora pale yellow, their apices with red patches; femora swollen; metafemur greatly enlarged with a transverse reddish band and three trichobothria; metatibia with scalelike and long setae and longitudinal rows of short spines on each side and thick spines on apical region; tarsus two segmented; metatarsus with short, thick spines; parempodia setiform; claw with subapical tooth.

Mesoscutum exposed, yellowish brown, with brown patches and tinged with red on sides.

Scutellum pale yellow, with a longitudinal pale stripe medially; apex with red markings.

Hemelytra pale yellow, with short shining scalelike setae; corium with brown pattern reaching cuneal incisure, outer margin of embolium with brown patches; cuneus broadly triangular, with brown patches reaching apex of membrane; membrane whitish, tinged with brown.

Ventral surface pale yellow, with red bands.

Pygophore basally broad and narrow toward apex (Fig. 1).

Parameres simple, left paramere flat, strongly curved, with a basal sensory lobe, apex rounded, beaklike (Fig. 2); right paramere simple, slightly larger than left paramere, C-shaped with an apex gradually narrowing distally (Fig. 3).

Phallus prominent (Fig. 4); *ductus seminis* not sclerotized, flexible with terminal circular sclerotized opening; theca membranous, covering endosoma, apex of endosoma globular, with numerous small sclerotized, interconnected processes or rounded structures.

Body of female very similar to that of male in shape, size, color, and vestiture (Fig. 8).

Etymology. The name of the species refers to India, the country where it was collected (adjective derived from the geographical name).

Habitat. The habitat surrounding street lamps consisted of trees dominated by tamarind (*Tamarindus indica* Linné) (Caesalpiniaceae), few trees of neem (*Azadirachta indica* A. Juss) (Meliaceae), *Acacia* sp., and bushes dominated by lantana (*Lantana camera* Linné) (Verbenaceae).

Discussion

Sulawesifulvius indicus sp. n. is similar to *S. schuhi*, the type species and only other species known for the genus (Gorczyca 2006a, Schuh 2002–2013 online). Both species are similar and could be confused on the basis of their external anatomy alone, in particular the body shape (small, oval, flattened dorsoventrally), the head structure (relatively short, inserted in anterior part of pronotum), the vertex with two raised tubercles, the prominent clypeus in dorsal view, the antennal shape (first antennal segment thick, shorter than the head, second antennal segment slightly narrowed in the middle, third antennal segment the longest and thinnest, fourth antennal segment spindle shaped), the pronotal shape and structure (lateral margins elevated, anterior margin enveloping eyes posteriorly, calli wide, raised, totally separated), the metafemoral shape (broad, with subapical depression on side) and the hemelytral structure (exocorium broad, cuneus elongate, partially enveloping membrane, characteristic pattern and vestiture). These species differ by the smaller size of *S. indicus* sp. n., the differences in coloration (their pattern are very similar but the dorsal coloration is yellowish brown, slightly tinged with red, in *S. indicus*; yellowish on the hemelytra and reddish on the head, pronotum and scutellum in *S. sulawesicus*), the male genital structures, particularly by the parameres (simple in *S. indicus*, with sharp processes in *S. schuhi*), and the shape of the pygophore.

The discovery of a new species of *Sulawesifulvius* in southern India considerably extends the distribution of the genus, previously recorded only from Sulawesi, Indonesia but does not modify significantly the original diagnosis of the genus (Gorczyca et al. 2004).

As noted by Gorczyca et al. (2004) a remote, superficial similarity can be observed between the genera *Peritropis* Uhler, 1891 and *Sulawesifulvius*. However, these genera can be easily separated by the structure of head, antennae, pronotum, legs, and hemelytra. Recent revisions of *Peritropis* for the Old (Gorczyca 2000, 2006b) and New Worlds (Wolski and Henry 2012) confirm this conclusion.

Acknowledgments

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RESEARCH ARTICLE

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Revision of the ant genus *Proceratium* Roger (Hymenoptera, Proceratiinae) in Fiji

Francisco Hita Garcia[1,2], Eli M. Sarnat[3], Evan P. Economo[2]

1 *Entomology, California Academy of Sciences, San Francisco, U.S.A.* **2** *Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa, 904-0495, Japan* **3** *University of Illinois Department of Entomology, Illinois, USA*

Corresponding author: *Francisco Hita Garcia* (fhitagarcia@gmail.com)

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Abstract

The Fiji archipelago harbours a surprisingly diverse and endemic ant fauna, despite its isolated and remote location in the South Pacific. The ant genus *Proceratium* is present on Fiji with three endemic species, of which *P. oceanicum* De Andrade, 2003 and *P. relictum* Mann, 1921 were previously known. In this study we describe the third species: *P. vinaka* **sp. n.** All three species are members of the widespread and species-rich *P. silaceum* clade. In order to integrate the new species into the current taxonomic system, we present an illustrated identification key to the worker caste of the three Fijian species. In addition, we provide a detailed description of *P. vinaka*, as well as species accounts for the other two species, which include diagnoses, taxonomic discussions, specimen photographs, and a distribution map.

Keywords

Endemic, identification key, Melanesia, Oceania, *Proceratium silaceum* clade, South Pacific, taxonomy

Introduction

The ant genus *Proceratium* Roger, 1863 is distributed throughout all zoogeographical regions, and contains 81 extant and 5 fossil species (Baroni Urbani and de Andrade 2003; Bolton 2014). Despite this global distribution, most *Proceratium* species are comparatively rare and seldom collected, which is likely due to their cryptobiotic lifestyle (Baroni Urbani and de Andrade 2003). In addition, the natural history of this genus remains mostly unknown, and is only available from a few fragmentary reports based on a small number of the known species. It seems that *Proceratium*, like the closely related *Discothyrea* Roger, are specialised predators of arthropod eggs. Brown repeatedly reported several species carrying, storing, and feeding on spider eggs (1958a, 1974, 1980). More recently, Fisher (2005) also observed the same behaviour and diet in *P. avium* Brown, 1974 from Mauritius. Interestingly, there is also evidence that in a few species of *Proceratium* the queens practice occasional larval hemolymph feeding (Masuko 1986; Baroni Urbani and De Andrade 2003). Most species seem to nest in the soil, below leaf litter, in rotten wood, under stones, or more rarely in tree branches (Brown 1958a, 1974; Baroni Urbani and de Andrade 2003; Fisher 2005). Colonies of *Proceratium* were traditionally considered to be relatively small, mostly containing much fewer than 100 workers (Brown 1958a, 1958b; Leston 1971), but recent studies show that they can have a few hundred workers in some species (Onoyama and Yoshimura 2002; Fisher 2005). Fisher (2005) reported the largest colony so far encountered with ca. 350 workers for *P. avium*.

The taxonomy of the genus is in a moderately good condition. Baroni Urbani and de Andrade (2003) revised the genus on a global scale and provided a morphology-based phylogeny. They also divided the genus into several mutually exclusive clades and provided identification keys to all regions. Nevertheless, due to the rarity of collections and specimens available in 2003, the data about intra- and interspecific variation is sometimes limited and will very likely have to be modified in the future when more material becomes available. A few species have been discovered and described since 2003 (Fisher 2005; Xu 2006; Hita Garcia et al. 2014) and more species can be expected in the future. Baroni Urbani and De Andrade (2003) recognised the following eight species from Oceania and provided an identification to the worker caste: *Proceratium austronesicum* De Andrade, 2003 (Papua New Guinea), *Proceratium caledonicum* De Andrade, 2003 (New Caledonia), *Proceratium ivimka* De Andrade, 2003 (Papua New Guinea), *Proceratium oceanicum* De Andrade, 2003 (Fiji), *Proceratium papuanum* Emery, 1897 (Malaysia, Indonesia, Papua New Guinea, Philippines, Solomon Islands), *Proceratium politum* De Andrade, 2003 (New Caledonia), *Proceratium relictum* Mann, 1921 (Fiji), and *Proceratium snellingi* Baroni Urbani & De Andrade, 2003 (Papua New Guinea). All eight species belong to the *P. silaceum* clade sensu Baroni Urbani and De Andrade (2003), which is the most species-rich clade within the genus with more than 30 described species distributed throughout most zoogeographic regions.

Here, we revise the genus *Proceratium* in Fiji and describe *P. vinaka* sp. n., which was presented as the morphospecies *Proceratium* sp. FJ01 in Sarnat and Economo (2012). We place the new species in the *P. silaceum* clade, which increases the known *Proceratium* diversity in Oceania to nine species. *Proceratium vinaka* is the third *Proceratium* species from Fiji, and we provide an illustrated identification key to the three Fijian species. In addition to the detailed species description of the new species, we give species accounts for *P. oceanicum* and *P. relictum*. We also present diagnoses, high-quality specimen photographs, and distribution maps for the Fijian species.

Abbreviations of depositories

The collection abbreviations mostly follow Evenhuis (2014). The material upon which this study is based is located and/or was examined at the following institutions:

MCZC Museum of Comparative Zoology, Harvard University, Cambridge, U.S.A.
USNM United States National Museum of Natural History, Washington D.C., U.S.A.
BPBM Bernice Pauahi Bishop Museum, Honolulu, U.S.A.

Material and methods

The measurements were taken with a Leica M165 C stereomicroscope equipped with an orthogonal pair of micrometres at a magnification of 100×. Measurements are presented in mm to two decimal places. The measurements and indices used in this study are based on Ward (1988), Snelling and Cover (1992), Baroni Urbani and de Andrade (2003), and Hita Garcia et al. (2014), with the exception of PeL (see note below):

EL Eye length: maximum length of eye measured in oblique lateral view.
HL Head length: maximum measurable distance from the mid-point of the anterior clypeal margin to the mid-point of the posterior margin of head, measured in full-face view. Impressions on anterior clypeal margin and posterior head margin reduce head length.
HLM Head length with mandibles: maximum head length in full-face view including closed mandibles.
HW Head width: maximum head width directly behind the eyes, measured in full-face view.
HFeL Hind femur length: maximum length of hind femur measured along its external face.
HTiL Hind tibia length: maximum length of hind tibia measured on its external face.
HBaL Hind basitarsus length: maximum length of hind basitarsus measured along its external face.
LT3 Abdominal tergum III length: maximum length of abdominal tergum III (=length of segment III) in lateral view.
LS4 Abdominal sternum IV length: maximum length of abdominal sternum IV following Ward (1988).
LT4 Abdominal tergum IV length: maximum length of abdominal tergum IV following Ward (1988).
PeL Petiolar length: maximum length of the petiolar node in dorsal view. [Note: we have modified PeL compared to previous publications by measuring only the petiolar dorsum without the anterior prolongation of the petiole. Since

the species treated here all possess a squamiform node, we are confident that measuring the dorsum of the node provides more comparative information than measuring the petiole as a whole.]

PeW Petiolar width: maximum width of petiole measured in dorsal view.

SL Scape length: maximum length of scape shaft excluding basal condyle.

TL Total body length: combined length of HLM + WL + PeL + LT3 + LT4.

WL Weber's length: diagonal length of mesosoma in lateral view from the anteriormost point of pronotal slope (excluding neck) to posteroventral margin of propodeal lamella or lobe.

CI Cephalic index: HW / HL × 100

OI Ocular index: EL / HW × 100

SI Scape index: SL / HL × 100

DPeI Dorsal petiole index: PeW / PeL × 100

ASI Abdominal segment index: LT4 /LT3 × 100

IGR Gastral reflexion index: LS4 / LT4

The morphological terminology used in this study follows Snelling and Cover (1992) and Baroni Urbani and de Andrade (2003) with a few important modifications outlined in Hita Garcia et al. (2014). The use of postpetiole, gastral segments and abdominal segments in Baroni Urbani and de Andrade (2003) is confusing at times. To avoid this we do not use the terms postpetiole and gaster and instead use abdominal segment III for the postpetiole and abdominal segment IV for the gastral segment I following Fisher (2005). In addition, instead of the term 'spur of foretibia' used by Baroni Urbani and de Andrade (2003), we prefer the term 'calcar of strigil' following Keller (2011). Furthermore, in order to adequately describe pubescence and pilosity we follow Wilson (1955) and use the terms 'erect', 'suberect', 'subdecumbent', 'decumbent' and 'appressed'. The terminology for the description of surface sculpturing is based on Harris (1979).

This description of *P. vinaka* and its separation from *P. oceanicum* and *P. relictum* is based on the worker caste. However, the thorough ant inventory performed on the archipelago also yielded many male specimens (Sarnat and Economo 2012). All male specimens were captured from malaise traps, and thus cannot be reliably associated with the worker castes of their respective species in lieu of molecular techniques or future collection of nest series. Although preliminary morphological analysis suggests the male-worker caste associations proposed in Sarnat and Economo (2012) are likely valid, these hypotheses require additional testing before the males can confidently be described as conspecific with the nominal Fijian *Proceratium*. To this end we are including specimens of all available castes in an on-going molecular phylogenetic study, the results of which will be presented elsewhere. We refrain from including males in the distribution maps of the current study, but acknowledge that the ranges of the three species treated here are likely much broader than those illustrated in Figure 6.

Results

Synopsis of Fiji *Proceratium* species

Proceratium oceanicum De Andrade, 2003
Proceratium relictum Mann, 1921
Proceratium vinaka Hita Garcia, Sarnat & Economo, sp. n.

Identification key to Fiji *Proceratium* species (workers)

1 Significantly smaller species (HW 0.52; WL 0.66); lateral expansions of frontal carinae conspicuously triangular and acute (Fig. 1A); petiolar node moderately squamiform (DPeI 263), and only weakly narrowing from base to apex; subpetiolar process rounded, not dentiform nor spiniform (Fig. 1D)........ ***P. vinaka***

– Significantly larger species (HW 0.76–1.03; WL 0.99–1.38); lateral expansions of frontal carinae weakly triangular and moderately rounded (Fig. 1B, C); petiolar node extremely squamiform (DPeI 620–693) and strongly narrowing from base to apex; subpetiolar process conspicuously dentiform or spiniform (Fig. 1E, F)... **2**

2 Smaller species (HW < 0.80; WL < 1.10); in full-face view head thinner (CI 93); in profile propodeum rounded from dorsum to declivity (Fig. 2A); subpetiolar process thinly dentiform (Fig. 1E).............................. ***P. oceanicum***

– Larger species (HW > 1.00; WL > 1.30); in full-face view approximately as long as wide (CI 101); in profile propodeum with weak angles from dorsum to declivity (Fig. 2B); subpetiolar process thickly spiniform (Fig. 1F) ......***P. relictum***

Notes on the *Proceratium* fauna of Fiji

In this study we describe a new species collected during a recent survey of the ant fauna of Fiji (Sarnat and Economo 2012). Like the majority of the Fijian ant fauna, the new species is endemic to the archipelago. This high endemism is due in part to several *in situ* ant radiations, some of which (e.g. *Lordomyrma* Emery, *Pheidole* Westwood) have been confirmed with molecular analyses (Lucky and Sarnat 2010; Sarnat and Moreau 2011) while others (e.g. *Camponotus* Mayr, *Strumigenys* Smith, *Leptogenys* Roger) are suspected based on morphology (Sarnat and Economo 2012). The ecological and evolutionary assembly processes involved in the development of these faunas have also been the subjects of considerable historical (Wilson 1961) and contemporary (Economo and Sarnat 2012) interest.

The Fiji archipelago harbours an interesting assemblage of endemic *Proceratium* species. *Proceratium oceanicum* and *P. relictum* are certainly the most unusual members

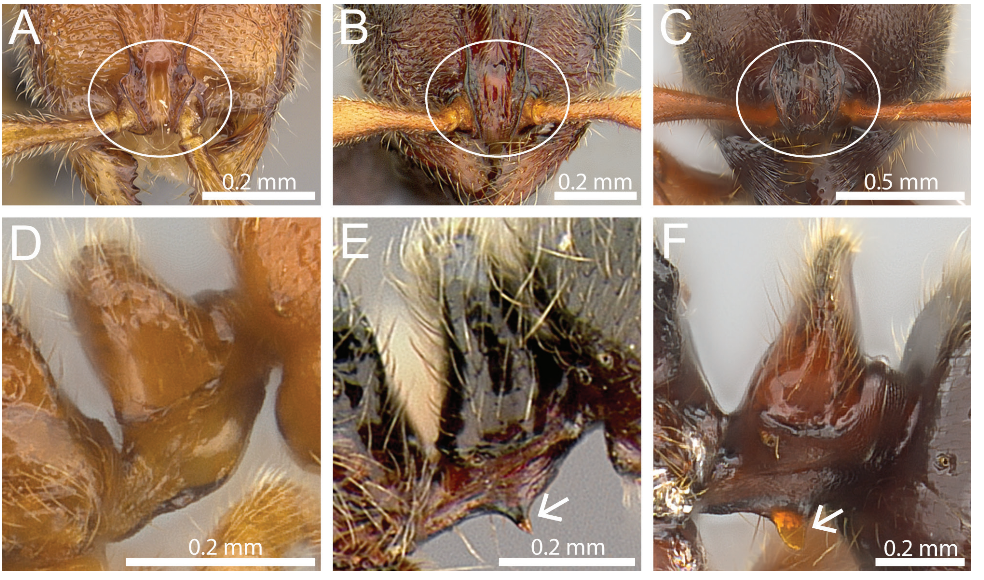

Figure 1. Anterior part of cephalic dorsum in full-face view showing clypeus and frontal carinae (within white ellipse) and petiolar node in profile (white arrows indicate subpetiolar process). **A, D** *P. vinaka* (CASENT0171053) **B, E** *P. oceanicum* (CASENT0171053) **C, F** *P. relictum* (CASENT0194740).

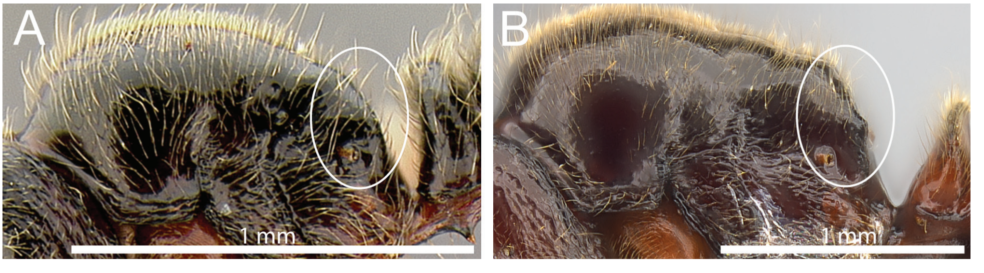

Figure 2. Mesosoma in profile showing posterodorsal propodeum (within white ellipse). **A** *P. oceanicum* (CASENT0171053) **B** *P. relictum* (CASENT0194740).

of the *P. silaceum* clade, as already pointed out by Baroni Urbani and De Andrade (2003). The extremely squamiform petiolar node shape is unique within the clade, and is also not seen in any other member of the genus. In addition, the ventral petiolar process is dentiform or spiniform and not rectangular or triangular lamelliform as in most other clade members. Indeed, the shape of the ventral process of *P. oceanicum* and *P. relictum* is closer to the shape observable in most members of the *P. stictum* clade than to all other *P. silaceum* clade species. Consequently, it is possible that *P. oceanicum* and *P. relictum* represent an independent evolutionary lineage outside the widespread *P. silaceum* clade that could have developed their unique morphology due the remote and isolated position of the archipelago. However, due to the fact that all species in Oceania belong to the *P. silaceum* clade, it is also possible that *P. oceanicum* and *P. relictum* constitute a small, but distinct, lineage derived from a basal branch of the

P. silaceum clade. This latter explanation seems more likely if one compares the shape of the petiolar node. Only the members of the *P. silaceum* clade display a squamiform node, and *P. oceanicum* and *P. relictum* are unique mostly in the extent to which their petiolar nodes narrow apically. Nevertheless, only a comprehensive phylogenetic study combining molecular and morphological data might reveal the evolutionary relationships within the clade and among the other *Proceratium* clades. The newly described *P. vinaka* does not share the aberrant morphology observed in its two Fijian congeners. Rather, it is morphologically similar to the other clade species found on New Caledonia, Papua New Guinea, Solomon Islands, or Australia. It can be well distinguished from all of them by the character combination and diagnosis provided below.

Proceratium oceanicum **De Andrade, 2003**

Figs 1B, E, 2A, 3, 6

Proceratium oceanicum De Andrade, 2003: 310. [see also: Sarnat and Economo 2012: 166]

Type material. Holotype, pinned worker, FIJI, Viti Levu, Nadarivatu, -17.5667°, 177.967°, rainforest, on soil, under grass, 16.II.1962, (*R.W. Taylor*) (ANIC: ANIC32-017668) [not examined].

Non-type material examined. FIJI: Taveuni, Mt. Devo, 3.9 km SE Tavuki Village, -16.83278°, -179.97343°, 775 m, ex soil, leaf litter, decaying wood, 16.VI.2005 (*E.M. Sarnat*); Viti Levu, Koroyanitu Eco Park 5.0 km NE Abaca Village, -17.66667°, 177.5525°, 700 m, disturbed forest, sifted litter, 19.IV.–14.V.2003 (*M. Tokotaa*); Viti Levu, Naqaranibuluti Nature Reserve, near summit, 0.75 km SE Nadarivatu, -17.57278°, 177.9725°, 1000 m, primary rainforest, 26.VIII.2006 (*E.M. Sarnat*); Viti Levu, Nausori Highlands, 12.I.1972 (*W.L. Brown*).

Diagnosis. The following character combination distinguishes *P. oceanicum* from the remainder of the *P. silaceum* clade: relatively larger species (HW 0.76–0.78; WL 0.99–1.00); in full-face view head weakly longer than wide (CI 93); lateral expansions of frontal carinae weakly triangular and moderately rounded; petiolar node extremely squamiform (DPeI 680–693) and strongly narrowing from base to apex; subpetiolar process thinly dentiform.

Worker measurements (N=2). TL 3.38–3.41; EL 0.03; SL 0.55–0.58; HL 0.81–0.83; HLM 1.00–1.02; HW 0.76–0.78; WL 0.99–1.00; HFeL 0.63; HTiL 0.48–0.50; HBaL 0.38–0.40; PeL 0.63; PeW 0.43; DPeI 680–693; LT3 0.54–0.56; LS4 0.35–0.40; LT4 0.71–0.78; OI 4; CI 93; SI 68–70; IGR 0.49–0.52; ASI 133–139.

Distribution and biology. Workers of *P. oceanicum*, even though rarely encountered, were sampled from Viti Levu and Taveuni, but tentatively associated males also suggest its presence on Vanua Levu. All collections are from primary or disturbed rainforest. Unfortunately, there is no available data on the biology of *P. oceanicum*.

Taxonomic notes. As already outlined above, *P. oceanicum* and *P. relictum* are highly distinctive species that can be easily distinguished from all other congeners by the

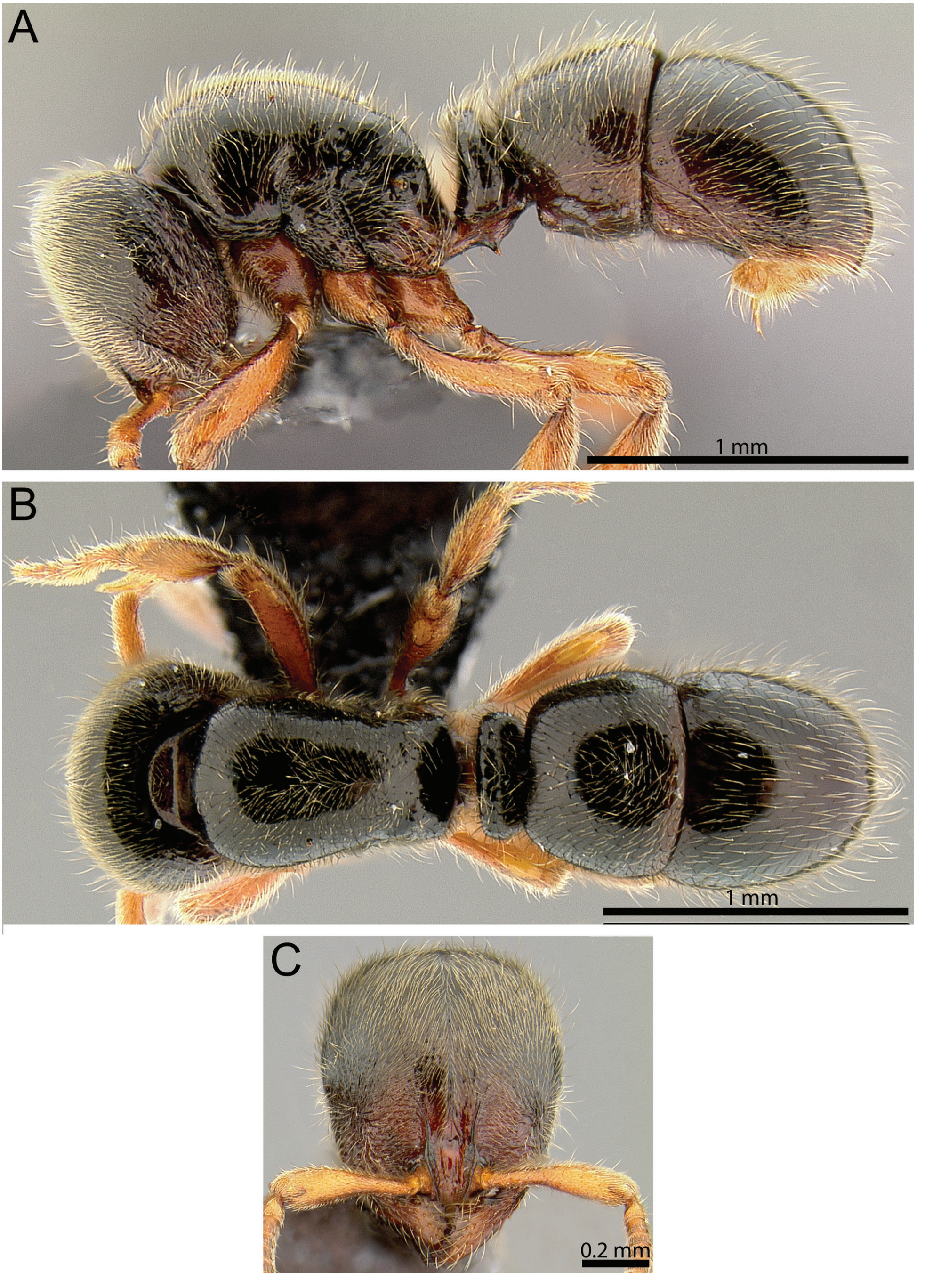

Figure 3. *Proceratium oceanicum* (CASENT0171053). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

extremely squamiform petiolar node. This character, among others, also separates both clearly from the new species *P. vinaka*. Despite its sympatric occurrence, *P. oceanicum* and *P. relictum* are not likely to be confused. The latter is significantly larger in size (HW > 1.00; WL > 1.30), has a noticeably broader head (CI 101), and the subpetiolar process is thickly spiniform, whereas *P. oceanicum* is conspicuously smaller (HW < 0.80; WL < 1.10), possesses a narrower head (CI 93), and its subpetiolar process thinly dentiform. Additionally, in profile the propodeum of *P. oceanicum* is rounded while it is weakly, but clearly marginate in *P. relictum*.

Proceratium relictum **Mann, 1921**

Figs 1C, F, 2B, 4, 6

Proceratium relictum Mann, 1921: 413. [see also: Baroni Urbani and de Andrade 2003: 306; Sarnat and Economo 2012: 167]

Type material. Syntypes, pinned workers and queen, FIJI, Taveuni, Somosomo (*W.M. Mann*) (MCZC, USNM) [examined].

Non-type material examined. FIJI: Taveuni, Mt. Devo, 3.6 km SE Tavuki Village, -16.83056°, -179.97433°, 734 m, garden/forest edge, on ground, foraging, hand collection, 22.III.2005 (*E.M. Sarnat*); Vanua Levu, Mt. Delaikoro, Delaikoro Rd., 3.6 km SE Dogoru Village, -16.57525°, 179.31638°, 699 m, primary rainforest, 31.VIII.2006 (*M. Tokotaa*); Vanua Levu, 1.5 km N Yasawa Village, -16.46806°, 179.64362°, 300 m, disturbed forest, 1.IX.2003 (*A. Rakabula*).

Diagnosis. The following combination of characters separates *P. relictum* from the remainder of the *P. silaceum* clade: comparatively large species (HW 1.03; WL 1.38); in full-face view head approximately as long as wide (CI 101); lateral expansions of frontal carinae weakly triangular and moderately rounded; petiolar node extremely squamiform (DPeI 620) and strongly narrowing from base to apex; subpetiolar process thickly spiniform.

Worker measurements (N=1). TL 4.45; EL 0.04; SL 0.78; HL 1.01; HLM 1.28; HW 1.03; WL 1.38; HFeL 0.98; HTiL 0.71; HBaL 0.67; PeL 0.83; PeW 0.52; DPeI 620; LT3 0.69; LS4 0.42; LT4 1.02; OI 4; CI 101; SI 77; IGR 0.41; ASI 148.

Distribution and biology. *Proceratium relictum* seems to be restricted in its distribution to the two northern islands Taveuni and Vanua Levu. Tentatively associated males collected from malaise traps support this restricted distribution and absence of the species from Viti Levu. The species appears to be tolerant of at least moderate levels of disturbance as it was collected from rainforest, disturbed forest, and forest edge garden. Collections of workers are rare and there is no available information about its natural history.

Taxonomic notes. *Proceratium relictum* and *P. oceanicum* form a very close species pair easily distinguishable from the new species *P. vinaka* and all other *Proceratium* species by the extremely modified petiolar node. Detailed information on how to separate *P. relictum* from *P. oceanicum* is presented in the species account of the latter and the identification key.

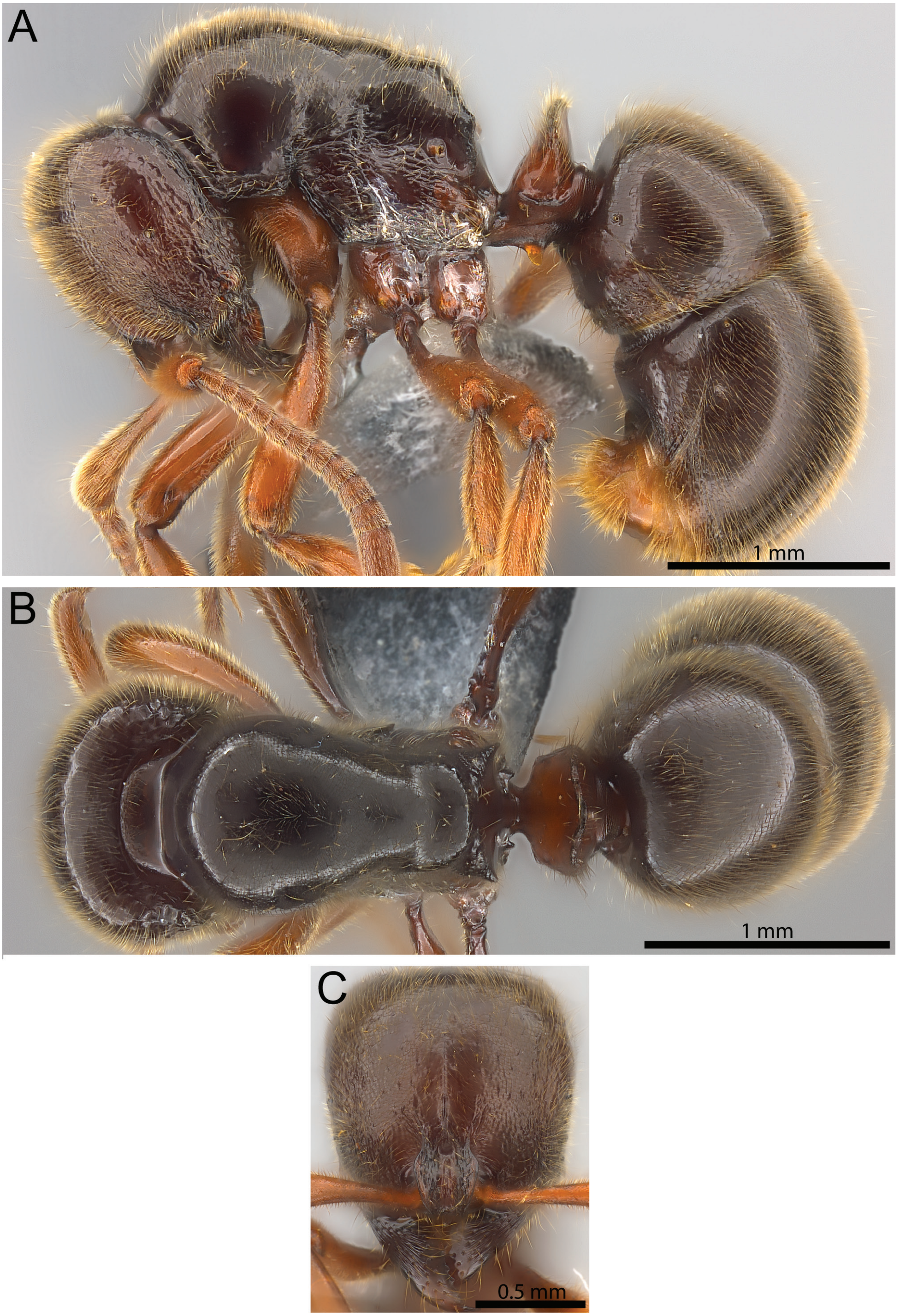

Figure 4. *Proceratium relictum* (CASENT0194740). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

Proceratium vinaka **sp. n.**
http://zoobank.org/A6667E4F-4322-4895-8ECB-C8DA6DDAC48A
Figs 1A, D, 5, 6

Type material. Holotype, pinned worker, FIJI, Viti Levu, Savatu Dist., Mt. Tomanivi 2.4 km E Navai Vlg., -17.61806°, 178.0055°, 950 m, mid-elevation rainforest, soil, leaf litter, decaying wood, collection code EMS#2153-4, 25.VI.2005 (*E.M. Sarnat*) (BPBM: CASENT0187587).

Diagnosis. *Proceratium vinaka* differs from the other members of the *P. silaceum* clade by the following combination of characters: relatively smaller species (HW 0.52; WL 0.66); in full-face view head weakly longer than wide (CI 93); lateral expansions of frontal carinae conspicuously triangular and acute; petiolar node moderately squamiform (DPeI 263) and only weakly narrowing from base to apex; subpetiolar process rounded, not dentiform nor spiniform.

Worker measurements (N=1). TL 2.41; EL 0.03; SL 0.37; HL 0.56; HLM 0.79; HW 0.52; WL 0.66; HFeL 0.38; HTiL 0.29; HBaL 0.24; PeL 0.10; PeW 0.25; DPeI 263; LT3 0.37; LS4 0.27; LT4 0.51; OI 6; CI 93; SI 66; IGR 0.54; ASI 138.

Worker description. In full-face view head longer than broad (CI 93), sides weakly convex, gently broadening posteriorly, vertex shallowly concave. Clypeus conspicuously reduced, relatively narrow, and anteriorly truncate. Frontal carinae relatively short, moderately separated, and not covering antennal insertions, approximately parallel on anterior third and strongly diverging posteriorly, lateral expansions of frontal carinae very broad, raised, and conspicuously triangular and acute; frontal area weakly concave; cephalic dorsum medially with weak carina. Eyes reduced, very small (OI 6), consisting of single ommatidium and located on midline of head. Antennae 12-segmented, scapes short (SI 66), not reaching posterior head margin and noticeably thickening apically. Mandibles elongate-triangular; masticatory margin of mandibles with eight teeth/denticles in total, apical tooth long and acute, second tooth from apex smaller and less acute, remaining six denticles significantly smaller and blunt. Mesosoma in profile moderately convex and clearly shorter than maximum head length including mandibles. Lower mesopleurae with well demarcated sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae not inflated posteriorly; propodeum in profile unarmed and rounded, propodeal lobes weakly developed, lamellate and blunt; declivitous face of propodeum gently sloping posteriorly; in posterodorsal view sides of propodeum separated from declivitous face by weak margins; in profile propodeal spiracle rounded and above mid height. Legs moderately long; all tibiae with pectinate spur; calcar of strigil without basal spine; pretarsal claws simple; arolia absent. Petiolar node in profile moderately squamiform, high, and subrectangular, anterior face of petiole relatively straight, node weakly narrowing from base to apex, dorsum of node weakly convex; petiole in dorsal view much broader than long and transverse, around 2.6 times broader than long (DPeI 263); ventral process of petiole relatively reduced, inconspicuous, convex, and without any rectangular, dentiform, or spiniform projections. In dorsal view abdominal segment III anteriorly much broader

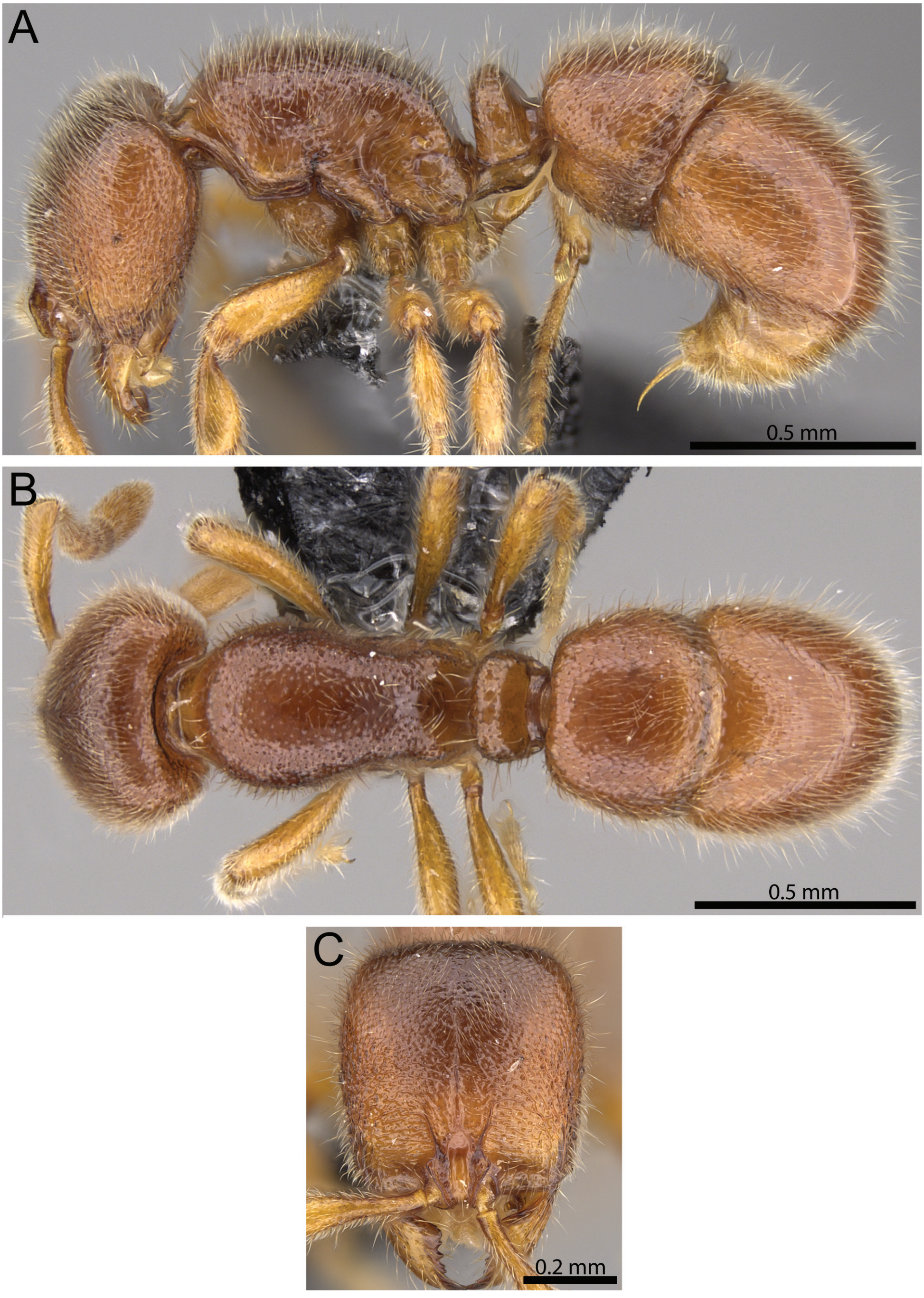

Figure 5. *Proceratium vinaka* (CASENT0187587). **A** Body in profile **B** Body in dorsal view **C** Head in full-face view.

than petiole; its sides diverging posteriorly; abdominal sternite III anteromedially with a marked subtriangular projection appearing convex in profile. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV moderately recurved (IGR 0.54), conspicuously rounded on its curvature, especially posteriorly; abdominal tergum IV around 1.4 times longer than abdominal segment III (ASI 138); remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. All dorsal surfaces of body (including antennal scapes and legs) covered with dense mat of relatively short, decumbent to erect hairs combined with fewer, but significantly longer, erect hairs.

Mandibles conspicuously striate at the base and mostly smooth and shining towards apex; sides of head and anterior cephalic dorsum irregularly foveolate and/or punctate and irregularly rugulose, sculpture on posterior of cephalic dorsum very weak and shining; sculpture on mesosoma, petiole, abdominal tergites III and IV weakly to moderately irregularly foveolate and/or punctate, generally appearing quite smooth and shiny, abdominal sternites III and IV irregularly foveolate and/or punctate and irregularly rugulose, rough in appearance. Body colour uniformly yellowish to light orange brown.

Etymology. The name of new species is Fijian and means 'thank you' or 'hello'. With this we want to dedicate the new species to the people of Fiji for their hospitality and kindness shown to EMS and EPE during their years of fieldwork on the archipelago. The species epithet is a nominative noun in apposition, and thus invariant.

Distribution and ecology. The single known worker of *P. vinaka* was collected at Mt. Tomanivi on Viti Levu. The type locality is a relatively pristine mid-elevation rainforest. Nevertheless, several tentatively associated males from malaise traps suggest that *P. vinaka* has a much broader distribution and is also found on Taveuni and Vanua Levu. As in the cases of *P. oceanicum* and *P. relictum*, there is no information on the biology of the new species.

Taxonomic notes. Despite the morphological similarity of most species of the *P. silaceum* clade, *P. vinaka* possesses an interesting character combination that renders it easily identifiable within the *Proceratium* fauna of Oceania. It cannot be confused with the other two *Proceratium* species found on Fiji. Both, *P. oceanicum* and *P. relictum*, have extremely squamiform petiolar nodes that strongly narrow from base to apex, whereas *P. vinaka* has a moderately squamiform node that narrows only very weakly from base to apex. This node shape is characteristic for the *P. silaceum* clade and found in all species except *P. oceanicum* and *P. relictum*. In addition, the latter two species have either a dentiform or spiniform ventral petiolar process, which contrasts with the very much reduced and convex process of *P. vinaka*. Interestingly, this highly reduced ventral process seen in *P. vinaka* is quite unique and not found in any other member of the *P. silaceum* clade in Oceania. All other species have either a well-developed lamelliform and approximately rectangular process, or the process is dentiform or spiniform. Another character that distinguishes *P. vinaka* from *P. oceanicum* and *P. relictum* is the development of the lateral expansions of the frontal carinae, which are weakly triangular and moderately rounded in the latter two species, whereas they are conspicuously triangular and acute

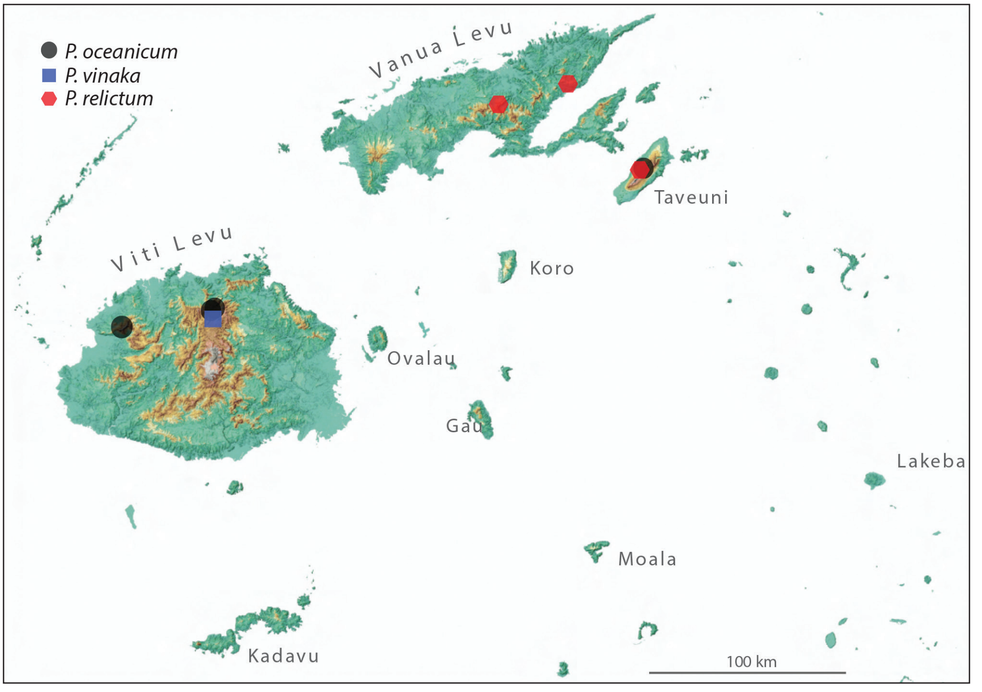

Figure 6. Map of Fiji showing the known distribution of the three species of *Proceratium* known from the archipelago (*P. oceanicum* – black circle; *P. relictum* – red hexagon; *P. vinaka* – blue square).

in *P. vinaka*. This also separates it from other morphologically similar species found in Oceania, such as *P. caledonicum*, *P. papuanum*, or *P. politum* since they all have rounded or subtriangular extensions that are never as acute as in *P. vinaka*.

Proceratium vinaka was treated as *Proceratium* sp. FJ01 in Sarnat and Economo (2012).

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RESEARCH ARTICLE

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A new species of *Metaeuchromius* (Lepidoptera, Crambidae) from the Tibetan glacier area of China

Wei-Chun Li[1], Dong Liu[1]

1 *College of Agronomy, Jiangxi Agricultural University, Nanchang, 330045, China*

Corresponding author: *Wei-Chun Li* (weichunlee@126.com)

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Abstract
Metaeuchromius glacialis Li, **sp. n.** is described from the Tibetan glacier area of China. The new species is similar to *M. circe* Bleszynski by the distal projection of costa exceeding the apex of valva, and the phallus with strong spine-like cornuti in the male genitalia. Images of male adult, tympanal and scent organs as well as genitalia of the new species are provided.

Keywords
Pyraloidea, Crambinae, taxonomy, Qinghai-Tibetan Plateau

Introduction

Metaeuchromius was established with *Eromene yuennanensis* Caradja, 1937 as the type species (Bleszynski 1960). The genus has fourteen species with a Palearctic and Oriental distribution (Bleszynski 1965; Park 1990; Schouten 1997; Nuss and Speidel 1999; Chen et al. 2002; Sasaki 2005; Li et al. 2009; Nuss et al. 2014). Prior to this study, eight species of *Metaeuchromius* were recorded in China (Li et al. 2009). However, the known species are rarely recorded around the monsoon temperate glaciers of the south-eastern part of the Qinghai-Tibetan Plateau in China. Moreover, it is becoming more and more critical to pay close attention to the species living around mountain glaciers because global warming is highly likely to cause changes in the biodiversity of these regions (Li and Liu 2014). In the present paper, *Metaeuchromius glacialis*, collected from Galongla Mountain, Tibetan glacier area, is described as new to science.

Material and methods

Specimens were collected by a 250-W high-pressure mercury lamp. They were hand-collected alive and killed by ammonium hydroxide just prior to mounting and spreading (Landry and Landry 1994). The type specimens of *Metaeuchromius* species are deposited in the Natural History Museum of London (NHM) have been examined by corresponding author. All the type specimens of the new species are deposited in the Insect Museum, Jiangxi Agricultural University, Nanchang, China (JXAUM).

The terminology for the terminal dots formula of the forewings follows Schouten (1997), the terminology for the tympanal organs follows Maes (1985) and Nuss (2005).

Genitalia preparation followed the standard procedure, using boiling 10% KOH solutions to digest internal tissues; after careful cleaning and removal of scales, genitalia were examined, compared, and described before being mounted on microscope slides by corresponding author. The images of the adults were taken with a digital camera (Canon G12). The illustrations of the genitalia were prepared with a digital camera DV320 OPTPro2010_Chs attached to a digital microscope Optec BK-DM320.

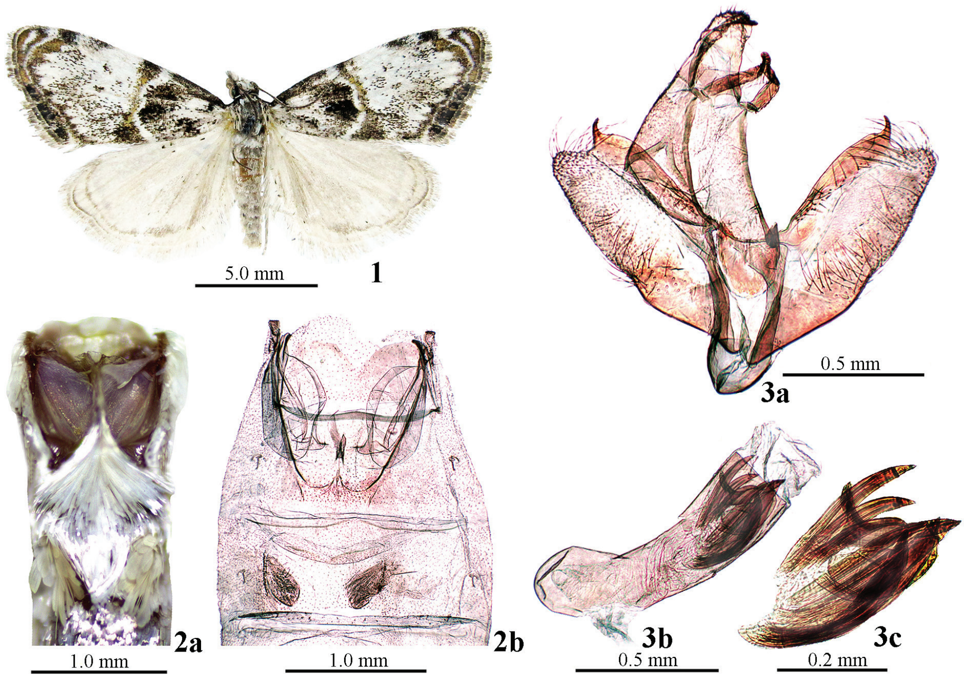
Taxonomic account

***Metaeuchromius glacialis* Li, sp. n.**
http://zoobank.org/D38737BC-E4CF-432C-A1D4-ECFB14E07C8E
Figs 1–3

Holotype. ♂, China, Tibet, Medog, the foot of Mt. Galongla (29°44.2947'N, 95°40.6068'E), 3415 m, 22.VII.2014, coll. Wei-Chun Li and Dong Liu et al.

Paratypes. 4 ♂♂, same data as the holotype except dated 20–23.VII.2014.

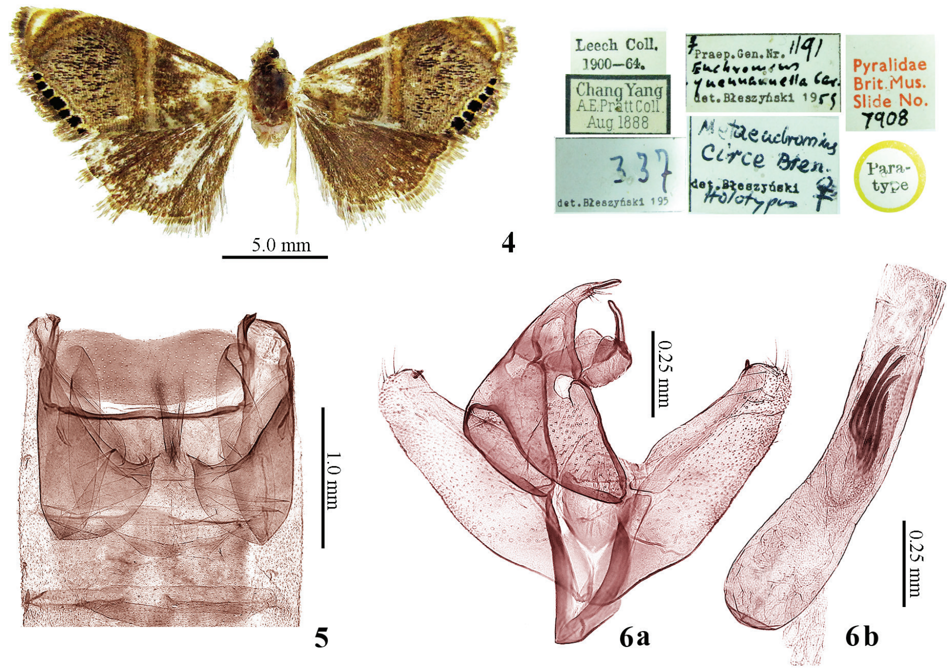
Diagnosis. In male genitalia, this new species is similar to *Metaeuchromius circe* Bleszynski, 1965 in the distal projection of costa exceeding the apex of valva, and the phallus with strong spine-like cornuti. Based on a comparison with the type specimens and additional specimens (2 ♂♂, China, Hunan Province, Shimen County, Mt. Huping, ca. 1200 m, 18.VII.2013, coll. Wei-Chun Li et al.) of *M. circe*, the new species can be distinguished by the forewing with a conspicuously convex medial fascia and terminal dots with formula 2-3-1 (Fig. 1) whereas the medial fascia of *M. circe* is straight and the terminal dots with formula 2-3-2 (Fig. 4). The new species has the saccus tympani of male tympanal organ extending to two thirds of the second sternite and the third sternite with two scent organs (Fig. 2) while the saccus tympani of *M. circe* exceeds the posterior margin of the second sternite and there is no scent organ (Fig. 5). The male genitalia of the new species have a strong spine-like projection at the



Figures 1–3. *Metaeuchromius glacialis* Li, sp. n. **1** Adult, Holotype **2** Abdomen, paratype **a** Tympanal and scent organs with scales **b** Tympanal and scent organs without scales **3** Male genitalia, paratype **a** Without phallus **b** Phallus **c** Cornuti.

end of costa of valva and the phallus with eight cornuti (Fig. 3) while *M. circe* only has a small pointed costal tip and four cornuti (Fig. 6).

Description. Adult (Fig. 1). Forewing length 9.0–10.0 mm. Frons pale brown. Vertex white except pale brown in middle. Labial palpus approximately one and half as long as compound eye's diameter, pale brown. Maxillary palpus pale brown, distally white. Antenna scapus white; flagellomere pale brown. Patagium and thorax white. Tegula blackish brown mixed with white, posterior margin with long and thin white scales. Forewing densely covered with blackish brown scales from basal one fifth to medial fascia, the other area sparsely suffused with pale brown scales; costa with longitudinal blackish brown stripe extending from base to near medial fascia; medial fascia conspicuously convex, incurved slightly near middle, running to before middle of dorsum, golden, edged with pale brown; discoidal cell with two brown spots; apex golden mixed with pale brown, with one white stripe; subterminal line golden mixed with pale brown; six terminal black dots running from middle of termen to tornus, fomula 2-3-1, each group delimited by white, each dot of a group divided by golden; cilia pale brown. Hindwing white, suffused with gray scales; subterminal fascia pale brown, inconspicuous; cilia white. Fore- and midlegs pale brown, tarsi with white rings; hindleg yellowish white.



Figures 4–6. *Metaeuchromius circe* Bleszynski**.** **4** Adult, paratype, female **5** Tympanal organ **6** Male genitalia, additional specimen **a** Without phallus **b** Phallus.

Male abdomen (Fig. 2). Praecinctorium with a cluster of slender white scales; bulla tympani of tympanal organ open, bean-shaped, inner margin convex anteriorly and concave posteriorly; saccus tympani broad, rounded, extending to two thirds of second sternite; venula secunda present. Third sternite with two clusters of yellowish white scales on lateral side (Fig. 2a), bearing two oblong scent organs, opening towards lateral side, outside wall with pits, a cluster of slender scales attached to pits on inward tip (Fig. 2b).

Male genitalia (Fig. 3). Uncus curved downward, tapering to blunt apex. Gnathos curved upward slightly, distally rounded. Tegumen arms approximately twice as long as gnathos. Valva broad basally, narrowed towards apex; apex rounded. Costa strongly sclerotized, ending with a strong spine-like projection directed upward, reaching apex of valva. Juxta basally convex, gently broadened towards tip; distal margin incurve and forming two triangular lateral projections. Phallus nearly as long as valva; cornuti composed of eight strong spines.

Female unknown.

Distribution. This species is only known from Galongla Mountain, in Medog County, Tibet, China.

Natural history. Unknown except that the moths fly late July and are attracted to light. The habitat in which this species has been collected is located at an altitude of 3415 m, at the foot of Galongla Mountain. Most parts of the mountain are covered

Figure 7. Natural environment of collecting localitiy of *Metaeuchromius glacialis* Li, sp. n.

with snow; the vegetation on the south slope is a blend of alpine meadows, shrubs and conifer trees (Fig. 7).

Etymology. The specific name is derived from the Latin *glacialis* = glacier, in reference to the species occurance in the Tibetan glacier area.

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DATA PAPER

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VIS – A database on the distribution of fishes in inland and estuarine waters in Flanders, Belgium

Dimitri Brosens[1], Jan Breine[2], Gerlinde Van Thuyne[2], Claude Belpaire[2], Peter Desmet[1], Hugo Verreycken[1]

1 *Research Institute for Nature and Forest (INBO), Kliniekstraat 25, 1070, Brussels, Belgium* **2** *Research Institute for Nature and Forest (INBO), Duboislaan 14, 1560, Groenendaal, Belgium*

Corresponding author: *Gerlinde Van Thuyne* (gerlinde.vanthuyne@inbo.be); *Jan Breine* (jan.breine@inbo.be)

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Abstract

The Research Institute for Nature and Forest (INBO) has been performing standardized fish stock assessments in Flanders, Belgium. This Flemish Fish Monitoring Network aims to assess fish populations in public waters at regular time intervals in both inland waters and estuaries. This monitoring was set up in support of the Water Framework Directive, the Habitat Directive, the Eel Regulation, the Red List of fishes, fish stock management, biodiversity research, and to assess the colonization and spreading of non-native fish species. The collected data are consolidated in the Fish Information System or VIS. From VIS, the occurrence data are now published at the INBO IPT as two datasets: 'VIS - Fishes in inland waters in Flanders, Belgium' and 'VIS - Fishes in estuarine waters in Flanders, Belgium'. Together these datasets represent a complete overview of the distribution and abundance of fish species pertaining in Flanders from late 1992 to the end of 2012. This data paper discusses both datasets together, as both have a similar methodology and structure. The inland waters dataset contains over 350,000 fish observations, sampled between 1992 and 2012 from over 2,000 locations in inland rivers, streams, canals, and enclosed waters in Flanders. The dataset includes 64 fish species, as well as a number of non-target species (mainly crustaceans). The estuarine waters dataset contains over 44,000 fish observations, sampled between 1995 and 2012 from almost 50 locations in the estuaries of the rivers Yser and Scheldt ("Zeeschelde"), including two sampling sites in the Netherlands. The dataset includes 69 fish species and a number of non-target crustacean species. To foster broad and collaborative use, the data are dedicated to the public domain under a Creative Commons Zero waiver and reference the INBO norms for data use.

Keywords
Ecosystem functioning, fish-based index of biotic integrity, fish distribution, freshwater, brackish water, estuary, LifeWatch, open data, occurrence, observation, River Scheldt, River Yser, River Meuse

Data published through

The occurrence datasets are available at:

VIS - Fishes in inland waters in Flanders, Belgium
Source: http://dataset.inbo.be/vis-inland-occurrences
GBIF: http://www.gbif.org/dataset/823dc56e-f987-495c-98bf-43318719e30f

VIS - Fishes in estuarine waters in Flanders, Belgium
Source: http://dataset.inbo.be/vis-estuarine-occurrences
GBIF: http://www.gbif.org/dataset/274a36be-0626-41c1-a757-3064e05811a4

Reports (only in Dutch) can be generated or downloaded from: http://vis.milieuinfo.be/publicaties/rapporten-afvissingen

Rationale

The Fish Information System or VIS (Figure 1) is a database created by the Research Institute for Nature and Forest (INBO) which is used to monitor the status of fishes and their habitats in Flanders, Belgium and to calculate the biotic integrity (Karr 1981, Belpaire et al. 2000, Breine et al. 2004, 2007, 2010) of fish assemblages. It contains data regarding occurrences, individual morphometrics, stocks, pollutants, indices, and non-native fish species. Sampling has been going on since 1992, the database model was designed in 1994 (Verbiest et al. 1994), the first database developed in 1996 (Verbiest et al. 1996), and the consolidated database set up in 2001. VIS is used for supporting NATURA 2000, an ecological network of protected areas in Europe and to calculate the EQR (Ecological Quality Ratio) in the framework of the EU Water Directive (Directive 2000/60/EC). Further, the database provides updated informa-

Figure 1. The logo of VIS.

tion for Flemish Red Lists of fishes and lampreys (Verreycken et al. 2014) and on the distribution status of non-native and invasive fish species. The data are also crucial in fish stock management and for reporting on the status of the European eel stock as required by the Eel Regulation (Council Regulation (EC) N° 1100/2007).

Taxonomic coverage

The inland waters dataset contains 64 fish species reported from Flemish enclosed waters and watercourses, as well as a number of non-target species (mainly crustaceans). This dataset also includes a number of typical brackish water fish species which sometimes can be found in inland water sites in proximity to the sea and/or behind the sluice gates. The class of Actinopterygii is best represented (63 species), along with one Petromyzontida (*Lampetra planeri*) and 7 crustaceans from the order Decapoda.

The estuarine waters dataset contains 69 fish species found in the estuaries of the River Yser and the River Scheldt, as well as 9 non-target crustacean species. The class of Actinopterygii is most represented (67 species), along with two Petromyzontida. All the crustaceans in this dataset are from the order of the Decapoda.

In Figures 2 and 3 the distribution of occurrences by taxonomic order in the inland and estuarine waters dataset is shown.

Taxonomic ranks for inland waters

Kingdom: Animalia

Class: Actinopterygii, **Orders:** Mugiliformes, Osmeriformes, Atheriniformes, Clupeiformes, Gadiformes, Pleuronectiformes, Siluriformes, Salmoniformes, Scorpaeniformes, Esociformes, Anguilliformes, Gasterosteiformes, Perciformes, Cypriniformes, **Families**: Anguillidae, Atherinidae, Centrarchidae, Clariidae, Clupeidae, Cobitidae, Cottidae, Cyprinidae, Esocidae, Gadidae, Gasterosteidae, Gobiidae, Ictaluridae, Lotidae, Moronidae, Mugilidae, Nemacheilidae, Osmeridae, Percidae, Petromyzontidae, Pleuronectidae, Salmonidae, Scophthalmidae, Siluridae, Soleidae, Umbridae

Class: Petromyzontida, **Order:** Petromyzontiformes, **Family:** Petromyzontidae

Class: Malacostraca, **Order:** Decapoda, **Families:** Atyidae, Cambaridae, Palaemonidae, Varunidae

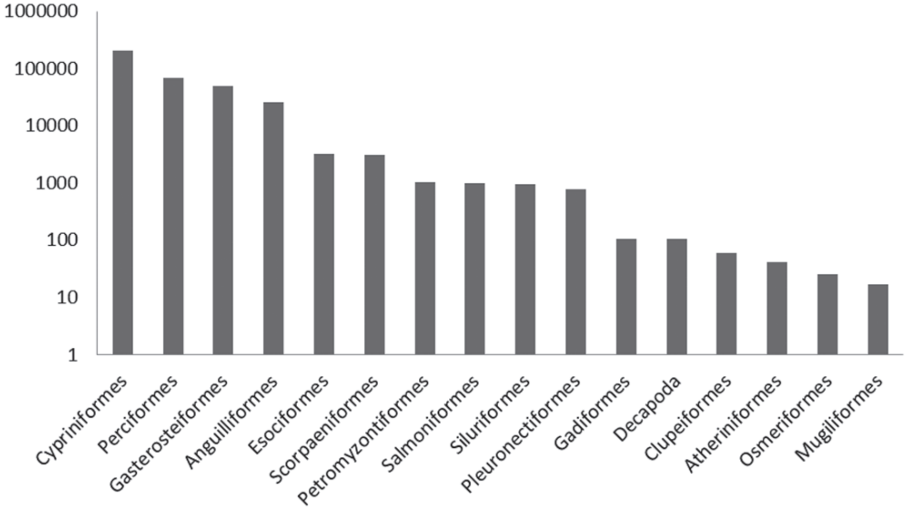

Figure 2. Distribution of all occurrences in the inland waters dataset by taxonomic order. Orders are ordered by number of occurrences, occurrences are displayed on a logarithmic scale.

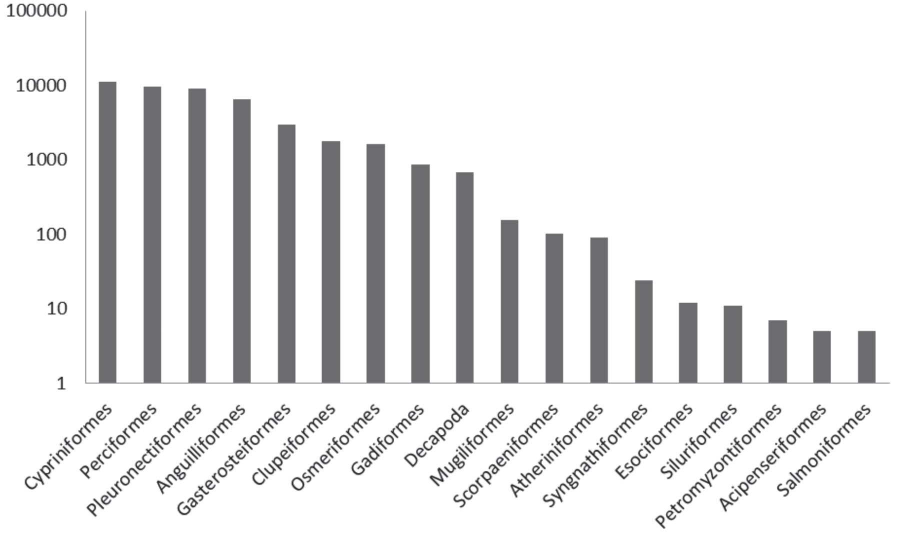

Figure 3. Distribution of all occurrences in the estuarine waters dataset by taxonomic order. Orders are ordered by number of occurrences, occurrences are displayed on a logarithmic scale.

Taxonomic ranks for estuarine waters

Kingdom: Animalia

Class: Actinopterygii, **Orders:** Acipenseriformes, Anguilliformes, Atheriniformes, Clupeiformes, Cypriniformes, Esociformes, Gadiformes, Gasterosteiformes, Mugiliformes, Osmeriformes, Perciformes, Pleuronectiformes, Salmoniformes, Scorpaeniformes, Siluriformes, Syngnathiformes, **Families:** Acipenseridae, Agonidae, Ammodytidae, Anguillidae, Atherinidae, Blenniidae, Callionymidae, Carangidae, Centrachidae, Clupeidae, Cottidae, Cyprinidae, Esocidae, Gadidae, Gasterosteidae, Gobiidae, Liparidae, Lotidae, Moronidae, Mugilidae, Mullidae, Osmeridae, Percidae, Pholidae, Pleuronectidae, Salmonidae, Scophthalmidae, Siluridae, Soleidae, Syngnathidae, Trachinidae, Triglidae, Zoarcidae

Class: Petromyzontida, **Order:**Petromyzontiformes, **Family:**Petromyzontidae

Class: Malacostraca, **Order:** Decapoda, **Families:** Cambaridae, Cancridae, Crangonidae, Paguridae, Palaemonidae, Polybiidae, Portunidae, Varunidae

Geographic coverage

Flanders

Flanders is one of the three administrative regions in the country of Belgium, located in the centre of Western Europe (Figure 4). The Flemish region is situated in the north of the country and covers an area of 13,522 km² (44,29% of Belgium). Belgian has a temperate maritime climate that is influenced by the North Sea and the Atlantic Ocean with substantial precipitation in all seasons. The summers are moderate and the winters are mild. The two main geographical regions of Flanders are the coastal plain in the North-West and the Central plain, further inland. With 470 inhabitants/km², Flanders is one of the most densely populated areas of Europe. The three major rivers are the River Yser, the River Scheldt, and the River Meuse. All rivers in Flanders flow into the North Sea, but only the River Yser drains directly into the sea within the jurisdiction of Flanders.

Inland waters

The inland waters dataset comprises enclosed waters, including cut off river arms, gravel pits, ponds, natural lakes, and artificial lakes; and riverine habitats, including head streams, tributaries, and canals part of the drainage basins of the rivers Yser, Scheldt and Meuse (Figure 5). These three drainage basins are divided into eleven Flemish river catchments, which are divided into 102 subbasins. Overall, there are 48 unique enclosed waters sampled at 792 locations and 419 streams and rivers sampled at 1,452 locations.

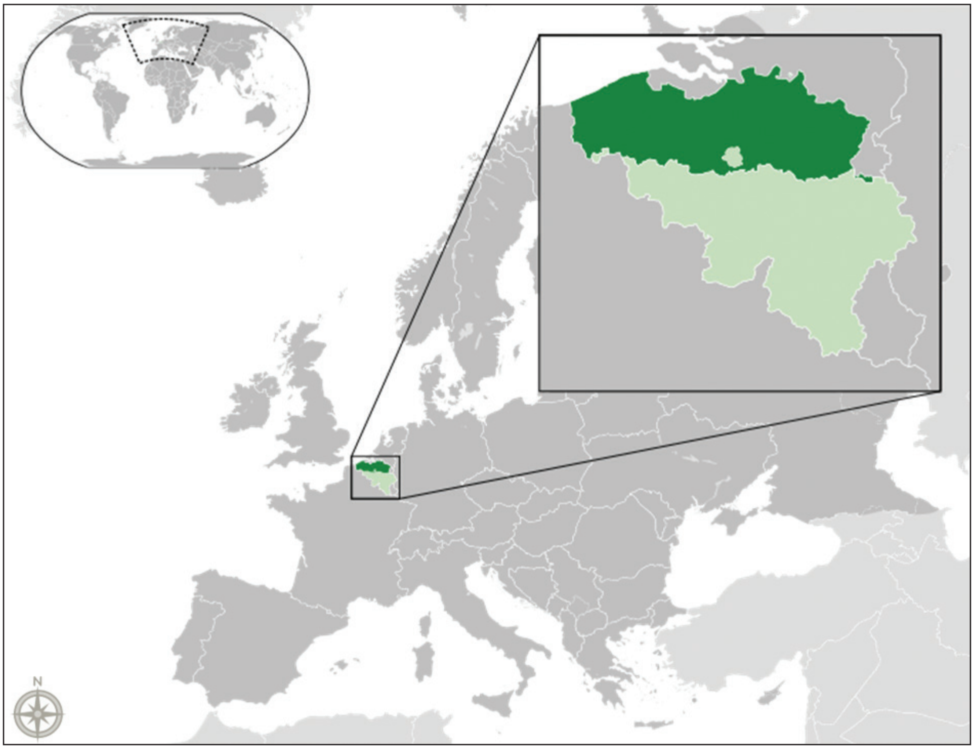

Figure 4. Flanders is an administrative region of Belgium, located in the centre of Western Europe. Image by Alphatron derived from Blank_map_of_Europe.svg, licensed under CC BY-SA 3.0.

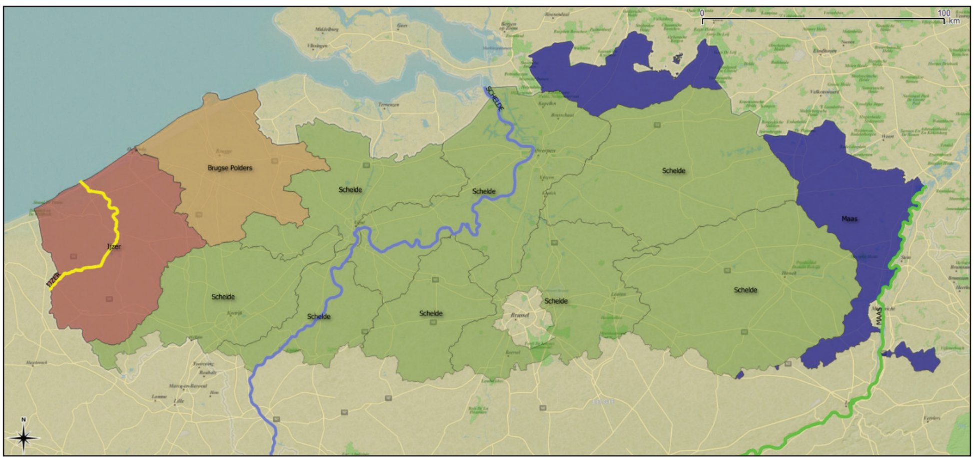

Figure 5. Drainages of the Rivers Yser (yellow in west), Scheldt (blue), and Meuse (green in east) are divided in 11 Flemish subbasins. The “Brugse polders” area drains directly to the sea. Image created in QGIS, basemap by Apple iPhoto map.

Estuarine waters

The estuarine waters dataset comprises the estuaries of the River Scheldt, including tidal parts of the rivers Rupel, Durme, Zenne, Dijle and Grote Nete, and the River Yser.

River Scheldt. The River Scheldt is a 435 km long lowland river originating on the plateau of Saint-Quentin (Figure 6) near Gouy, a small town in the French department of Aisne. The river enters Belgium close to Tournai. Then the river turns east, in the direction of Antwerp. After crossing the city of Antwerp, the Scheldt enters the Netherlands where it ends in the North Sea near Vlissingen. The tidal influence extends much further land inward than the freshwater-saltwater boundary. As a result, an extensive freshwater region under tidal influence is present. The tidal activity goes as far as Ghent, 160 km from the river mouth, where the tide is stopped by sluices. In the Zeeschelde (the Belgian part of the estuary), three zones are distinguished following the Venice system (1959): a mesohaline zone (5–18 g salt/kg) between Zandvliet and Antwerp, an oligohaline zone (0.5–5 g salt/kg) between Antwerp and Temse, including the Rupel tributary, and a tidal freshwater zone till Ghent including the Durme tributary. The marshes and mudflats create a valuable landscape for biodiversity.

The Scheldt estuary is one of the last natural deltas in Western Europe and many areas near its riverbanks are marked as Natura 2000 areas (Figure 7). Especially its freshwater estuary areas are unique.

River Yser. The River Yser is a 78 km long river originating in Kassel, located in French Flanders. It enters Belgium in the province of West Flanders and drains into the sea near the town of Nieuwpoort. Sea and fresh water meet in an estuary, resulting in 130 hectares of tidal mud flats, salt marshes, dunes, beaches, and polders (Figure 8).

Bounding box for covered area

Flanders: 50.68 to 51.51 latitude, 2.54 to 5.92 longitude.
Temporal coverage:
Inland waters: 1992-12-15 – 2012-11-27
Estuarine waters: 1995-04-01 – 2012-11-27

Dataset

Dataset description

The occurrence data from the VIS database are extracted, standardized, and published as two separate Darwin Core Archives: one for inland waters and one for estuarine waters. The main rationale behind this is that both datasets cover different habitats,

Figure 6. The river Scheldt (orange), from source to river mouth. Image created in Mapbox, basemap by OpenStreetMap contributors.

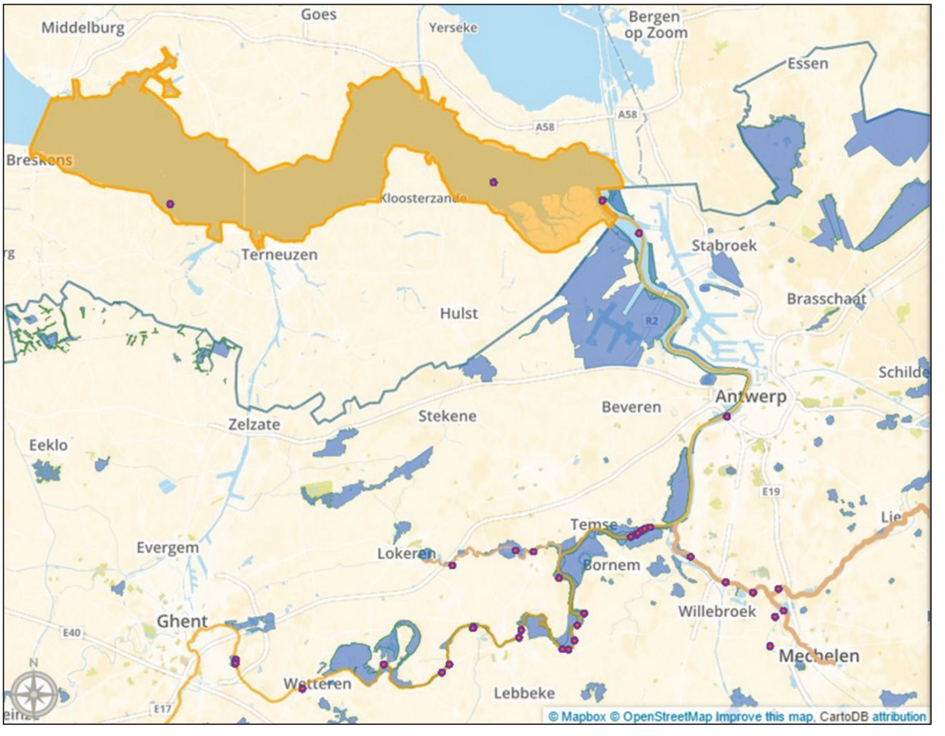

Figure 7. The Scheldt estuary, with sampling locations (pink points) and Natura 2000 areas in Flanders (blue areas). Image created in CartoDB and Mapbox, basemap by OpenStreetMap contributors.

Figure 8. The sampling locations (orange points) in the Yser estuary. Image created in CartoDB, basemap by Nokia Satellite maps.

differ in sampling strategies and methods, and are curated by different researchers. Nevertheless the data model used for inland waters and estuarine waters is identical and can be easily merged: together these datasets represent a complete overview of fish distribution in Flanders from late 1992 to the end of 2012. In 2013 a new set of sampling locations was defined and the data collected since then is currently only available upon request.

The data are standardized to Darwin Core (Wieczorek et al. 2012) with a custom SQL view (Figure 9) on the original VIS database and then published making use of the GBIF Integrated Publishing Toolkit (Robertson et al. 2014) instance at the INBO (http://data.inbo.be/ipt). The Darwin Core terms (http://rs.tdwg.org/dwc/terms/) in the dataset at the time of publication are:

occurrenceID, type, language, rights, rightsholder, accessRights, datasetID, institutionCode, datasetName, ownerInstitutionCode, basisOfRecord, informationWithheld, recordedBy, individualCount, samplingProtocol, samplingEffort, eventDate, habitat, locationID, continent, waterBody, countryCode, verbatimLocality, verbatimLatitude, verbatimLongitude, verbatimCoordinateSystem, verbatimSRS, decimalLatitude, decimalLongitude, geodeticDatum, coordinateUncertaintyInMeters, identifiedBy, scientificName, kingdom, taxonRank, scientificNameAuthorship, vernacularName, and nomenclaturalCode.

The data are dedicated to the public domain under Creative Commons Zero waiver. It would be much appreciated if you follow our norms for data use and notify the corresponding authors of the respective dataset if you use the data, especially for research purposes.

id	type	rightsHolder	datasetID	institutionCode	datasetName	basisOfRecord	occurrenceID
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INBO:VIS:00654574	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00654574
INBO:VIS:00657992	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00657992
INBO:VIS:00658001	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00658001
INBO:VIS:00658006	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00658006
INBO:VIS:00188011	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188011
INBO:VIS:00188005	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188005
INBO:VIS:00188020	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188020
INBO:VIS:00188070	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188070
INBO:VIS:00188100	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188100
INBO:VIS:00188094	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188094
INBO:VIS:00188067	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188067
INBO:VIS:00187972	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00187972
INBO:VIS:00187989	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00187989
INBO:VIS:00188040	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188040
INBO:VIS:00188057	Event	INBO	http://dataset.inbo.be/vis-inland-occurrences	INBO	VIS - Fishes in inland waters in Flanders, Belgiun	HumanObservation	INBO:VIS:00188057

Figure 9. Preview of the Darwin Core SQL view of the inland waters dataset.

Inland waters dataset

Object name: VIS - Fishes in inland waters in Flanders, Belgium
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
Distribution: http://dataset.inbo.be/vis-inland-occurrences
Publication date of data: 2013-12-20
Language: English
Licenses of use: http://creativecommons.org/publicdomain/zero/1.0/ & https://github.com/LifeWatchINBO/norms-for-data-use
Metadata language: English
Date of metadata creation: 2013-12-20
Hierarchy level: Dataset

Estuarine waters dataset

Object name: VIS - Fishes in estuarine waters in Flanders, Belgium
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
Distribution: http://dataset.inbo.be/vis-estuarine-occurrences
Publication date of data: 2014-04-02
Language: English
Licenses of use: http://creativecommons.org/publicdomain/zero/1.0/ & https://github.com/LifeWatchINBO/norms-for-data-use
Metadata language: English
Date of metadata creation: 2014-04-02
Hierarchy level: Dataset

Additional information

Length and weight measurement data of the individual fishes, absence information, occurrence data since 2013, as well as abiotic data of the sampling points (pH, temperature, etc.) are not included in the Darwin Core Archives and are available upon request.

Methodology

Study extent description

Over 2,000 locations in estuaries, inland rivers, streams, canals, and enclosed waters in Flanders, Belgium have been sampled, from March to November, since 1992 (Figure 10). In 2001, these locations were consolidated in a monitoring network ("VISmeetnet") of 900 sampling points. Four locations in the Yser estuary and 43 locations in the Scheldt were sampled since 1995. While the Yser estuary only covers a small geographical area, the Scheldt estuary is with 33,000 hectares one of the largest estuaries in Europe. It is also one of the few remaining European estuaries that includes the entire gradient from fresh to saltwater tidal areas (Van den Bergh et al. 2009). The 43 sampling locations in the Scheldt estuary are mainly located in the River Scheldt, but also in the Rivers Durme, Rupel, Dijle, Zenne and Nete.

The geographic coordinates in both datasets are those of the defined sampling locations (dwc:locationID). However, as these coordinates are not always exact the actual coordinates of the catch, which may be located further up- or downriver, the coordinate uncertainty (dwc:coordinateUncertaintyInMeters) has been set to 250 meter.

Sampling description

In inland waters, standardized sampling methods were used as described in Belpaire et al. (2000) and Van Thuyne (2010) and are specified in the dataset as dwc:samplingProtocol. Per water body, the same method was used for each sampling event. The default method is electric fishing, but additional techniques such as gill nets, fykes, and seine netting (variable sizes) were used as well. Electric fishing was carried out using a 5 kW generator with an adjustable output voltage of 300–500 V and a pulse frequency of 480 Hz. The number of electric fishing devices and hand-held anodes used depends on the river width (Belpaire et al. 2000). In riverine environments, electric fishing was carried out on both riverbanks in upstream direction. All fishes were identified to species level, counted, and their length and weight was measured.

The default method used in estuarine waters is paired fyke netting, which has been intercalibrated by the North East Atlantic Calibration Group, but additional techniques such as anchor netting, seine netting, pound netting, electric fishing, and eel fyke netting were used as well (Breine et al. 2011). All fishes were identified to species level, counted and their length and weight was measured.

Fyke nets are relatively unselective fishing gear catching demersal and pelagic species (Hamerlynck and Hostens 1994) and also they are easy to install in a great variety of habitat types. As few studies compare fyke catches with other gear (e.g. Hinz 1989, Thiel and Potter 2001), we compared presence/absence data obtained with fyke nets with presence/absence data of fish impinged at cooling-water filter screens of the nuclear power plant of Doel situated in the study area. The data was collected in the same

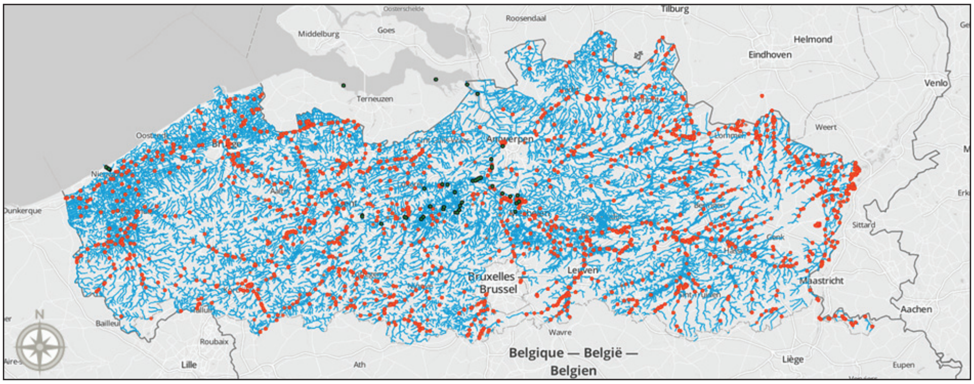

Figure 10. Map of all sampling locations in VIS. Orange points represent inland waters, green points represent estuarine waters. Image created in CartoDB and Mapbox, basemap by OpenStreetMap contributors.

period between 1995 and 1998. During this period we collected the same species with both survey methods but the species richness per day per fyke net was generally higher than that obtained on the filter screens (Breine et al. 2007). In addition preliminary results from a gear intercalibration exercise in different estuaries in Ireland (Whyte et al. 2007) indicated that for species diversity, the results of fyke net catches are comparable to those obtained with other gear (beach seine, beam trawl, otter trawl).

Quality control description

Strict field protocols where used. The Manual for Application of the European Fish Index (EFI) (Fame consortium 2004) served as a guideline for electrofishing and was used in support of the EU water framework directive.

Users of the data can comment on the inland waters and estuarine waters dataset at https://github.com/LifeWatchINBO/vis-inland-occurrences and https://github.com/LifeWatchINBO/vis-estuarine-occurrences respectively.

Method step description

Water type	Method	Effort
Running freshwaters (width: 1.5 m, depth: < 1.30 m)	electrofishing with 1 anode by wading	100 m
Running freshwaters (width: 6 m, depth: < 1.30 m)	electrofishing with 2 anodes by wading	100 m
Running freshwaters (width: > 6 m, depth: < 1.30 m)	electrofishing with 2 anodes by wading	250 m with 1 anode on each riverbank, 2 m from bank

Water type	Method	Effort
Running freshwaters, streaming rivers (width: > 6 m, depth: > 1.30 m)	electrofishing with 2 anodes by boat	250 m with 2 anodes on each riverbank, 2 m from bank
Canals, slowly running rivers (width: > 6 m, depth: > 1.30 m)	electrofishing with 2 anodes by boat AND 2 fykes	250 m with 2 anodes on each riverbank, 2 m from bank AND 1 fyke for 48 hours parallel with and on both riverbanks
Canalized rivers with too high conductivity for electrofishing (depth: < 1.30 m)	seine netting	100 m, two times complete seine netting
Lakes	electric fishing AND fykes	15% of riverbank (minimum 1000 m, maximum 2000 m) or 100% if perimeter is less than 1000 m AND 1 fyke/hectare (minimum 4, maximum 20 fykes)
Estuaries	fyke fishing, anchor netting, pound netting, electric fishing	Fykes: 2 paired nets for two successive days per site. Winged fyke: one per site for two successive days. Anchor netting: per site 4 surveys of one hour (two for each tide). Electric fishing: only in flood control areas (250 m shore transects/ha).

Project data

Project title

VIS – Fish Information System

Personnel

Principal investigator: Hugo Verreycken, Jan Breine, Gerlinde Van Thuyne
Resource contact, resource creator, metadata provider, point of contact: Gerlinde Van Thuyne (Inland Waters), Jan Breine (Estuarine Waters)
Content providers: Daniel Bombaerts, Jan Breine, Jean-Pierre Croonen, Adinda De Bruyn, Franky Dens, Marc De Wit, Linde Galle, Isabel Lambeens, Yves Maes, Gerlinde Van Thuyne
Developer: Tom De Boeck
Processors: Dimitri Brosens, Peter Desmet

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