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# Two new eriophyid mite species associated with *Clematis terniflora* var. *mandshurica* in China (Acari, Eriophyidae)

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### Abstract

Two new eriophyid mite species associated with *Clematis terniflora* var. *mandshurica*, namely *Aculops jilinensis* **sp. n.** and *Phyllocoptes terniflores* **sp. n.**, are described. Both species infest the tender leaves of host plants, inducing severe curling and blistering.

### Keywords

*Aculops*, *Phyllocoptes*, plant feeding, taxonomy

## Introduction

*Clematis terniflora* DC. var. *mandshurica* (Rupr.) Ohwi, called “la liao tie xian lian” in Mandarin, belongs to the family Ranunculaceae, and is native to China (Heilongjiang, Jilin, Liaoning, Shanxi, Inner Mongolia), Korea, Mongolia, and the Russian Far East (website of Flora Republicae Popularis Sinicae – http://frps.eflora.cn/frps/Clematis%20terniflora and Germplasm Resources Information Network – https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?id=404246). It is also known in folk medicine and planted as an ornamental plant in the northeast of China.

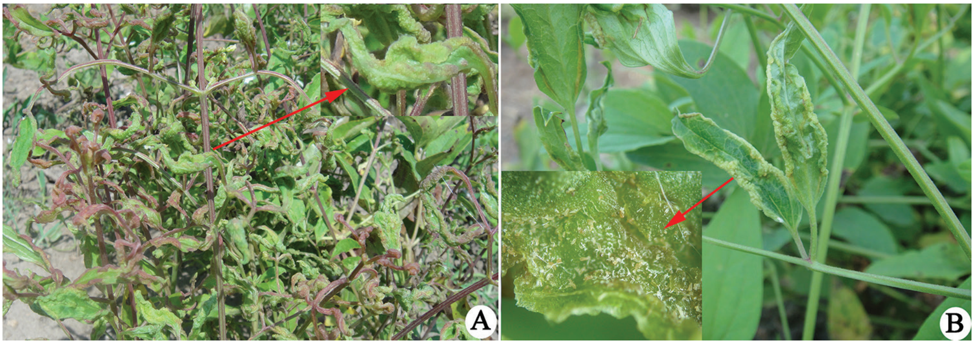


**Figure 1.** Damage symptoms associated with *Aculops jilinensis* sp. n. and *Phyllocoptes ternifiores* sp. n. on *Clematis terniflora* var. *mandshurica*: **A** leaves have severely curled and blistered, red arrow indicates the magnified curled leaf **B** leaves have moderately curled and blistered, red arrow indicates part of the mite population hidden inside the curled surface.

To date, no eriophyid mite species were reported from *C. terniflora* var. *mandshurica*, although at least nine species are known from other *Clematis* spp. worldwide, namely *Aceria vitalbae* (Canestrini, 1892) (from *C. vitalba* L.), *Calepitrimerus clematisis* Song, Xue & Hong, 2008 (from *Clematis* sp.), *Cupacarus subnotatus* (Nalepa, 1924) (from *C. recta* L.), *Epitrimerus flammulae* Gerber, 1901 (from *C. flammula* L.), *Phyllocoptes atragenes* Liro, 1941 [from *C. alpina* (L.) Mill.], *P. heterogaster* (Nalepa, 1890) (from *C. recta*) (Nalepa, 1891), *P. heteronotus* Nalepa, 1924 (from *C. recta*), *P. monochetus* Nalepa, 1924 (from *C. recta*), and *Platyphytoptus vitalbae* Farkas, 1960 (from *C. vitalba*).

During field surveys in 2015, some leaves were found to be severely curled and blistered (Figure 1). The curled and blistered leaves were checked with the aid of a microscope in the laboratory. Eriophyid mites were found and two new species were identified by the first and third authors.

## Materials and methods

Sampling was made on the host plants in the field by the aid of a hand lens (30×), in Jilin Agricultural Science and Technology University, Jilin City, Jilin Province, China. The eriophyid mites gathered with host plant were placed in vials and stored in 75% ethanol, each vial was marked with the collection data. In the laboratory, the samples including mites were poured into a Petri dish and mite specimens were picked up using a fine pin and placed in Keifer's Booster to clear them. They were then slide-mounted with modified Berlese medium (Amrine and Manson 1996).

Specimens were examined with the aid of a Zeiss A2 (Germany) research microscope with phase contrast (A-plan phase contrast objectives: ×10/0.25 (NA), ×20/0.45 (NA); EC plan-NEOFLUAR phase objectives: ×40/0.75 (NA); ×100/1.3 (NA), oil immersion) and schematic drawings were made. Micrographs were taken at ×100 magnification

(×10 eyepiece magnification) with a camera AxioCam MRc attached to the microscope, and connected to a computer, using Axiovision (4.8.2) image analysis software.

The morphological terminology used follows Lindquist (1996) and the generic classification is made according to Amrine et al. (2003). Specimens were measured following de Lillo et al. (2010). For each species, the holotype female measurement precedes the corresponding range for holotype and paratypes (given in parentheses). All measurements are in micrometres (μm) and represent lengths, when not otherwise specified. All type specimens are deposited as slide-mounted specimens in the Arthropod/Mite Collection of the Department of Entomology, Nanjing Agricultural University (NJAU), Jiangsu Province, China.

## Taxonomy

**Family Eriophyidae Nalepa, 1898**
**Subfamily Phyllocoptinae Nalepa, 1892**
**Tribe Anthocoptini Amrine and Stasny, 1994**
**Genus *Aculops* Keifer, 1966b**

***Aculops jilinensis* sp. n.**
http://zoobank.org/A3F6DB8B-8143-4DFC-990E-CD2EAB8BC505
Figs 2, 3

**Diagnosis.** Body fusiform; prodorsal shield with acuminate frontal lobe, median and admedian lines complete and connected at base by a pair of short lines, forming an "arrow", submedian lines connected by a pair of diagonally reaching lines; scapular seta short 15 (14–20) on rear shield margin, projecting posteriorly; opisthosoma dorsally with evenly curved annuli (54–73 dorsally, 71–84 ventrally) and all standard setae for the Eriophyidae; legs with standard setae, empodium simple, 7-rayed; coxigenital region with three pairs of setae and many granules, female genital coverflap with 13 (12–13) longitudinal ridges and two to three transverse lines at base.

**Description.** FEMALE: (n = 9). Body fusiform, opisthosoma broadest 12 annuli posterior of the prodorsal shield, then tapering regularly until its posterior apex; 179 (179–271), 50 (50–70) wide, 53 (50–60) thick; light yellow. ***Gnathosoma*** 19 (19–25), projecting obliquely downwards, pedipalp coxal seta (*ep*) 4 (3–4), dorsal pedipalp genual seta (*d*) simple, 6 (6–9), cheliceral stylets 11 (11–20). ***Prodorsal shield*** 38 (30–42), 45 (35–45) wide, subtriangular; frontal lobe acuminate, 6 (5–7). Median and admedian lines complete and connected at base by a pair of short, almost transversal (slightly oblique) lines, forming an "arrow"; median and admedian lines are also connected at centre by a pair of short, diagonally directed lines, forming an inverted "V"; submedian lines formed by two pairs of incomplete lines (submedian lines I and submedian lines II); submedian lines I reaching about midway, merged with a pair of lines converging posteriorly ('a' in Figure 2AD), themselves joining perpendicularly another

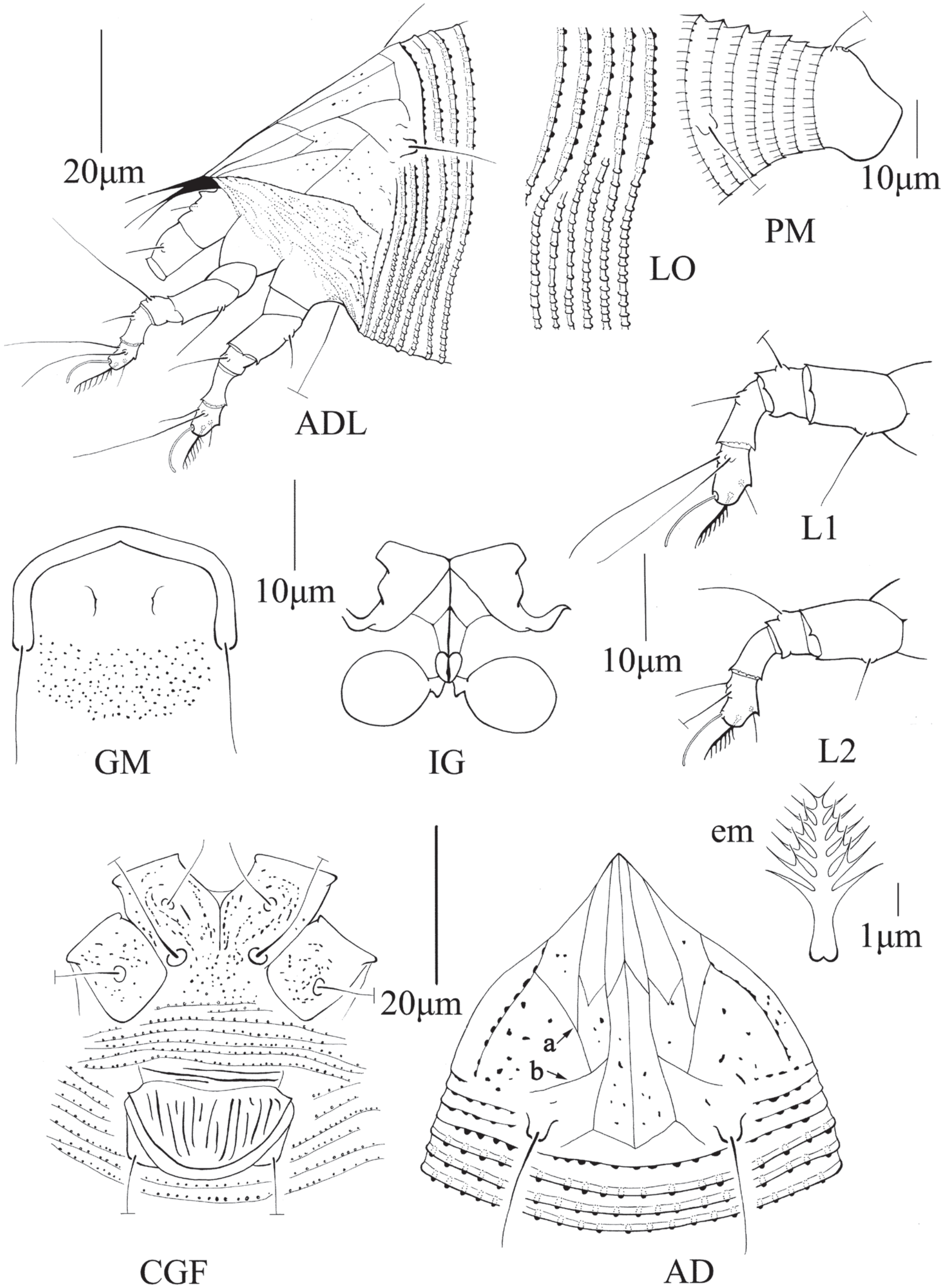


**Figure 2.** Schematic drawings of *Aculops jilinensis* sp. n.: **ADL** lateral view of anterior body region (slightly rotated dorsad) **LO** lateral view of annuli at mid-region of opisthosoma **PM** lateral view of posteriormost region of opisthosoma **GM** male genital region **IG** female internal genitalia **L1** leg I **L2** leg II **em** empodium **CGF** female coxigenital region **AD** prodorsal shield.

pair of lines oriented anteromesally ('b' in Figure 2AD); submedian lines II flanking lateral edges of shield, joining with lines 'a'; submedian lines II, together with lines 'a' and 'b', forming a triangular cell, opened posterolaterally; submedian lines I connected with admedian lines at center by a pair of "V" shaped lines; many granules distributed in the 'triangular' cell and between median, admedian and submedian lines. Scapular tubercles on rear shield margin, 24 (23–26) apart, scapular seta (*sc*) 15 (14–20), projecting posterior. ***Coxigenital region*** with 7 (5–10) microtuberculated annuli. Coxal plates with granules throughout; anterolateral seta on coxisternal plate I (*1b*) 9 (7–10), 13 (13–14) apart, proximal seta on coxisternal plate I (*1a*) 43 (35–45), 9 (8–11) apart, proximal seta on coxisternal plate II (*2a*) 48 (40–50), 25 (23–25) apart. Prosternal apodeme 6 (6–8). ***Leg I*** 37 (29–37), femur 9 (9–12), basiventral femoral seta (*bv*) 10 (9–11); genu 7 (5–7), antaxial genual seta (*l"*) 21 (20–25); tibia 9 (7–9), paraxial tibial seta (*l'*) 6 (6–8), located at 1/3 from dorsal base; tarsus 6 (6–7), paraxial, fastigial, tarsal seta (*ft'*) 19 (18–20), antaxial, fastigial, tarsal seta (*ft"*) 22 (22–26), paraxial, unguinal, tarsal seta (*u'*) 4 (4–5); empodium (*em*) 9 (7–9), simple, 7-rayed, tarsal solenidion ($\omega$) 9 (8–10), rod-like. ***Leg II*** 26 (23–26), femur 9 (9–13), basiventral femoral seta (*bv*) 9 (8–12); genu 4 (4–5), antaxial genual seta (*l"*) 10 (8–11); tibia 7 (6–8); tarsus 6 (5–6), paraxial, fastigial, tarsal seta (*ft'*) 7 (6–9), antaxial, fastigial, tarsal seta (*ft"*) 25 (21–25), paraxial, unguinal, tarsal seta (*u'*) 5 (4–5); empodium (*em*) 7 (7–8), simple, 7-rayed, tarsal solenidion ($\omega$) 9 (9–10), rod-like. ***Opisthosoma*** dorsally arched, with 56 (54–73) dorsal semiannuli bearing rounded microtubercles except last 7-9th semiannuli with elongated microtubercles; ventrally with 72 (71–84) semiannuli, with (longitudinally) elongated microtubercles. Seta *c*2 30 (30–35) on ventral semiannulus 12 (11–13), 45 (43–50) apart; seta *d* 73 (60–73) on ventral semiannulus 24 (20–28), 33 (30–45) apart; seta *e* 17 (15–20) on ventral semiannulus 42 (40–50), 17 (17–25) apart; seta *f* 25 (22–26) on 6$^{th}$ ventral semiannulus from rear, 18 (16–18) apart. Seta *h1* 5 (4–5), seta *h*2 70 (60–72). ***Female genitalia*** 14 (14–17), 21 (21–24) wide, coverflap with 13 (12–13) longitudinal ridges and two to three transverse lines at base, seta 3*a* 34 (34–45), 16 (16–20) apart.

MALE: (n = 1, dorsal view). Body fusiform, 270, 50 wide; light yellow. ***Gnathosoma*** 25, projecting obliquely downwards, pedipalp coxal seta (*ep*) 3, dorsal pedipalp genual seta (*d*) simple, 5, cheliceral stylets 20. ***Prodorsal shield*** 32, 45 wide, subtriangular, frontal lobe acuminate, 5; shield design similar to that of female. Scapular tubercles on rear shield margin, 26 apart, scapular seta (*sc*) 15, projecting posteriorly. ***Coxigenital region*** with 7 microtuberculated annuli. Coxal plates with granules, anterolateral seta on coxisternal plate I (1*b*) 10, 14 apart, proximal seta on coxisternal plate I (1*a*) 43, 10 apart, proximal seta on coxisternal plate II (2*a*) 40, 27 apart. Prosternal apodeme 7. ***Leg I*** 35, femur 12, basiventral femoral seta (*bv*) 10; genu 7, antaxial genual seta (*l"*) 23; tibia 9, paraxial tibial seta (*l'*) 7, located at 1/3 from dorsal base; tarsus 7, paraxial, fastigial, tarsal seta (*ft'*) 28, antaxial, fastigial, tarsal seta (*ft"*) 23, paraxial, unguinal, tarsal seta (*u'*) 5; empodium (*em*) 9, simple, 7-rayed, tarsal solenidion ($\omega$) 10, rod-like. ***Leg II*** 30, femur 8, basiventral femoral seta (*bv*) 12; genu 5, antaxial genual seta (*l"*)

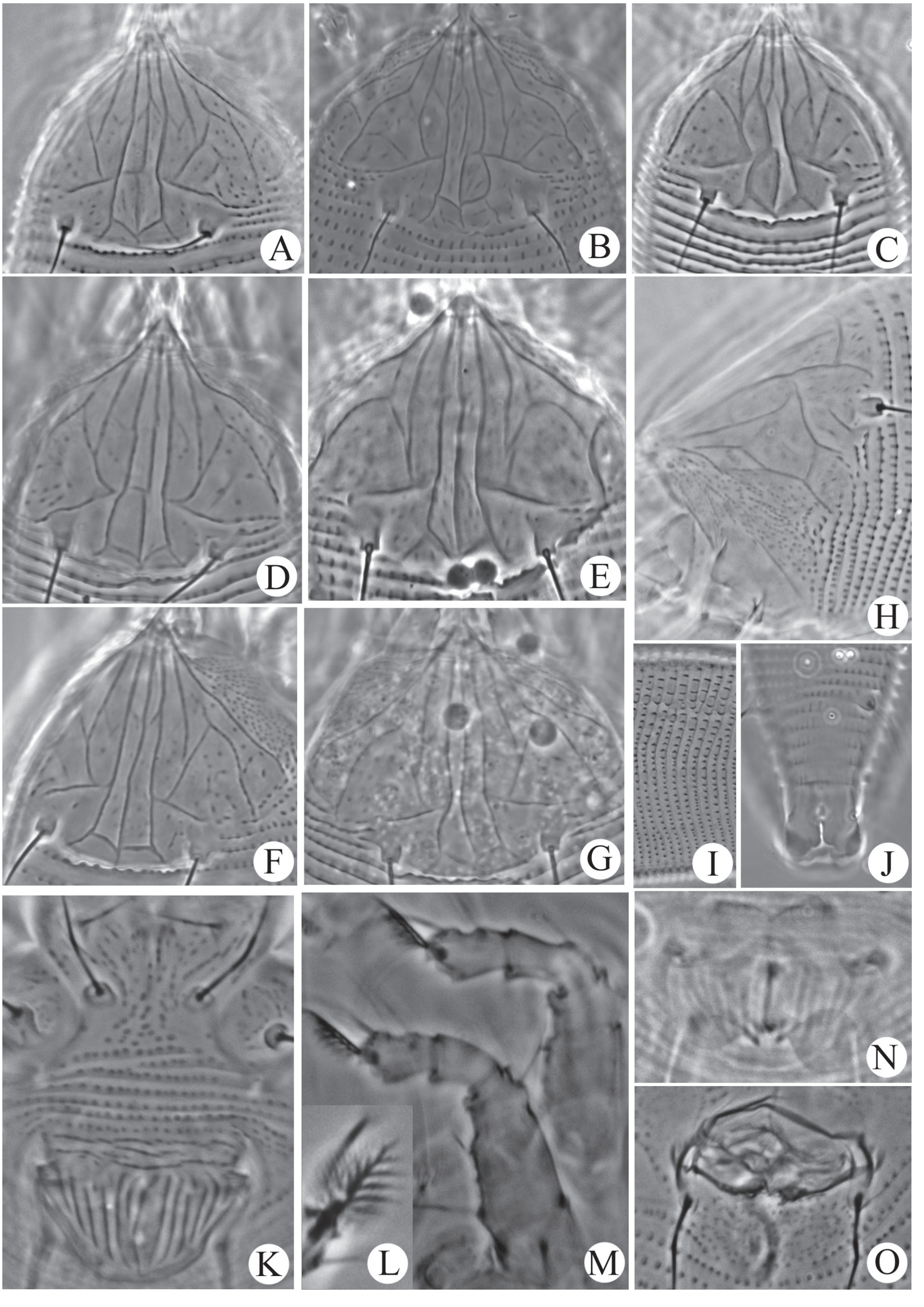


**Figure 3.** Micrographs of *Aculops jilinensis* sp. n.: **A–G** prodorsal shield **H** lateral view of anterior body region **I** lateral view of annuli at mid-region of opisthosoma **J** ventral view of posteriormost region of opisthosoma **K** female coxigenital region **L** empodium **M** legs I (right) and II (left) **N** female internal genitalia **O** male genital region.

13; tibia 7; tarsus 6, paraxial, fastigial, tarsal seta (*ft'*) 9, antaxial, fastigial, tarsal seta (*ft''*) 23, paraxial, unguinal, tarsal seta (*u'*) 5; empodium (*em*) 7, simple, 7-rayed, tarsal solenidion (*ω*) 10, rod-like. ***Opisthosoma*** dorsally arched, with 70 semiannuli, with rounded microtubercles on the posterior margin, last 7-9th semiannuli with elongated microtubercles, ventrally with 80 semiannuli, with elongated microtubercles. Seta *c2* 38 on ventral semiannulus 16, 55 apart; seta *d* 65 on ventral semiannulus 28, 45 apart; seta *e* 16 on ventral semiannulus 46, 26 apart; seta *f* 29 on $6^{th}$ ventral semiannulus from rear, 24 apart. Seta *h1* 5, seta *h2* 55. ***Male genitalia*** 24 wide, seta *3a* 40, 20 apart.

**Type material. Holotype** female (slide number NJAUAcariEriJ8A.1; marked Holotype), from *C. terniflora* var. *mandshurica* (Ranunculaceae), Jilin Agricultural Science and Technology University, Jilin City, Jilin Province, China, 43°57'16"N, 126°28'58"E, elevation 221m, 19 July 2015, coll. Yan-Mei Sun. **Paratypes** 8 females and 1 male on 9 microscope slides (slide number NJAUAcariEriJ8A.2–8A.10), same collection data and repository as holotype.

**Relationship to host.** Infesting the tender upper leaves; making leaves severely curled and blistered (Figure 1A); hiding inside the curled surfaces (Figure 1B).

**Etymology.** The specific designation *jilinensis* is derived from the name of location, Jilin City, where the new species was collected.

**Remarks.** Up to now, no eriophyoid mite species in the genus *Aculops* was reported from the host plant family Ranunculaceae. The new species is similar to the other species in the genus *Aculops* but can be easily distinguished by characters of specific prodorsal shield design. However, it is mostly similar to *A. alachuae* Keifer, 1966b, which also has dorsal annuli with rounded microtubercles, coxal plates with granules, female genital coverflap with longitudinal ridges and prodorsal shield with lined design and many granules. The new species can be separated from *A. alachuae* by its 7-rayed empodium (4-rayed in *A. alachuae*), median and admedian lines connected at the base by a pair of transverse lines forming an "arrow" (an "arrow" is present at the base of median line, but not connected with admedian lines in *A. alachuae*), submedian lines connected by diagonally reaching lines (submedian lines separated in *A. alachuae*), scapular seta *sc* short, 15 (14–20) (seta *sc* 27 in *A. alachuae*). *Aculops alachuae* was reported infesting *Rhus copallinum* L. var. *leucantha* (Jacq.) DC. (Anacardiaceae) from Florida, USA, galling host plant leaves (Keifer, 1966b). The new species is also similar to *A. euphorbicolus* (Keifer, 1964), which also have annuli with rounded microtubercles (53 dorsal annuli), coxal plates with granules, female genital coverflap with longitudinal ridges and prodorsal shield with lined design, 7-rayed empodium, but can be differentiated by prodorsal shield with many granules between lines (prodorsal shield without granules in *A. euphorbicolus*), median line complete (median line incomplete in *A. euphorbicolus*), opisthosoma with 72 (71–84) ventral annuli (opisthosoma with 60 ventral annuli in *A. euphorbicolus*), female genital coverflap with 13 (12–13) longitudinal ridges and two to three transverse lines at base (female genital coverflap with 8–10 ridges and two rows of granules in *A. euphorbicolus*). *Aculops euphorbicolus* was reported from *Euphorbia corollata* L. (Euphorbiaceae) from Virginia (USA), making deformed flower clusters or galls (Keifer, 1964).

Some intraspecific differences in the design of the prodorsal shield were observed, especially between the median and admedian lines. The median line is complete in all specimens examined except the specimen illustrated in Figure 3C (median line interrupted at centre). Besides connected at base, median and admedian lines are always separated in specimens in Figures 3E and G. Median and admedian lines connected at base, basal 2/3 and 1/3 in Figures 3A, B, D, and F.

## Tribe Phyllocoptini Nalepa, 1892
## Genus *Phyllocoptes* Nalepa, 1887

### *Phyllocoptes terniflores* sp. n.

http://zoobank.org/BA0B864A-96A5-48C4-A9BC-C2F3F499364E
Figs 4, 5

**Diagnosis.** Body fusiform; prodorsal shield with broad frontal lobe, scapular setae ahead of rear shield margin, projecting upward-centrally, median, admedian and submedian lines formed by granules aligned and making a network; opisthosoma dorsally with three ridges, middorsal ridge fade as long as lateral ridges, with 55 (55–60) dorsal and 100 (92–100) ventral annuli, all standard setae of the Eriophyidae present; legs with standard setae, empodium simple, 5-rayed; coxigenital region with three pairs of setae and many granules, female genital coverflap with 12 (10–12) longitudinal ridges and two transverse lines at the base.

**Description.** FEMALE: (n = 10). Body fusiform, 256 (200–304), 73 (68–78) wide, opisthosoma broadest 12–13 annuli posterior of the prodorsal shield, then tapering regularly until its posterior apex; light yellow. ***Gnathosoma*** 25 (20–26), projecting obliquely downwards, pedipalp coxal seta (*ep*) 3 (3–4), dorsal pedipalp genual seta (*d*) simple, 9 (7–9), cheliceral stylets 15 (15-22). ***Prodorsal shield*** 50 (50–55), 57 (55–65) wide, semicircular; frontal lobe broad, 7 (6–7). Shield pattern composed of granules aligned and connected by faint lines. Median line: largely broken at centre; anterior part originated on the frontal lobe and ended at about 1/5 of the anterior prodorsal shield, thereafter, connected with admedian lines by a pair of transverse lines; posterior part originated at about 4/5 of prodorsal shield, vanished at rear of prodorsal shield, connected with admedian lines by a pair of transverse line at anterior. Admedian lines complete and sinuous and connected with submedian lines by two pairs of transverse lines at basal 3/4 and center of prodorsal shield. Submedian lines flanking lateral edges of shield branched into two curled lines, forming a large open semicircle at lateral side of prodorsal shield; many aligned granules distributed between submedian lines. Scapular tubercles ahead of rear shield margin, 22 (22–26) apart, scapular seta (*sc*) 12 (12–14), projecting upward-centrally. ***Coxigenital region*** with 13 (11–13) microtuberculated annuli. Coxal plates with granules and irregular lines throughout, anterolateral seta on coxisternal plate I (*1b*) 15 (13–15), 15 (15–17)

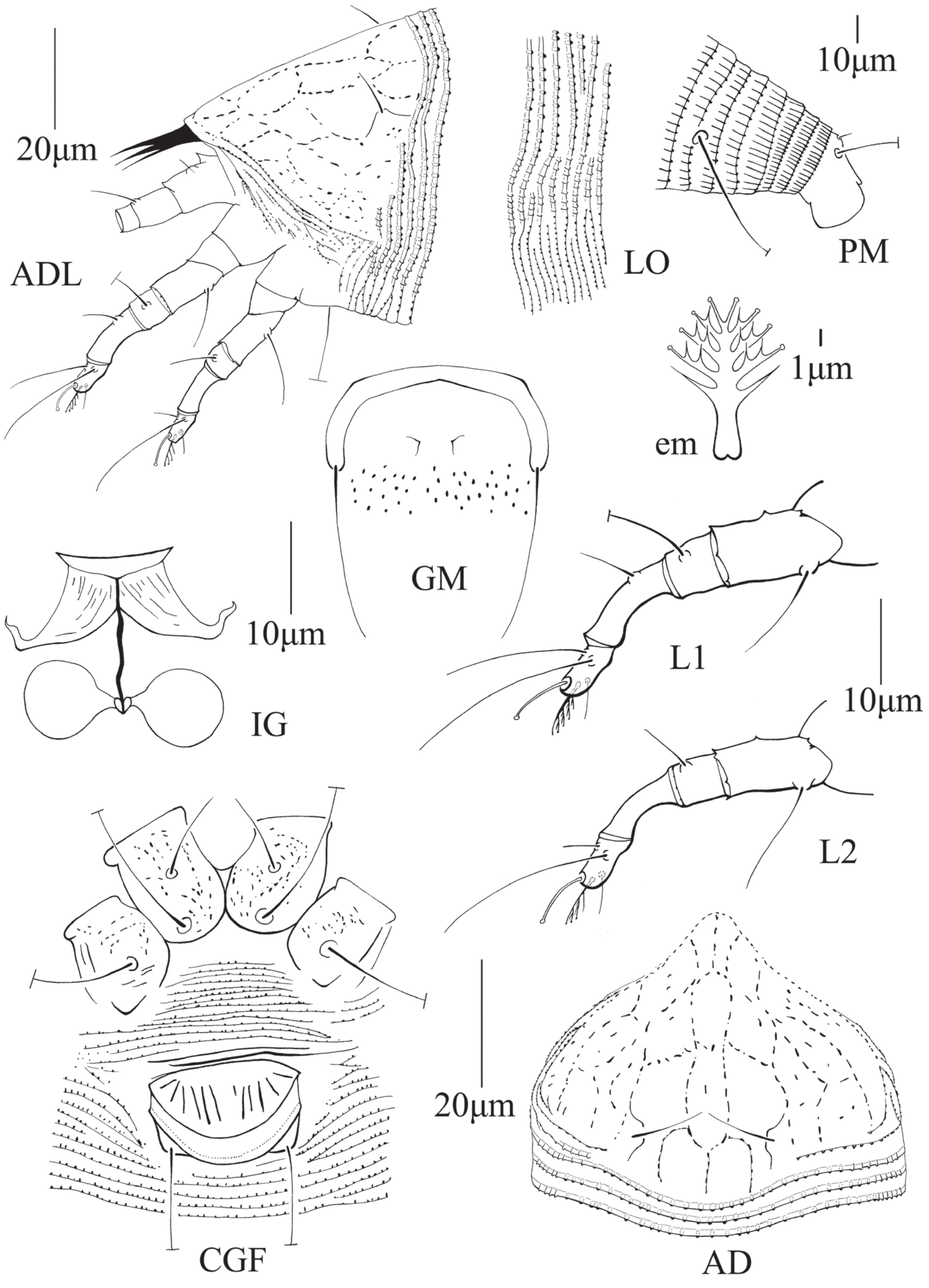


**Figure 4.** Schematic drawings of *Phyllocoptes ternifIores* sp. n.: **ADL** lateral view of anterior body region (slightly rotated dorsad) **LO** lateral view annuli **PM** lateral view of posterior opisthosoma **em** empodium **GM** male genital region **IG** female internal genitalia **L1** leg I **L2** leg II **CGF** female coxigenital region **AD** prodorsal shield.

apart, proximal seta on coxisternal plate I (*1a*) 45 (35–45), 12 (11–14) apart, proximal seta on coxisternal plate II (*2a*) 65 (63–65), 32 (31–35) apart. Prosternal apodeme 6 (6–7). ***Leg I*** 36 (36–38), femur 13 (13–15), basiventral femoral seta (*bv*) 13 (13–14); genu 7 (6–8), antaxial genual seta (*l"*) 38 (35–40); tibia 12 (10–12), paraxial tibial seta (*l'*) 7 (5–7), located at 1/3 from dorsal base; tarsus 7 (7–8), paraxial, fastigial, tarsal seta (*ft'*) 17 (17–20), antaxial, fastigial, tarsal seta (*ft"*) 25 (25–28), paraxial, unguinal, tarsal seta (*u'*) 5 (4–5); empodium (*em*) 8 (7–8), simple, 5-rayed, tarsal solenidion ($\omega$) 8 (7–8), knobbed. ***Leg II*** 35 (33–35), femur 14 (13–15), basiventral femoral seta (*bv*) 15 (12–15); genu 6 (5–6), antaxial genual seta (*l"*) 9 (6–9); tibia 10 (8–10); tarsus 6 (6–7), paraxial, fastigial, tarsal seta (*ft'*) 5 (5–6), antaxial, fastigial, tarsal seta (*ft"*) 24 (24–28), paraxial, unguinal, tarsal seta (*u'*) 5 (4–5); empodium (*em*) 8 (7–8), simple, 5-rayed, tarsal solenidion ($\omega$) 9 (9–10), knobbed. ***Opisthosoma*** dorsally with 55 (55–60) semiannuli, with rounded microtubercles on the posterior margin, except last 6th semiannuli with elongated microtubercles; ventrally with 100 (92–100) semiannuli, with nearly rounded microtubercles on central part; moreover, with elongated microtubercles in side area and the ventral semiannulus between seta *e* and *f*; last 6 ventral semiannuli with elongated and linear microtubercles. Seta *c2* 40 (40–43) on ventral semiannulus 21 (20–22), 67 (65–74) apart; seta *d* 54 (43–45) on ventral semiannulus 43 (39–43), 48 (47–50) apart; seta *e* 32 (29–32) on ventral semiannulus 69 (63–69), 26 (24–26) apart; seta *f* 37 (36–37) on $6^{th}$ ventral semiannulus from rear, 28 (25–28) apart. Seta *h1* 5 (4–5), seta *h2* 87 (83–87). ***Female genitalia*** 17 (17–20), 24 (24–27) wide, coverflap with 12 (10–12) longitudinal ridges and two transverse lines at the base, seta 3*a* 27 (23–28), 19 (19–21) apart.

MALE: (n = 1). Body fusiform, 233, 72 wide; white. ***Gnathosoma*** 20, projecting obliquely downwards, pedipalp coxal seta (*ep*) 3, dorsal pedipalp genual seta (*d*) simple, 7, cheliceral stylets 15. ***Prodorsal shield*** 50, included the frontal lobe, 55 wide, with a broad based frontal lobe broad, 8, shield design similar to that of female. Scapular tubercles ahead of rear shield margin, 22 apart, scapular seta (*sc*) 11, projecting centrad. ***Coxigenital region*** with 14 microtuberculated annuli. Coxal plates with irregular lines, anterolateral seta on coxisternal plate I (*1b*) 9, 14 apart, proximal seta on coxisternal plate I (*1a*) 33, 10 apart, proximal seta on coxisternal plate II (2*a*) 50, 28 apart. Prosternal apodeme 10. ***Leg I*** 34, femur 12, basiventral femoral seta (*bv*) 9; genu 5, antaxial genual seta (*l"*) 27; tibia 10, paraxial tibial seta (*l'*) 6, located at 1/3 from dorsal base; tarsus 7, paraxial, fastigial, tarsal seta (*ft'*) 16, antaxial, fastigial, tarsal seta (*ft"*) 24, paraxial, unguinal, tarsal seta (*u'*) 4; empodium (*em*) 7, simple, 5-rayed, tarsal solenidion ($\omega$) 8, knobbed. ***Leg II*** 27, femur 11, basiventral femoral seta (*bv*) 10; genu 10, antaxial genual seta (*l"*) 6; tibia 9; tarsus 6, paraxial, fastigial, tarsal seta (*ft'*) 5, antaxial, fastigial, tarsal seta (*ft"*) 24, paraxial, unguinal, tarsal seta (*u'*) 5; empodium (*em*) 6, simple, 5-rayed, tarsal solenidion ($\omega$) 8, knobbed. ***Opisthosoma*** dorsally with 45 semiannuli, with rounded microtubercles on the posterior margin, last $5^{th}$ semiannuli with elongated microtubercles; ventrally with 82 semiannuli, with nearly rounded microtubercles on central part; moreover, with elongated microtubercles in side area and the ventral semiannulus between seta *e* and *f*; last six ventral semiannuli with elon-

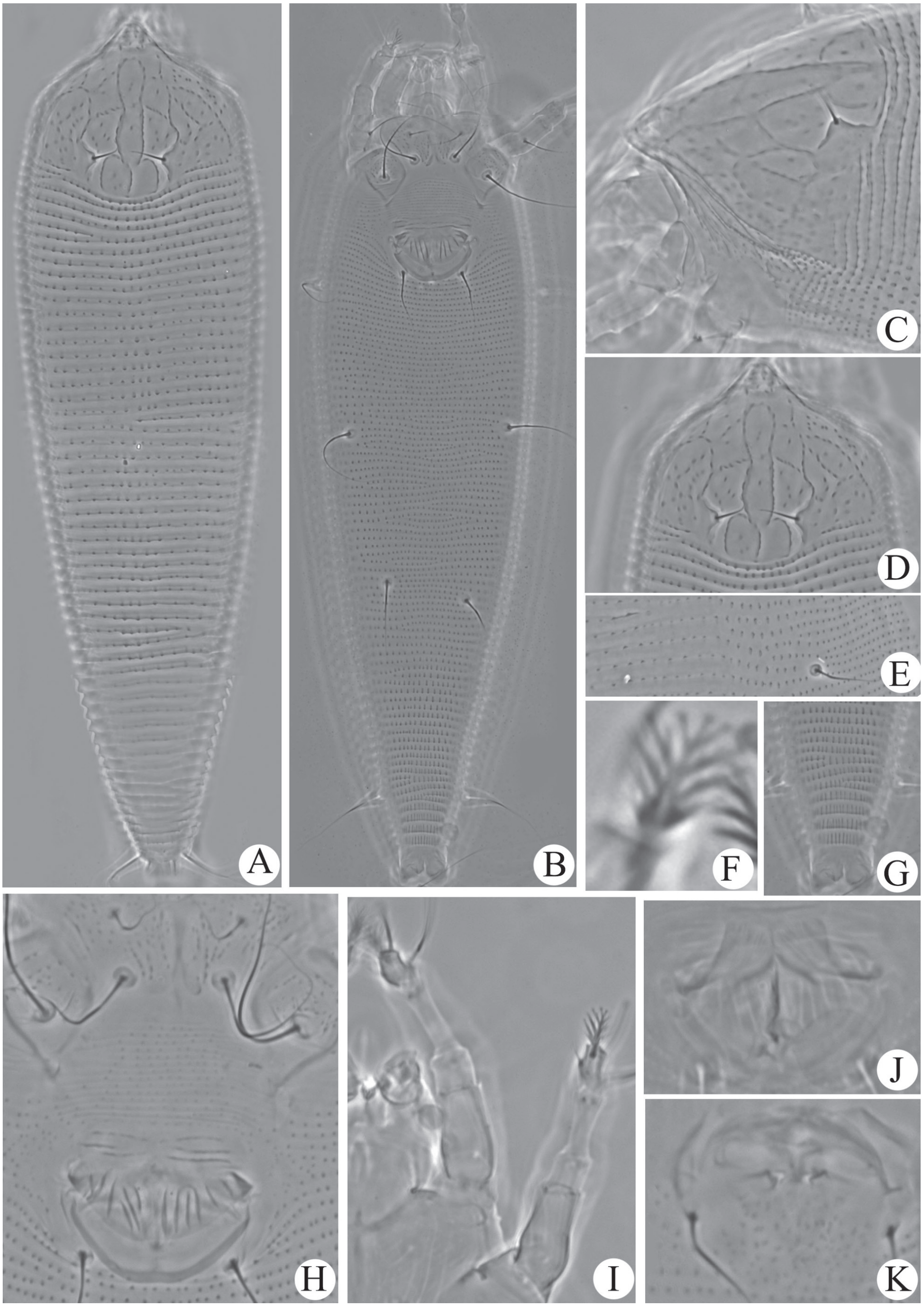


**Figure 5.** Micrographs of *Phyllocoptes ternifIores* sp. n.: **A** dorsal view of female **B** ventral view of female **C** lateral view of anterior body region **D** prodorsal shield **E** lateral view annuli **F** empodium **G** ventral view of posterior opisthosoma **H** coxigenital region and female genitalia **I** leg I and leg II **J** female internal genitalia **K** male genital region.

gated and linear microtubercles. Seta *c2* 30 on ventral semiannulus 18, 62 apart; seta *d* 30 on ventral semiannulus 30, 40 apart; seta *e* 20 on ventral semiannulus 50, 23 apart; seta *f* 26 on 6$^{th}$ ventral semiannulus from rear, 23 apart. Seta *h1* 5, seta *h2* 60. ***Male genitalia*** 19 wide, seta *3a* 14.

**Type material. Holotype** female (slide number NJAUAcariEriJ8B.1; marked Holotype), from *C. terniflora* var. *mandshurica* (Ranunculaceae), Jilin Agricultural Science and Technology University, Jilin City, Jilin Province, China, 43°57'16"N, 126°28'58"E, elevation 221m, 19 July 2015, coll. Yan-Mei Sun. **Paratypes** 9 females and 1 male on ten microscope slides (slide number NJAUAcariEriJ8B.2–8B.11), same collection data and repository as holotype.

**Relationship to host.** Infesting the tender upper leaves and making leaves severely curled and blistered (Figure 1A); hiding inside the curled surfaces (Figure 1B).

**Etymology.** The specific designation *terniflores* is derived from the species name of the host plant, *terniflora*.

**Remarks.** The new species was compared with others in the genus *Phyllocoptes* infesting *Clematis* sp. This species is similar to *P. atragenes* [from *C. alpina*, infesting host plant as curled leaves], but can be differentiated from the latter by its shield pattern: the median and admedian lines are discontinuous (median and admedian lines continuous in *P. atragenes*), dorsal opisthosoma with 55 (55–60) annuli (dorsal opisthosoma with 48 annuli in *P. atragenes*) and dorsal annuli with rounded microtubercles (dorsal annuli smooth in *P. atragenes*). This species is also similar to *P. heterogaster* (Nalepa, 1891) [from *C. recta*, infesting host plant as abnormal hair], but can be differentiated from the latter by having its coxal plates with granules and short lines (coxal plates smooth in *P. heterogaster*), empodium 5-rayed (empodium 4-rayed in *P. heterogaster*), median line present on anterior of prodorsal shield (median line absent from anterior of prodorsal shield in *P. heterogaster*).

Besides species from *Clematis* sp., the new species is also similar to *P. calirubi* Keifer, 1938 [from *Rubus ursinus* Cham. & Schltdl. (Rosaceae)], *P. exochordae* Keifer, 1972 [from *Exochorda racemosa* (Lindl.) Rehder (Rosaceae)] and *P. neenachensis* Keifer, 1966a [from *Oenothera deltoides* Torr. & Frém. (Onagraceae)] by dorsal and ventral annuli with rounded microtubercles, female genital coverflap with longitudinal ridges and especially prodorsal shield design formed by granules aligned (besides with the generic characters of *Phyllocoptes*). The new species can be differentiated from the later three species by large size of body, 256 (200–304) (140–155 in *P. calirubi*, 200–215 in *P. exochordae* and 145–195 in *P. neenachensis*), median line present at anterior of dorsal shield (median lines absent from anterior of dorsal shield in all three species), coxal area with many granules and short lines (coxal area with few short lines in *P. calirubi*; coxal area I with short lines, coxal area II smooth in *P. exochordae*; coxal area with granules and short lines in *P. neenachensis*), solenidion knobbed (solenidion unknobbed in all three species), empodium 5-rayed (empodium 5-rayed in *P. calirubi*, empodium 6-rayed in *P. exochordae* and empodium 4-rayed in *P. neenachensis*) and short scapular seta 7 (6–7) (scapular seta 11 in *P. calirubi* and *P. exochordae*, scapular seta 10 in *P. neenachensis*).

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RESEARCH ARTICLE

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# A new species of *Charinus* Simon 1892 from Brazil, with notes on behavior (Amblypygi, Charinidae)

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## Abstract

A new species of *Charinus* is described and illustrated from the Brazilian Atlantic Forest. *Charinus ruschii* **sp. n.** is found in Santa Lúcia reserve, Espírito Santo state, and is sympatric with *C. brasilianus* and *C. montanus*. The new species can be easily distinguished from the other species of the genus by the combination of the following characters: number of spines on the pedipalp tarsus, size and shape of the female genitalia, shape of the sternum and number of teeth in the cheliceral claw. The behavioral repertory is also described for this species based on five hours of qualitative and 24 hours of quantitative observations in order to define the behavioral categories. Five behavioral categories were detected and 21 behavioral acts. The most conspicuous category was *Immobility*, followed by *Antenniform leg movement*, *Environmental exploration*, *Self-grooming*, and *Feeding*. It was also found that juveniles spend longer time inside the shelter, even during peaks of adult activity, which could be related to a survival strategy.

## Keywords

Activity rhythms, Atlantic Forest, behavioral repertory, taxonomy, Whip spider

## Introduction

Whip spiders (order Amblypygi) are peculiar flattened arachnids with unique spiny, robust pedipalps and extremely elongate first pair of legs (Weygoldt 2000). The group is widely distributed in the tropics (Giupponi and Miranda (2016), Miranda et al. (2016); but see Miranda et al. (in press)), and consists of more than 200 species with the majority of the diversity in the family Charinidae Simon, 1892. Charinidae contains three genera, *Catageus* Thorell, 1889 with one species, *Charinus* Simon, 1892 with 70 species, and *Sarax* Simon, 1892 with 17 species. The genus *Charinus* has a pantropical distribution, occurring in the Caribbean region, Central and South America, Africa, Europe, Asia and Oceania, but most of the species have been described from the Americas. However, its diversity is still not completely revealed, as shown by the many new species discovered during the last decade (Armas 2006, 2010, Armas et al. 2016, Giupponi and Miranda 2016, Jocqué and Giupponi 2012, Miranda et al. in press, Miranda and Giupponi 2011, Miranda et al. 2016, Réveillion and Maquart 2015, Seiter et al. 2015, Teruel 2016, Teruel and Questel 2011, 2015, Torres-Contreras et al. 2015, Vasconcelos et al. 2016, Vasconcelos et al. 2013, 2014).

Like most other arachnids, whip spiders are nocturnal animals that hide in shelters during the day (such as rock crevices or inside and under logs) and venture out to forage at night (Pinto-da-Rocha et al. 2002, Weygoldt 2000). The biology of some Phrynidae and Phrynichidae species are known (e.g. reproduction, microhabitat selection/use, spatial orientation, and social behavior; reviewed in Weygoldt (2000) and Chapin and Hebets (2016)). However, little information is available for charinids, which counts with just few general behavioral studies examining reproductive biology and behavioral repertory (Gray and Robinson 1986, Pinto-da-Rocha et al. 2002, Weygoldt 2008).

Animal behavior is defined as any act performed by an animal and involves much more than movements for locomotion or displacement, it also encompass fine movements and inactivity (Del-Claro and Prezoto 2003). As a starting point to understand the biology and ecology of an animal, behavioral repertoires (or ethograms) are important tools and give information about animal's main activities, peaks of activity, interactions, and how it distributes its activities during the day (Beck 1972, Del-Claro 2004, Lehner 1996). This kind of study allows quantitative comparisons of behavioral repertoires among different species and between individuals of different sexes (Osses et al. 2008). The observations of a given animal are represented in tables of qualification (description of behavioral categories) and quantification (frequency of each behavioral category in *t* time) of the acts (Del-Claro 2004, Santos et al. 2003).

Few studies have been published on the behavioral repertoires of arachnids, including Opiliones (Elpino-Campos et al. 2001, Osses et al. 2008, Pereira et al. 2004), Scorpiones (Mineo et al. 2003), Ricinulei (García et al. 2015), Schizomida (Oliveira and Ferreira 2014) and Thelyphonida (Punzo 2000). There are also few works on Amblypygi, including a study on *Charinus asturius* Pinto-da-Rocha, Machado and Weygoldt, 2002 (Pinto-da-Rocha et al. 2002), and two papers on *Heterophrynus* sp. (Beck 1972, Beck and Görke 1974).

This paper contributes to the knowledge of *Charinus* in the Neotropics with the description of *Charinus ruschii* sp. n. and its behavior repertoire. This species occurs in the Brazilian Atlantic Forest (state of Espírito Santo, Southeastern Brazil), and is the third *Charinus* species discovered in Santa Teresa municipality (Fig. 4). *C. ruschii* differs significantly from the other known species in the area (*C. brasilianus* Weygoldt, 1972 and *C. montanus* Weygoldt, 1972), as described in detail below.

## Materials and methods

Individuals of *Charinus ruschii* were collected at Estação Biológica de Santa Lúcia (EBSL), a biological station of 440 ha located 10 km from Santa Teresa (19°57'S; 40°31'W), in Espírito Santo state, southeastern Brazil (Mendes and Padovan (2000); Fig. 4). The EBSL is inside a remnant of Atlantic rainforest, in a geomorphologic crystalline complex with high rocky outcrops ranging in altitudes from 600 to 900 m (Thomaz 1996). Mean annual precipitation for Santa Teresa region is 1345 mm with a peak in November and a dry season in June and July (Mendes and Padovan 2000).

For nomenclature and measurements, the methods of Quintero (1981) are generally followed. The terminology of pedipalp and leg segments follows Harvey and West (1998). The article called tarsus by Harvey and West (1998) is divided here into tarsus and claw, as there is no fusion of these two segments in Charinidae. The spines of the pedipalpal patella and teeth of the chelicerae are counted from the apex to the base. Measurements of the entire type series were taken, and the measuring of the pedipalp articles was taken between the condyles of each segment in order to establish fixed points and comparable length. Total body length is usually used as diagnostic of *Charinus* species, but was not included here due to the contractile nature of the abdomen. Instead, the carapace width, pedipalp femur length, and femur I length seems to have more reliable diagnostic characters and are here used.

Photographs were made using a BK plus Imaging System from Visionary Digital (Palmyra, PA, USA; http://www.visionarydigital.com/) equipped with a Canon 7D digital camera at the Zoological Museum, University of Copenhagen (ZMUC). Stacks of images from multiple focal planes were combined using Zerene Stacker (Zerene Systems LLC, http://zerenesystems.com/cms/stacker) and processed in Photoshop CS6 (Adobe, San Jose, CA, USA) to adjust color, brightness, and contrast, and remove blemishes. The plates were mounted in Corel Draw X5 (Corel, Mountain View, CA). One female was examined with scanning electron microscopy (SEM). The SEM work was carried out with a JEOL JSM-6390LV at the Center for Scanning Electron Microscopy of the Museu Nacional/UFRJ.

The distribution map was produced and edited using ArcGis 10.2 (ESRI 2014) with vector layers for countries and states, and a raster background layer for the vegetal cover and urban occupation (made available by the Brazilian Ministry of the Environment, http://mapas.mma.gov.br/mapas/aplic/probio/datadownload.htm). The coordinates were obtained with Google Earth given the localities in the labels and information in the literature.

Abbreviations of the repositories cited:

**MNRJ** Museu Nacional do Rio de Janeiro, Rio de Janeiro, Brazil;
**MZSP** Museu de Zoologia da Universidade de São Paulo, São Paulo;
**SMF** Senckenberg Naturmuseum und Forschungsinstitut, Frankfurt, Germany.

The behavioral repertory of *Charinus ruschii* was recorded in the Laboratory of Arachnology at the *Escola Superior São Francisco de Assis/ESFA*, Brazil. Between June and July 2004, 17 specimens of *Charinus ruschii* (12 adult females and 5 juveniles) were collected inside caves and rock crevices at the study area. The individuals were kept separately from each other in captivity in plastic boxes (15 cm long X 11 cm wide X 7 cm high), which contained one rock (that was used by them as a shelter), mud as substrate, and a piece of wet cotton to maintain humidity. Each plastic box received a number that was used in the randomization process (see below). The laboratory room was kept under darkness as this species lives in caves and rock crevices, and red light was used during observations to avoid disturbing the individuals. The whip spiders were fed with fruit flies (*Drosophila* sp.), moth flies (*Psychoda* sp.), and unidentified species of butterflies and moths every three days (one prey per day of feeding). Five hours of observations allowed the definition of five categories and 21 different behavioral acts (Table 1). The individuals were kept seven days under captivity before the behavioral observations.

Twenty-four hours of quantitative observations were made for 24 days, in which 60 observations of 1 minute was performed each day. The hour of the day to be studied was randomly chosen (24 pre-defined days) and thus was spread throughout the whole study. That is, in day 1 we could perform the study from 10 am to 11 am, whereas in day 2 from 7 pm to 8 pm, and so on. The specimens were numbered from 1 to 17 and the order to be observed was randomly defined before the behavioral study (following Pinto-da-Rocha et al. (2002); Machado, G. (pers. comm, 6 April 2004)). In total, 1440 minutes of observation were recorded totaling 24 hours and covering day and night. During the day, and after feeding, whip spider specimens remained resting. Voucher material is deposited in the Arachnology section of the Museu Nacional do Rio de Janeiro, Universidade Federal do Rio de Janeiro (MNRJ). The voucher numbers are in the list of type material.

## Additional material examined

*Charinus acaraje* Pinto da Rocha, Machado & Weygoldt, 2002: Brazil, Bahia, Santa Luzia, Gruta do Lapão, R.L.C. Baptista *leg.* (3 males, 5 females, 1 juvenile, MNRJ 9297).

*Charinus asturius* Pinto da Rocha, Machado & Weygoldt, 2002: **holotype**: Brazil, São Paulo, Ilha Bela, Morro Pacuíba [23°44'S 45°19'W], i.1998, G. Machado *leg.* (1 male, MZSP 18930); **paratypes**: same data as holotype (1 female, MZSP 18930; 1 female with empty egg sac and numerous prenymphal exuviae, MZSP 18934);

same locality as holotype, 18.i.1999, R. Pinto-da-Rocha and G. Machado *leg*. (4 males, 3 females, 1 immature female, 6 protonymphs, MZSP 16900).

*Charinus brasilianus* Weygoldt, 1972: **holotype** and **paratype**: Brazil, Espírito Santo, Serra, 10 km north of Vitória, 200–400 m, xi.1970, P. Weygoldt *leg*. (1 male, 1 female, MNRJ 9014); **other paratypes:** same data as holotype (3 males, 3 females, 3 juveniles, SMF 25397); **additional material**: Nova Valssugana [19°54'09"S 40°39'31"W], Santa Teresa, v.2005, T. Gonçalves-Souza *leg*., G.S. Miranda det. (2 males, MNRJ 9271); Reserva Santa Lúcia, Santa Teresa, 15–19.x.2003, Almeida, Baptista, Giupponi, Mendes and Pedroso *leg*., G.S. Miranda det. (1 female, MNRJ 9232).

*Charinus eleonorae* Baptista & Giupponi, 2003: **paratypes**: Brazil, Minas Gerais, Itacarambi, Gruta Olhos d'Água, 26.vi.2001, R.L.C. Baptista & A.P.L. Giupponi *leg*. (7 males, 6 females, 2 males juvenile, 2 females juvenile, 2 small juveniles, MNRJ 9033).

*Charinus insularis* Banks, 1902: Ecuador, Galapagos Islands, Isla Santa Cruz, Turtle Bay, 14.i.1965, W.D. Stockton det. (1 male, 1 female, Royal Belgian Institute of Natural Sciences); Ferme Horuerneru, sous de pierres dores en ravim argilex, alt 250 m, ix.1964, J. and N. Leleup *leg*., W.D. Stockton det. (2 females, Royal Belgian Institute of Natural Sciences).

*Charinus jibaossu* Vasconcelos, Giupponi & Ferreira et al., 2014, **paratypes**: Brazil, Minas Gerais, Pains, Gruta da Vila Corumbá [20°19'55.8"S 45°36'43.23"W], 25.i.2009, R.A. Zampaulo *leg*. (1 male, MNRJ 9217); Gruta da Mineração, 25.i.2009 (1 female, MNRJ 9277).

*Charinus koepckei* Weygoldt, 1972: **holotype**: Peru: Am Weg v. Chala n. Chaparra (Küste; lichte Waldloma, u.Stein.) um 500 m (1 female, SMF 25762).

*Charinus montanus* Weygoldt, 1972: **holotype** and **paratype**: Brazil, Espírito Santo, Domingos Martins, 1000 m, xi.1970, P. Weygoldt *leg*. (1 male, 1 female, MNRJ 9015); **other paratypes**: Domingos Martins, 50 Km. W. Vitória. Bergwäld. a., xi.1967, P. Weygoldt and Helversen *leg*. (5 females, 5 males, 3 juveniles, SMF 25398); **additional material**: Santa Teresa, M. Milleri-Pinto and T. Gonçalves-Souza *leg*., G.S. Miranda det. (4 females, 1 male, MNRJ 9243); Santa Teresa, Estação Biológica Santa Lúcia, G.S. Miranda det. (2 males, 2 females, MNRJ 9273); Santa Teresa, Reserva Santa Lúcia, 15–19.x.2003, Almeida, Baptista, Giupponi, Mendes & Pedroso *leg*., A.P.L. Giupponi det. (5 males, 3 juveniles, MNRJ 9087).

*Charinus mysticus* Giupponi & Kury, 2002: **paratype**: Brazil, Caverna Encantados, Gentil do Ouro, 16 km from Santo Inácio, road to Gameleira; cave with stream, about 8 m from entrance, 28.ix.1991, G. Skuk *leg*. (1 female, MNRJ 9022).

*Charinus potiguar* Vasconcelos Giupponi & Ferreira, 2013: **paratypes**: Brazil, Rio Grande do Norte, Caverna do Pau, Felipe Guerra [5°35'34.19"S 37°41'14.64"W], 08.i.2007, R.L. Ferreira *leg*. (1 male, MNRJ 9212); Caverna do Geilson [05°35'53.23"S 37°41'17.56"W], 23.iv.2007, D. M. Bento *leg*. (1 female, MNRJ 9213).

*Charinus troglobius* Baptista & Giupponi, 2002: **paratype**: Brazil, Bahia, Carinhanha, Gruna do Zé Bastos, Serra do Ramalho, 28.vi.2001, R.L.C. Baptista & A.P.L. Giupponi *leg*. (2 males, MNRJ 9069, 9081; 1 female, MNRJ 9078).

**Table 1.** Category description and behavioral act frequencies of *Charinus ruschii* sp. n. in 1440 minutes of observation.

| Categories/behavioral acts | Frequency (%) |
|---|---|
| **Immobility: stand still in an environment** | **48.89** |
| Stand still with abdomen leaning over the ground: specimen stays totally still outside the shelter with the body leaning on the ground | 6.81 |
| Stand still with abdomen distant from the ground: specimen stays totally still outside of the shelter with abdomen distant from the ground | 20.00 |
| Inside the shelter: specimen stays still inside the shelter with the body leaning over the ground | 22.08 |
| **Antenniform leg movement: stand still with the antenniform legs in movement** | **41.60** |
| Stand still with abdomen leaning over the ground and moving antenniform legs backward: specimen stays still and smoothly moving antenniform legs backward | 2.92 |
| Stand still with abdomen distant from the ground and antenniform legs waving under the body: specimen stays still with alternate movements of the antenniform legs backward and forward | 31.25 |
| Stand still with antenniform legs touching the ground: specimen stays still and touching the ground with antenniform legs | 1.53 |
| Stand still with antenniform legs erect: keep the body distant from the ground and smooth movements of the antenniform legs over the body | 1.94 |
| Stand still with antenniform legs pointing forward: antenniform legs in a forward position making smooth movements | 3.96 |
| **Environmental exploration** | **6.11** |
| Laterally walking: walking to the sides inside the plastic box, like a crab | 1.18 |
| Walking with the antenniform leg erect and pointed forward: slowly walking without moving the antenniform legs and in a forward position | 2.36 |
| Walking with antenniform legs erect and pointed backward: slowly walking without moving the antenniform legs and in a backward position | 0.14 |
| Walking and touching the ground with antenniform legs: slowly walking touching and feeling the ground with antenniform legs | 0.56 |
| Walking with antenniform legs pointed forward and second pair of legs touching the ground: slowly walking throughout the box with antenniform legs in a forward position and second pair of legs touching the ground | 0.55 |
| Walking with first and second pair of legs touching the ground: slowly walking all over the box touching its walls with antenniform legs and the ground with second pair of legs | 1.04 |
| Walking with antenniform legs in a lateral position and second pair of legs touching the ground: walking with antenniform legs in a perpendicular position in respect to body axis and second pair of legs touching the ground | 0.28 |
| **Feeding** | **0.76** |
| Eating a prey: to lacerate the prey with the chelicerae, with abdomen distant from the ground. | 0.76 |
| **Self-grooming** | **2.64** |
| Cleaning the pedipalps: rub the pedipalps all over the chelicerae | 1.18 |
| Cleaning first pair of legs: rub the antenniform legs over the pedipalps and/or the chelicerae | 0.69 |
| Cleaning second pair of legs: rub the second pair of legs over the pedipalps and/or the chelicerae | 0.35 |
| Cleaning third pair of legs: rub the third pair of legs over the chelicerae | 0.07 |
| Cleaning fourth pair of legs: rub the fourth pair of legs over the chelicerae | 0.35 |

## Results

### Taxonomy

**Family CHARINIDAE Quintero, 1986**
**Genus *Charinus* Simon, 1892**

***Charinus ruschii* sp. n.**
http://zoobank.org/1AAB23A6-5DD9-4580-A97B-956F2BF0E000
Figures 1, 2, 3, 4

**Diagnosis.** *Charinus ruschii* can be easily recognized by the sucker-like female gonopod, presence of three spines on the pedipalp tarsus, large size (carapace *circa* 80% wider than that of *C. brasilianus* and *C. montanus*), small unique platelets of the sternum, similar size of the proximal segment of tarsus I compared to the other segments, and cheliceral claw with 10 teeth.

**Type material. Holotype**: Brazil, Espírito Santo, Santa Teresa municipality [19°56'12.60"S 40°35'53.99"W], T. Gonçalves-Souza and M. Milleri-Pinto *leg*. (1 female, MNRJ 9235). **Paratypes**: same data as holotype, T. Gonçalves-Souza and Milena *leg*. (4 females, 1 juvenile, MNRJ 9237); same data as holotype, T. Gonçalves-Souza and Milena *leg*. (2 females, MNRJ 9235); Estação Biológica Santa Lúcia, v.2005, T. Gonçalves-Souza *leg*. (1 female, MNRJ 9272); Man. Livre Div. Santa Teresa, M. Milleri-Pinto and T. Gonçalves-Souza *leg*. (2 females, MNRJ 9303).

**Etymology.** The species is named after the late agronomist and naturalist Augusto Ruschi (1916-1986), who played an important role in the investigation and conservation of the Atlantic Forest, and who was born in the city of the type locality of the new species. He was also involved in the creation of *Estação Biológica Santa Lúcia* (Biological Station *Santa Lúcia,* a forested reserve) where the new species was found. In 2016 is also the centenary of his birth.

**Description. *Carapace*** (Fig. 1A): flattened, wider than long (1.4 times), slightly bent downwards below lateral eyes; thin median furrow reaching fovea starting from median eye tubercle. Anterior margin rounded, with 6 frontal setae. Frontal process large, triangular, not visible from above. Three pairs of shallow furrows on lateral side of carapace, and an oval fovea. 1st pair of furrows placed just behind the lateral boss; furrows not reaching the middle line. Median eyes and tubercle present. Lateral eyes well developed, 1 small setae behind each triad of eyes; lenses directed upwards and anteriorly.

***Sternum*** (Fig. 1B): 4-segmented, all articles well sclerotized. Tritosternum with round basis, projecting anteriorly in a small blunt tubercle, surpassing the base of the pedipalp coxae, with 2 apical, 2 median and 2 basal setae, with smaller ones spread from the middle to the base. Middle piece (tetrasternum) in one convex piece, with pair of large setae in its apex, and several small ones at its base. Third piece (pentasternum) formed by 1 convex piece, smaller than middle piece, with 2 long setae at its top and several setae at its base. Sternites separated from each other by the length of the third piece. Metasternum paired in its anterior half, with an anterior setae in the

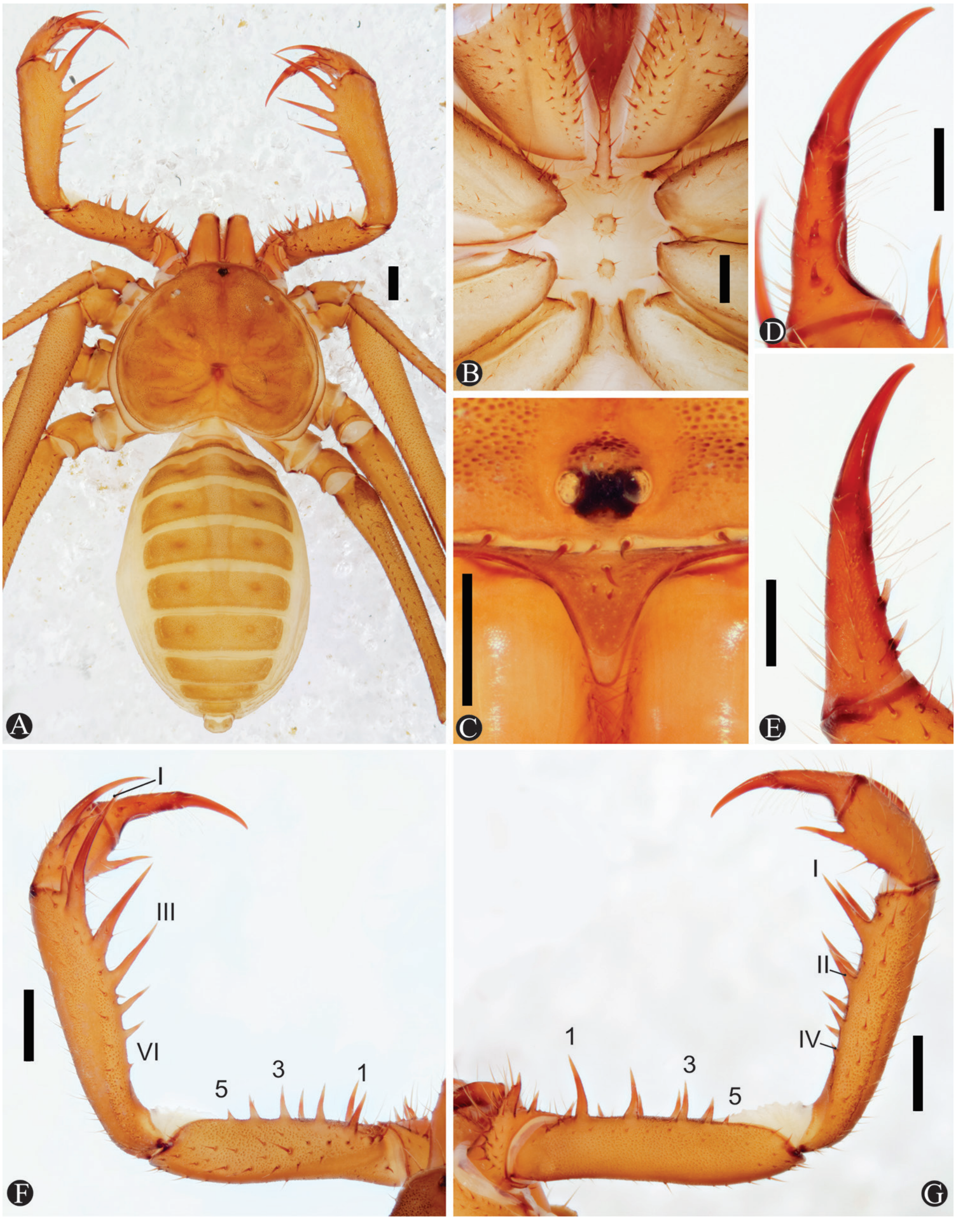


**Figure 1.** Habitus and details of *Charinus ruschii* sp. n. (holotype, MNRJ 9235). **A** Habitus dorsal **B** Sternum **C** Frontal process **D** Dorsal view of left pedipalp tarsus and claw **E** Frontal view of left pedipalp tarsus and claw **F** Dorsal view of left pedipalp **G** Ventral view of left pedipalp. Scale bars: **A, F, G**: 1 mm; **B, C, D, E**: 0.5 mm.

membranous region followed by 2 to 3 setae in the sclerotized area, in a longitudinal row from the non-sclerotized to the sclerotized region; distal border with a small elevation bearing 6–8 large setae.

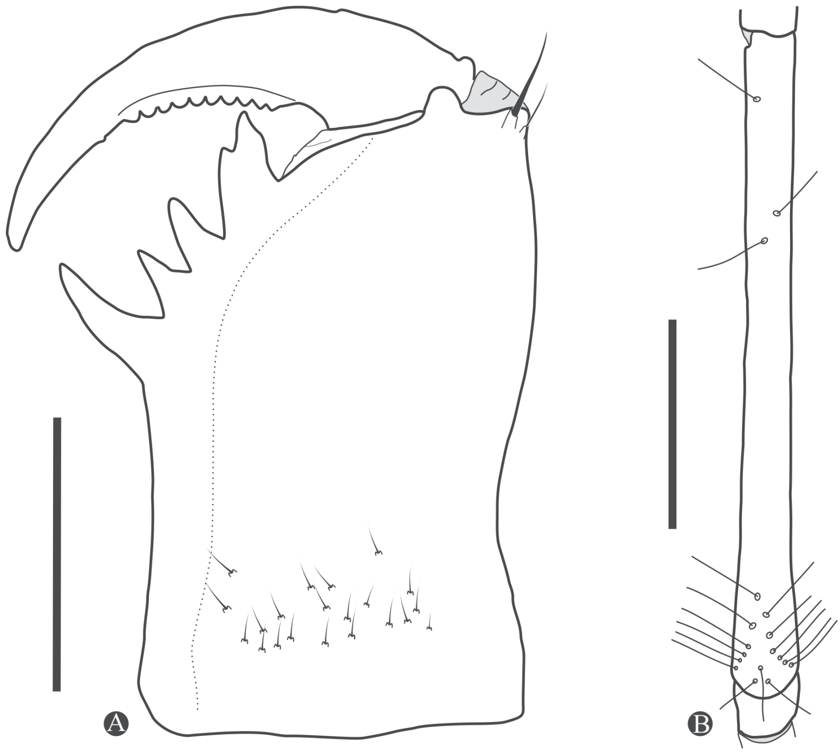


**Figure 2.** Chelicerae (**A**) and distitibia of leg IV (**B**) of *Charinus ruschii* sp. n. (MNRJ 9237 and MNRJ 9235, respectively). Scale bars: 1 mm

***Abdomen*** (Fig. 1A): oblong, with almost indistinguishable punctuations. Ventral sacs not present.

***Chelicera*** (Fig. 2A): cheliceral furrow with 4 internal (prolateral) teeth; first tooth (upper) bifid with proximal cusp much larger than distal cusp. Third tooth slightly thinner and shorter than second. Fourth tooth one third larger than the third. No tooth in the external row of the basal segment. Mesal face with several small setae. Claw with 10 denticles.

***Pedipalp***: **Trochanter** (Fig. 1G): large spiniform ventral apophysis, located in the posterior border of the trochanter, bearing 13 large setae, and with a blunt tip pointed forward; 2 subequal spines, one at about the center of the anterior row of setiferous tubercles, the other at the external border, above the apophysis, slightly curved inwards. ***Femur*** (Fig. 1F, G): 5 to 6 dorsal spines (I>II>III>IV>V>VI) with 2 prominent setiferous tubercles before first spine; 5 ventral spines (I>II>III>IV>V), with 1 small spine displaced from the main series, dorsal to spine 1; with 2 small setiferous tubercles before first spine. ***Patella*** (Fig. 1F, G): 6 dorsal spines (I>II>III>IV>V>VI); one setiferous tubercle distal to I (about one third the size of I); spine I with 3 large and several small setae in the first third; spine II with 3–4 large setae at basal third; spine III with 1 setae in its distal third. 4–5 ventral spines decreasing in size. ***Tibia*** (Fig. 1F, G): 2

dorsal spines, the basal 2/3 the size of the distal. One ventral spine at distal half, 2/3 the basal spine dorsal. ***Tarsus*** (Fig. 1D, E): 3 dorsal spines (present since early stages of development); 2 distal, subequal between each other and 1/5 the size of the article; the proximal spine small, circa of 1/3 the size of the other two, positioned close to the proximal spine and with long setae in its base. Cleaning organ about 1/2 of the article length. ***Claw*** (Fig. 1D, E): long, with an acute, curved tip.

***Legs***: all segments setose. Ventral corner of the prolateral face of femora II–IV projecting in a distinct spiniform process. Femur length: I>III>II>IV. Tibia I with 23 articles; distal segments with 2 small trichobothria, 1 on the dorsal and 1 on the lateral (mesal) side of the segment; 1 trichobothria in the second, third and fourth (from distal to proximal) segments, close to the distal border, all dorsally positioned; no trichobothria on other segments. Tarsus (basitarsus+distitarsus) I with 41 articles covered with large number of sensilla (Fig. 3B–F). Tip of leg I with small modified claw, emerging from common base (Fig. 3F). Lateral claws smaller than middle claw. Segments covered with at least 2 sensilla types, the bristle sensilla (*br*) and the club sensilla (*c*; Figs 3C, D). The club sensilla are found in the first 3 or 4 segments of tarsus I, whereas the bristle sensilla are present in all segments of tarsus and tibia I, decreasing in number from the tip to the base of the segments.

***Leg IV*: *Basitibia***: divided into 4 pseudo-articles, with 1 trichobothrium on the first third of the last pseudo-segments (trichobothrium *bt*). ***Distitibia*** (Fig. 2B): 3 proximal and 15 distal trichobothria (total of 18); trichobothrium *bc* closer to *sbf* than to *bf*; *sf* and *sc* with 6 trichobothria. Basitibia-distitibia length DT>BT1>BT4>BT3>BT2. Tarsus: with well marked white ring in the distal part of first segment of distitarsus IV.

**Color pattern (alcohol preserved material)**. Chelicerae, pedipalps, carapace, and abdomen yellowish-brown; tibia and tarsus of legs lighter colored. Live animals grey.

**Genitalia.** female gonopod (Fig. 3A): posterior margin of genital operculum straight, with several setae along its margin and on its surface. Gonopods sucker-like, with a broad base, a constriction in the middle of the short stalk, and a rounded opening of the atrium; stalk slightly curved inwards. Base soft and wrinkled.

**Male.** not known.

## Behavioral repertory

The most conspicuous behavioral category was *Immobility* (48.89%), followed by *Antenniform movement* (41.60%), *Environmental exploration* (6.11%), *Self-grooming* (2.64%) and *Feeding* (0.76%) (Table 1). Within the *Immobility* category, the most frequently performed behavioral act was *Inside the shelter* (22.08%), and 83.04% of the total were performed by juvenile. In the *Antenniform movement* category the behavioral act *Stand with the abdomen distant from the ground and first pair of legs waving over the body* was the most frequent (31.25%), showing the relevance of the antenniform legs and its sensory structures (Beck et al. 1977, Hebets 2002, Hebets and Chapman 2000, Igelmund 1987), which main functions are: (1) intra-specific signals, (2) navigation,

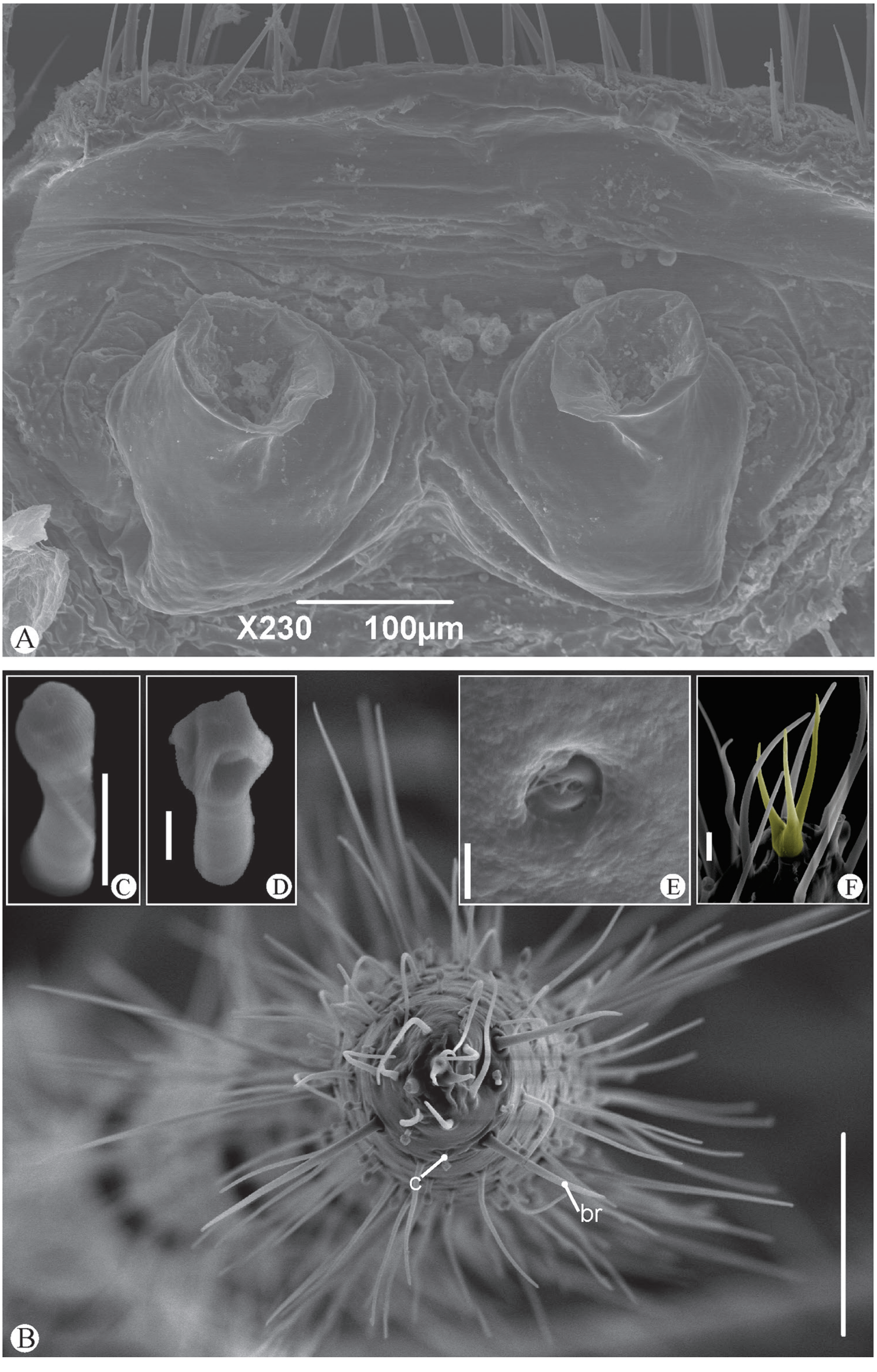


**Figure 3.** *Charinus ruschii* sp. n. female gonopod and detail of leg I (MNRJ9237). **A** Dorsal view of the female gonopod **B** Frontal view of the tip of leg I **C** Detail of sensitive hair type 1 **D** Detail of sensitive hair type 2 **E** Glandular opening close to the tip of the tarsus **F** Modified claw in the tip of the leg. Abbreviations: br: bristle sensilla; c: club sensilla. Scale bars: **B**: 100 um; **C**: 5 um; **D, E**: 2 um; **F**: 10 um.

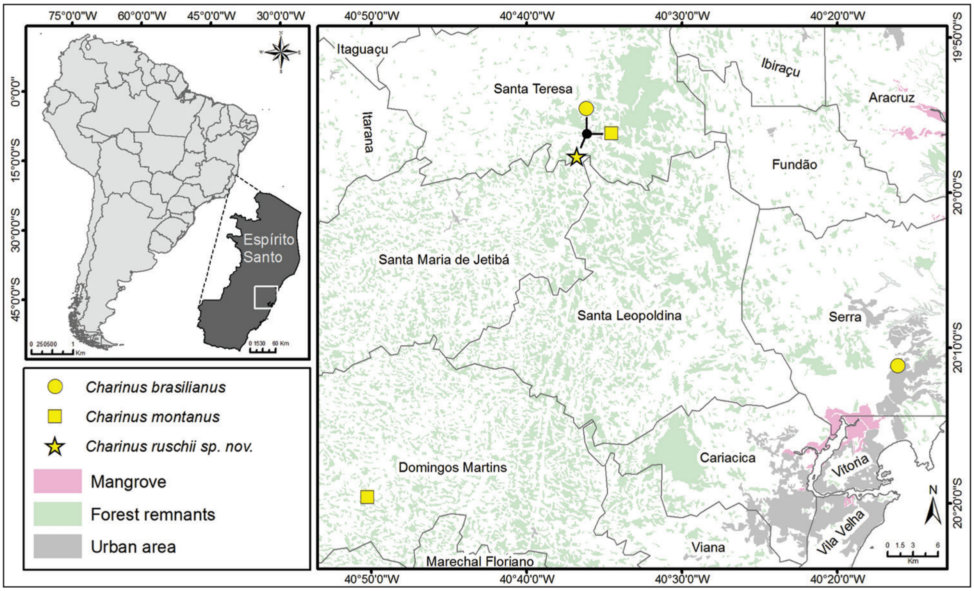


**Figure 4.** Distribution map of *Charinus* in the state of Espírito Santo.

(3) olfactory sensitivity, and (4) foraging. The main act of *Environmental exploration* was *Walking with first pair of legs erect and pointed forward* (2.36%); due to sensorial function, the forward position of the first pair of legs could be related to foraging (Hebets 2002, Weygoldt 2000). Likewise, Pereira et al. (2004) found better significance in environmental exploration categories linked with the use of the second pair of legs in the harvestman *Ilhaia cuspidata* Roewer, 1913, that has sensorial function too. In the *Self-grooming* category, *Cleaning the pedipalps* was the most expressive act (1.32%). Whip spiders in general use their chelicerae and pedipalps for cleaning their appendages (Alexander 1962, Weygoldt 2000); in the tarsus of the pedipalps is present a structure formed by two parallel rows of modified setae that cleans the legs (i.e. cleaning organs or cleaning brush, *sensu* Weygoldt (2000)). Legs with higher percentage of cleaning were the antenniform legs (0.69%), probably related to their sensorial function (i.e. sensilla and trichobothria; Foelix et al. (1975); Fig. 3). Also, Pereira et al. (2004) observed that legs with sensorial structures were the most cleaned in *I. cuspidata*. *Feeding* represented only 0.76% of all behaviors. Specimens of *Psychoda* sp. were always eaten when given to the whip spiders, whereas drosophila and butterflies were found dead after three days of being offered. The motivation of *C. ruschii* to feed on live animals was similar to that of *Damon gracilis* Weygoldt, 1998 (Weygoldt 2000), and different to that of *Heterophrynus batesii* (Butler, 1873) which accept dead animals (Beck and Görke 1974).

Similarly to other whip spiders and other arachnids such as harvestmen, scorpions, spiders, and vinegaroons (e.g., Foelix (1996); Punzo (2000); Elpino-Campos et al. (2001); Pinto-da-Rocha et al. (2002); Mineo et al. (2003)), *C. ruschii* shows highest peaks of immobility during the day than the night, beginning its period of activity (*Environmental exploration*) at dusk (i.e. 18:00 hrs). The *Immobility* behavior was common from 08:00hrs to 14:00 hrs, and *Environmental exploration* was between 22:00hrs and 02:00hrs. Despite of the described patterns of immobility and foraging, some *C. ruschii* specimens were inactive during the night and feed themselves during the day (Fig. 5), which could be explained by the lower or non-incidence of light during the day in the caves where they live. Day activities were also observed in other cave species, such as *C. asturius* and two genera of harvestmen, *Iporangaia* Mello-Leitão, 1935 and *Iguapeia* Mello-Leitão, 1935 (Hoenen and Gnaspini 1999).

## Remaining inside the shelter

In the laboratory experiment, specimens of *C. ruschii* remained outside the shelter during the day, as observed by Pinto-da-Rocha et al. (2002) in *C. asturius*. This is different to observations *in situ* for both *C. ruschii* and *C. asturius*.

In average, each adult (n = 12) spent 4 minutes of their total time inside the shelter (i.e. 1440 minutes), while the mean for juveniles (n = 5) was 13.2 times higher than adults (mean = 52.8 min; test w for separate variance estimates $t = 7.875$, $P < 0.0001$; Fig. 5). Field observations of juvenile *C. montanus* show high rates of recapture in their shelter (i.e. high site fidelity). These data suggest that juveniles probably spend more time inside the shelter and this can be considered a survival strategy, which decreases the chances of being caught during the foraging periods (Chapin and Hebets 2016); the time

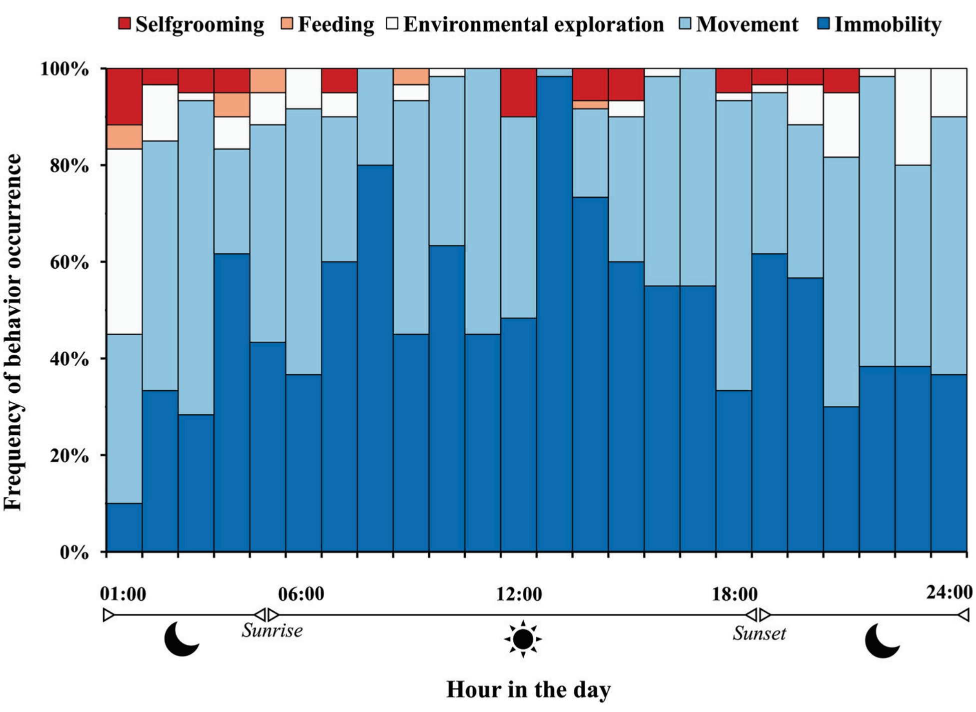


**Figure 5.** Behavioral category frequency for all *Charinus ruschii* sp. n. individuals in 1440 minutes of observation. Sun icon represents the diurnal period and moon icon the dark period.

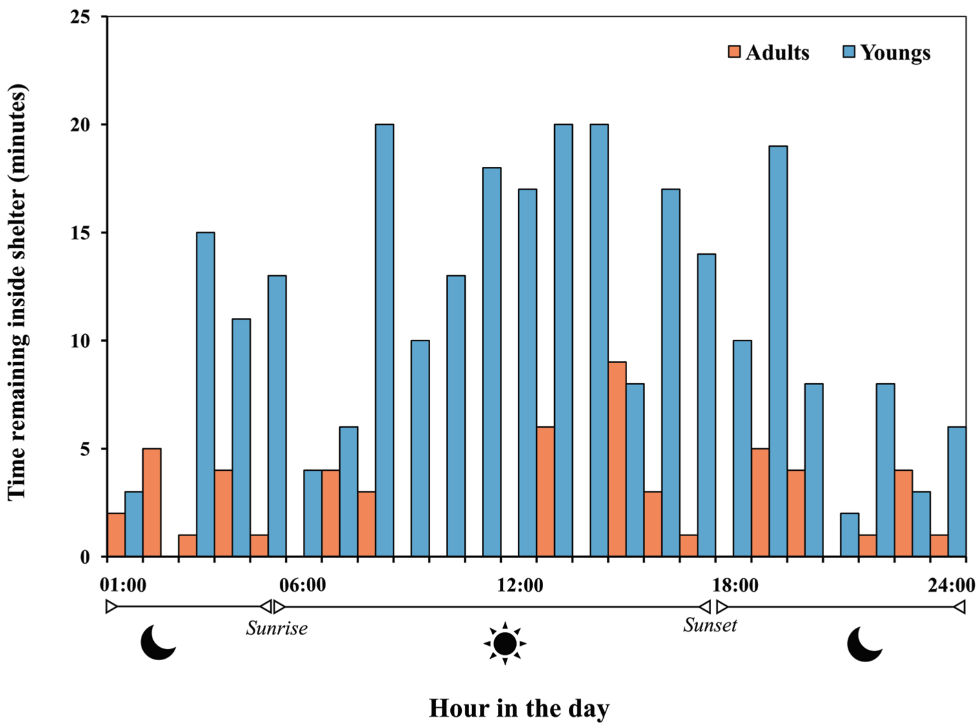


**Figure 6.** Difference between time remaining inside shelters in juveniles (n = 5) and adults (n = 12) amblypygids.

spent foraging is also smaller than those spent by the adults, the juveniles adopt a "sit-and-wait" hunting strategy. Even in the peaks of activity (22:00 hrs and 02:00 hrs; Figs 5 and 6), most juveniles stayed inside the shelter. Salvestrini and Gasnier (2001) studied the differences in activity patterns between juveniles and adults of females and males of the spiders *Ctenus amphora* Mello-Leitão, 1930 and *C. crulsi* Mello-Leitão, 1930, and confirmed that juvenile spiders were significantly more sedentary than adults from both sexes in *C. amphora* and male adults from *C. crulsi*. They suggested that sedentary behavior could be related to a foraging strategy, diet and resource available. Even more, Kreiter and Wise (1996), Schmitt et al. (1990) and Sullivan and Morse (2004) argued that, in general, adult spiders show more activity than juveniles, and that the difference between males and females is related to a sexual behavior in searching for males.

## Discussion

### Taxonomy

*Charinus ruschii* has a sucker-like female gonopod, which associates it with the *C. brasilianus* species group (*sensu* Weygoldt (2005)). The *brasilianus* species group occurs in the eastern part of South America and Oman, and includes *C. asturius*, *C. acaraje*, *C. brasilianus*, *C. bromeliaea* Jocqué and Giupponi, 2012, *C. caatingae* Vasconcelos & Ferreira, 2016, *C. eleonorae*, *C iuiu* Vasconcelos & Ferreira, 2016, *C. jibaossu*, *C. montanus*, *C. mysticus*, *C. potiguar*, *C. taboa* Vasconcelos, Giupponi & Ferreira, 2016, and *C. troglobius* from South America, and *C. dhofarensis* Weygoldt, Pohl & Polak, 2002 from Oman.

*Charinus ruschii* is a rather large species (see Table 2), but not as large as *C. mysticus* and *C. jibaossu*, the two largest species of the group. *Charinus mysticus* and the new species also have three spines on the pedipalp tarsus, trichobothria *bc* closer to *sbf* than to *bf*, and short stalk of the female gonopod. However, *C. mysticus* can be easily distinguished from the new species by the development of the median eyes and tubercle (reduced in *C. mysticus* and well-developed in *C. ruschii*), the shape of the frontal process apex (rhombus in the old species and acute in the new), and the number of teeth on the chelicerae claw (4 in *C. mysticus* and 10 in *C. ruschii*).

*Charinus jibaossu* is quite similar to the new species, despite its larger size, but differences occur in the number of ventral spines on the pedipalpal patella (3 in *C. jibaossu* and 5 in *C. ruschii*), the size of the stalk of the female gonopod (long in *C. jibaossu* and short in *C. ruschii*) and the presence/absence of a constriction close to the apical border of the female gonopod (absent in *C. jibaossu* and present in *C. ruschii*). All specimens of *C. ruschii* have three spines on the pedipalp tarsus, whereas *C. jibaossu* is polymorphic, with one to three spines in this segment of the pedipalp (Vasconcelos et al. 2014).

*Charinus potiguar* is also similar to *C. ruschii*, but the frontal process is shorter, the dorsal pedipalp femur has 3 spines (in contrast to 5), the dorsal patella has 5 spines (in opposition to 6), the ventral patella has 2 spines (while the new species has 5), the pedipalp tarsus has 2 spines (*C. ruschii* has 3), the female has long stalked gonopod with divergent "V" shaped openings, and the proximal tooth of the basal segment of the chelicerae lacks the distal expansion.

The presence of well-developed median eyes and tubercle distinguish *C. ruschii* from *C. eleonorae* (which has reduced median eyes and tubercle) and from *C. troglobious* (which is completely blind). *Charinus eleonorae* also has a uniquely high number of setae on the frontal border of the carapace (ten) while all other species of the group have at most six. *Charinus troglobius* has a distinctively short tritosternum, which does not extend between the pedipalp coxae, a morphology that is quite different from almost all other species of the genus.

The pedipalp spine number is the distinguishing character between *C. ruschii* and *C. bromeliaea*. This species has three dorsal and three ventral spines on the femur, and four dorsal and two ventral patella spines. On the other hand, the femur of *C. ruschii* has five dorsal and five ventral, and the patella has six dorsal and five ventral spines. Moreover, *C. bromeliaea* has two dorsal spines on the pedipalpal tarsus, while *C. ruschii* has three. Similarly, *C. asturius* and *C. acaraje* have fewer spines on the pedipalp compared to *C. ruschii*. *Charinus acaraje* also possesses an extremely reduced frontal process, a character present only in this species.

**Table 2.** Measurements and means sizes (in mm) of the three sympatric species from Santa Teresa (ES, Brazil): *Charinus ruschii* sp. n., *C. brasilianus* and *C. montanus*.

| Species | Sex | Carapace length | Carapace width | Pedipalp femur length | Pedipalp patella length | Pedipalp tibia length | Pedipalp tarsus length | Pedipalp claw length | Femur I | Tibia I | Tarsus I |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. ruschii* sp. n. | F | 3.40 | 4.85 | 2.81 | 2.72 | 1.31 | 2.00 | 0.79 | | | |
| | F | 3.56 | 5.06 | 3.19 | 3.13 | 1.50 | 1.04 | 0.92 | 10.90 | 19.70 | 20.30 |
| | F | 3.50 | 4.90 | 2.80 | 2.68 | 1.36 | 1.00 | 0.83 | 9.23 | 28.70 | 28.20 |
| | F | 3.75 | 5.28 | 3.60 | 3.50 | 1.65 | 1.20 | 1.04 | 11.41 | 18.90 | 20.00 |
| | F | 3.44 | 4.88 | 3.50 | 3.00 | 1.50 | 1.13 | 0.94 | 10.90 | 18.40 | 19.00 |
| | F | 3.40 | 4.70 | 2.90 | 2.75 | 1.40 | 1.00 | 0.80 | 9.10 | 15.50 | 15.90 |
| | F | 3.52 | 5.20 | 3.15 | 3.05 | 1.50 | 1.10 | 0.90 | 10.51 | 17.80 | 18.90 |
| | F | 4.7 | 6.50 | 5.25 | 5.00 | 1.88 | 1.31 | 1.25 | 12.90 | 23.40 | |
| | F | 4.49 | 6.41 | 5.44 | 5.19 | 1.88 | 1.56 | 0.63 | 14.20 | 27.10 | 27.20 |
| **Mean** | | **3.75** | **5.31** | **3.63** | **3.45** | **1.55** | **1.26** | **0.90** | **11.14** | **21.19** | **21.36** |
| *Charinus brasilianus* | F | 3.00 | 4.50 | 2.55 | 2.45 | 1.15 | 0.84 | 0.72 | 6.80 | 10.90 | 11.28 |
| | M | 3.05 | 4.45 | 3.05 | 3.10 | 1.20 | 0.80 | 0.60 | | | |
| | M | 3.68 | 5.28 | 7.50 | 7.50 | 1.60 | 0.88 | 0.90 | 7.95 | | |
| | M | 2.88 | 5.19 | 5.69 | 5.94 | 1.44 | 1.00 | 0.65 | 7.69 | 13.85 | 11.54 |
| | M | 3.44 | 5.52 | 6.67 | 6.79 | 1.80 | 1.10 | 0.80 | 8.97 | 16.54 | 15.64 |
| **Mean of females** | | **3.00** | **4.50** | **2.55** | **2.45** | **1.15** | **0.84** | **0.72** | **6.80** | **10.90** | **11.28** |
| **Mean of males** | | **3.26** | **5.11** | **5.73** | **5.83** | **1.51** | **0.95** | **0.74** | **8.21** | **15.19** | **13.59** |
| *Charinus montanus* | F | 3.00 | 4.81 | 2.35 | 2.50 | 1.20 | 0.75 | 0.75 | 5.94 | 10.64 | 7.31 |
| | F | 2.80 | 4.45 | 2.00 | 2.03 | 1.00 | 0.66 | 0.63 | 5.40 | 10.00 | 7.31 |
| | F | 2.50 | 4.10 | 1.72 | 1.72 | 0.92 | 0.64 | 0.58 | 4.94 | 9.10 | 6.03 |
| | F | 2.05 | 4.00 | 1.75 | 1.63 | 0.97 | 0.60 | 0.60 | 4.81 | 8.46 | 5.77 |
| | F | 2.55 | 4.15 | 1.88 | 1.72 | 0.94 | 0.69 | 0.78 | 4.70 | 9.36 | 6.79 |
| | M | 3.10 | 4.90 | 3.60 | 3.60 | 1.15 | 0.75 | 0.65 | 6.64 | 10.90 | 8.21 |
| | M | 2.94 | 4.50 | 3.25 | 3.25 | 2.19 | 1.81 | 0.63 | 5.64 | 9.62 | |
| | M | 3.30 | 4.95 | 3.85 | **4.10** | 1.20 | 0.80 | 0.75 | 6.28 | 11.54 | |
| | M | 2.95 | 4.65 | 3.56 | 3.75 | 1.94 | 1.25 | 1.06 | 6.00 | 9.62 | 5.77 |
| | M | 2.61 | 4.69 | 2.94 | 2.88 | 1.10 | 0.72 | 0.68 | 5.84 | 9.74 | 7.05 |
| **Mean of females** | | **2.58** | **4.30** | **1.94** | **1.92** | **1.01** | **0.67** | **0.67** | **5.16** | **9.51** | **6.64** |
| **Mean of males** | | **2.98** | **4.74** | **3.44** | **3.52** | **1.52** | **1.07** | **0.75** | **6.08** | **10.28** | **7.01** |

*Charinus montanus* and *C. brasilianus* live in sympatry with *C. ruschii* (Fig. 4), but these species have striking differing characters. *Charinus montanus* is a unusual species due to the presence of clavate setae over most of the body (prosoma, legs and pedipalps), an acute projection in the frontal carapace border (anterior to the median eyes), tarsus I with 28 segments, extremely long first tarsus I segment, flattened and wide sternum platelets, and dark brown body color (even in old museum specimens). *Charinus brasilianus*, on the other hand, has the usual *Charinus* shape, but is also dark brown colored, and the female gonopod has a unique invagination on the frontal side. Moreover, *C. montanus* and *C. brasilianus* have seven teeth in the cheliceral claw, while *C. ruschii* has ten, and the two older species are considerably smaller than the new one (with the exception of the long pedipalps of the sexually dimorphic males of *C. brasilianus*; Table 2).

Regarding the other South American species of *Charinus*, the new species differs from *C. insularis*, *C. koepckei* and *C. vulgaris* by the absence of claws in the female genitalia, a feature present in the latter three species. *Charinus ruschii* is also different from *C. insularis* in the number of ventral spines on the femur (five in the new species and 3–4 in *C. insularis*), the number of articles in the tarsus I (41 in *C. ruschii* and 43 in *C. insularis*) and number of teeth in the cheliceral claw (ten in *C. ruschii* and 6–8 in *C. insularis*). *Charinus koepckei* differs from *C. ruschii* in the presence of the tetra and pentasternum formed by two separate small rounded concave platelets, trichobothria *bc* midway between *bf* and *sbf*, and the cheliceral claw with seven teeth. The Amazonian *C. vulgaris* has fewer spines on the pedipalp (e.g. 2–3 dorsal and three ventral on the femur), lacks the median eyes and tubercle, and has only four teeth on the cheliceral claw.

*Charinus ruschii* has similar appearance to *C. gertschi* Goodnight & Goodnight, 1946, but can be differentiated by the number of spines on dorsal patella (six in the former and five in the latter) and the shape of the sternum (small convex sclerotized platelets, in contrast to broad flatten platelets, respectively).

The four-articled basitibia IV differentiates *Charinus ruschii* from *C. quinteroi* Weygoldt, 2002 and *C. platnicki* (Quintero, 1986), which have just two, and from *C. bordoni* (Ravelo, 1975), *C. camachoi* (González-Sponga, 1998), *C. longitarsus* Armas & Palomino-Cárdenas (2016), *C. pardillalensis* and *C. tronchonii* (Ravelo, 1975), which have three. Besides that, *C. platnicki* has cushion-like gonopods and extremely reduced median eyes and tubercle; *C. tronchonii*, *C. bordoni*, *C. pardillalensis* and *C. camachoi* lack median eyes and tubercle; and *C. longitarsus* have a remarkable long first tarsal segment on leg I, which separates it from *C. ruschii*.

The other *Charinus* of the world can be distinguished by the shape of the female genitalia. The *australianus* species group has cushion-like gonopods, the *bengalensis* species group have finger-like gonopods and the *seychellarum* species do not have a gonopod.

This is one of the first detailed descriptions of leg I of a species of Charinidae. The number and amount of sensory structures is considerably different from that described for Phrynidae (Foelix et al. 1975, Igelmund 1987), but it is rather similar to that of *C. ioanniticus* (Kritscher, 1959), a distant related species (Miranda et al. in press). *Charinus ruschii* has fewer types of hairs and sensory openings than *Heterophrynus elaphus*

Pocock, 1903, which has at least five different sensory structures (bristle sensilla, porous sensilla, club sensilla, rod sensilla, and the pit organ; Igelmund (1987)). *Charinus ruschii* has only two different sense organs: bristle sensilla and club sensilla (Fig. 3B–F). Another difference is the relative size of the claws at the end of tarsus I. *Charinus ruschii* has the lateral claws smaller than the median claw, while species of *Heterophrynus* have the opposite size relation (Foelix et al. (1975); Fig. 3E). The claws lack a subterminal opening, suggesting that in *Charinus* species the claws probably lack a sensory function, different to what is found in Phrynidae (Igelmund 1987).

### Behavior

The observations presented here enforce the "sit-and-wait" hunting strategy pattern within whip spiders (e.g. Alexander (1962), Gray and Robinson (1986), Pinto-da-Rocha et al. (2002), Weygoldt (2000)) and other arachnids (Mineo et al. 2003, Punzo 2000), with a frequent representation of immobility in their activity patterns.

More accurate studies are necessary to a complete understanding of survival tactics in Amblypygi, where comparisons between feeding strategies as well as activity rhythm in juveniles and adult males and females should be accessed. *Charinus ruschii* is currently known only from the type locality, Estação Biológica Santa Lúcia, and dwells in specific microhabitats, which might make them an endangered or vulnerable species in account to indiscriminate anthropic deforestation of the Atlantic Forest. The threat to this environment is of high concern due to the high levels of endemism (Myers et al. 2000).

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RESEARCH ARTICLE

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# The identity of the tropical African *Polichne mukonja* Griffini, 1908 (Orthoptera, Tettigoniidae, Phaneropterinae)

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## Abstract

*Polichne mukonja* Griffini, 1908 from Cameroon was hitherto known only from the holotype preserved at the Royal Belgian Institute of Natural Sciences, Brussels. This was probably due to the fact that the genus *Polichne* Stål, 1874 distributed only in Australia and Papua New Guinea. In view of this distribution, the tropical African species was therefore overlooked in the African literature. The recent discovery of two specimens at the Naturhistorisches Museum, Vienna, now provides us with a better understanding of the identity of this taxon, which is related to the African genus *Catoptropteryx* Karsch, 1890. *Polichne mukonja* is here transferred to a new genus *Griffinipteryx* and both taxa are proposed to be included in the new tribe Catoptropterigini.

## Keywords

Catoptropterigini trib. n., distribution, *Griffinipteryx* gen. n., taxonomy, tropical Africa

## Introduction

Griffini (1908), when describing *Polichne mukonja* from Cameroon (Mukonje Farm), highlighted that it was the first African species from this genus. The genus *Polichne* Stål, 1874 was indeed previously known only from Australia and Papua New Guinea.

However, it seemed very probable that the species described by Griffini belonged to a different genus from *Polichne*, but the detailed description by Griffini (1908), has been forgotten for more than a century. Curiously, Ragge (1968, 1980) also overlooked it, first when he listed all the African Phaneropterinae (1968) and then when revising the African Phaneropterinae with open tympana (1980).

A recent study of the material preserved at the Naturhistorisches Museum of Vienna revealed two specimens, both females (like the holotype). These were probably collected towards the end of 1800s, prior to the description of the species by Griffini (1908). These specimens possess the following characters: slender body, fore coxae armed, open tympana on both sides of fore tibiae, black stripe along the body, and very short ovipositor, similar to that of *Catoptropteryx* Karsch, 1890. They fit very well with the description by Griffini (1908) of *Polichne mukonja*. Jerome Constant (RBINS, Royal Belgian Institute of Natural Sciences, Brussels) kindly provided a photograph of the type specimen; later this was compared with the Vienna specimens and it was possible to establish that they both belonged to the species described by Griffini (1908). However, on the base of its characters, it is now possible to ascertain that the African species *Polichne mukonja* belongs to an entirely new genus to which its description is being presented in this work.

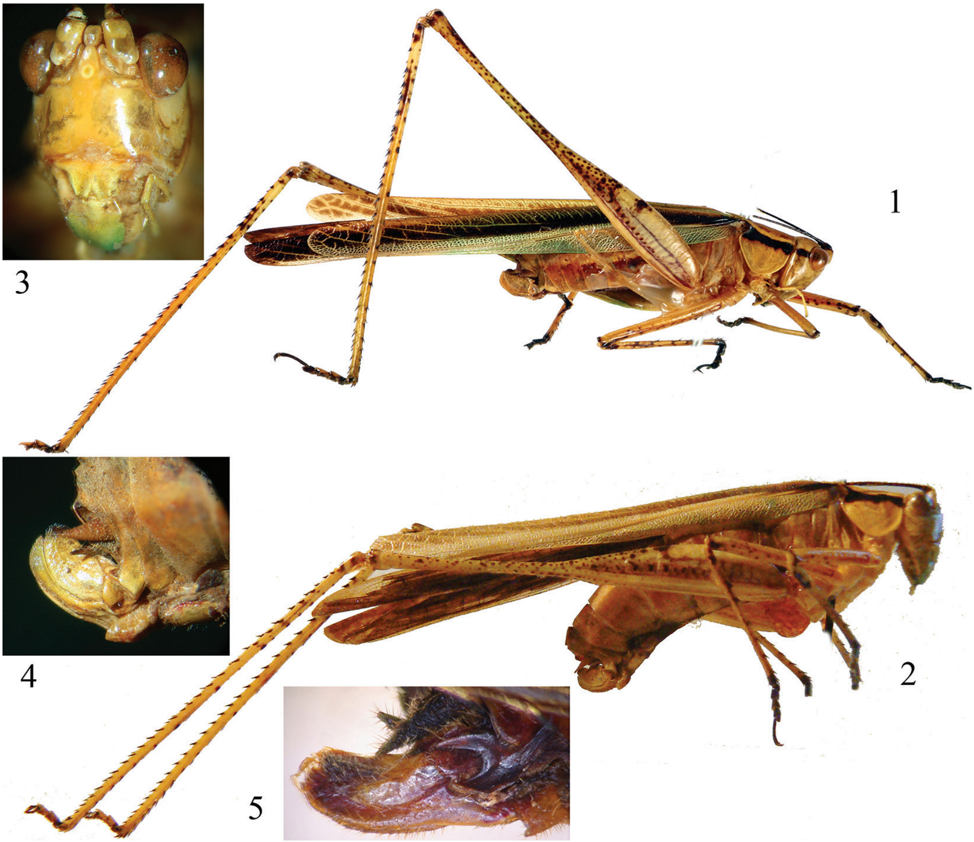
## Material and methods

The material examined (see below) is preserved at the Naturhistorisches Museum of Vienna (NMW). This study of *Polichne mukonja* has been carried out on specimens belonging to genera considered within the Ephippithytae group, particularly in the shape of the pronotum, the face and ovipositor and the presence of spines on the femora. Measurements were taken using a caliper Digimax measy 2000 (precision: 0.01 mm). The following measurements were taken (in mm): Body length: dorsal length from the head to the apex of the abdomen, ovipositor excluded; Pronotum length: length of the pronotum along dorsal median line; Pronotum height: maximum height of the pronotum; Hind femur: length of hind femur; Tegmina: length of tegmina; Ovipositor: maximum length from the subgenital plate to the tip of the ovipositor. Photographs were taken with a Nikon Coolpix 4500 digital camera, mounted on a Wild M5 Stereomicroscope, and photos were integrated using the freeware CombineZP (Hadley 2008).

## Results and discussion

***Griffinipteryx* gen. n.**
http://zoobank.org/BA4B0B72-6445-4E17-9D2C-841C5EA3348B
Figs 1–6

**Type species.** *Griffinipteryx mukonja* (= *Polichne mukonja* Griffini, 1908).




**Figures 1–5. 1** The Holotype of *Polichne mukonja* Griffini, 1908, now included in the new genus *Griffinipteryx* (photo by Jerome Constant, Royal Belgian Institute of Natural Sciences, Brussels) **2** *Griffinipteryx mukonja*, female from Cameroon (Naturhistorisches Museum, Vienna) **3** Face in frontal view of the same **4** Lateral view of the ovipositor of *Griffinipteryx mukonja* **5** Lateral view of the ovipositor of *Catoptropteryx extensipes* Karsch, 1896.

**Diagnosis.** *Griffinipteryx* is characterized by slender body, lateral lobes of pronotum as deep as wide, ovipositor much reduced (Figs 1–4, 6).

**Description.** Head and antennae: fastigium of vertex narrow and pointed, much narrower than the first antennal segment. Eyes round, prominent, face smooth without fronto-genal carinae, higher than wide.

*Thorax*: pronotum just longer than high, with a well-developed humeral excision, lateral lobes are as deep as wide.

*Legs*: long (ratio body length/length hind femur: 0.9), fore coxae armed with a fine spine, fore, mid and hind femora unarmed, fore, mid and hind tibiae with ventral and dorsal spines. Fore tibiae with anterior and posterior open tympana.

*Tegmina* elongated, well developed, shorter than hind wings.

Ovipositor very reduced, crenulated on upper apex.

**Etymology.** *Griffinipteryx* (Griffini + pteryx) is dedicated to the late Achille Griffini (1870–1932), distinguished Italian entomologist, who studied many African collections of Orthoptera and described *Polichne mukonja*; the Greek suffix *pteryx* (wing) is a reminder of the genus *Catoptropteryx*.

**Affinities.** *Catoptropteryx* is certainly the only other African genus related to *Griffinipteryx*. In particular, some *C. punctulata* Karsch, 1890 specimens have a similar colour pattern in the pronotum (Fig. 7), even if the black stripe is absent on the lateral lobes. *Catoptropteryx* may have small spines at the ventral inner margin of fore, mid and hind femora, while *Griffinipteryx* gen. n. has unarmed fore and mid femora (in actual fact a very small spine is present at the base of the ventral inner margin of the fore and on the ventral outer margin of the mid femora). Other differences are also detectable in the shape of the lateral lobes of the pronotum. In *Catoptropteryx* the pronotal lobes are deeper than wide, while in *Griffinipteryx* gen. n. they are as deep as wide (Figs 6–7). Also the length of the hind femora is proportionally longer in *Griffinipteryx* gen. n. than in *Catoptropteryx*. However, the most important character that separates the two genera is the shape of the ovipositor. While in *Catoptropteryx* the ovipositor is very reduced and simplified (cf. Fig. 2 of Huxley 1970), in *Griffinipteryx* gen. n. it is more apically chitinous, mainly in the apical dorsal margin, where it is a somewhat crenulated. In some species of *Catoptropteryx* the dorsal valve may also be crenulated (Huxley 1970), but the ovipositor appears longer with slender infra- and supra-gonangulum, and less chitinous. In *Griffinipteryx* the ovipositor and the subgenital plate are more chitinous and infra- and supra-gonangulum are stout (compare Figs 4 and 5).

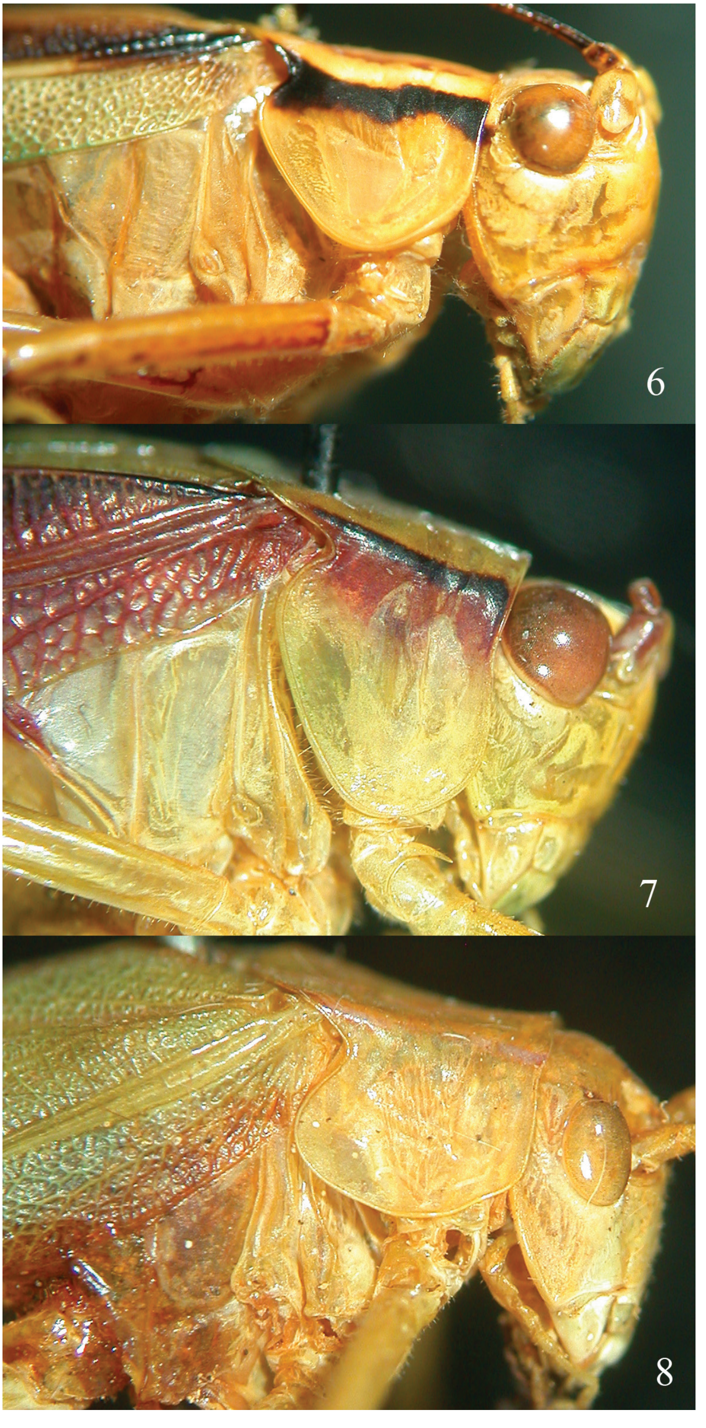
### *Griffinipteryx mukonja* (Griffini, 1908)

**Depository of the type.** Cameroon, Mukonje Farm (♀ holotype) (RBINS, Brussels) (photograph examined by courtesy of Jerome Constant).

**Material examined.** Cameroon, Johann-Albrechtshöhe [near Lake Barombi, ca. 80 km from Mukonje], Rhode (2♀) (coll. Brunner von Wattenwyl, NMW, Vienna).

**General habitus and colour.** Yellow-brownish, a black stripe from behind the eye on the head through the lateral lobes of the pronotum and gradually broadening along the tegmina. Abdomen yellow with some brown spots; legs yellow with many black dots; tympanum with a black anterior margin; fore and mid tarsi black, hind tarsi yellow with a black base.

**Description.** Female. Fastigium of vertex sulcate above; face smooth without fronto-genal carinae, higher than wide. Pronotum without lateral carinae, surface shiny, with a well-developed humeral excision on the lateral lobes. Anterior margin of pronotum straight, posterior margin gently rounded, pronotum lobes rounded on posterior margins. Fore coxae armed with a fine spine; a very small spine is present at the base of the ventral inner margin of fore and of ventral outer margin of the mid femora, hind femora unarmed; fore tibiae with 3 black spines on ventral inner margin, 3 spines + 1 apical spur on ventral outer margin, 1 spine dorsal on fore tibia above tympanum + 1 apical spur;




**Figures 6–8. 6** Lateral view of head and pronotum of *Griffinipteryx mukonja* from Cameroon **7** Lateral view of head and pronotum of *Catoptropteryx punctulata* Karsch, 1890 **8** Lateral view of head and pronotum of *Polichne parvicauda* (Stål, 1861), type species of the genus *Polichne*.

**Table 1.** Measurements of two females of *Griffinipteryx mukonja* (Griffini, 1908); measurements in brackets recorded by Griffini (1908).

| | |
|---|---|
| Body length | 22.7–24.5 (20) |
| Pronotum length | 4.8–4.9 (4.7) |
| Pronotum height | 4.3–4.4 |
| Length of hind femur | 25.8–26.0 (26.5) |
| Tegmina length | 27.5–29.2 (27) |
| Tegmina width | 3.4 (3.7) |
| Length of hind wing | 31.8–33.5 (31.3) |
| Ovipositor | 3.2–3.3 (2.4) |

mid tibiae with 4-5 black spines on ventral inner margin + 1 apical spur, 6 black spines ventral on outer margin + 1 apical spur, 1 dorsal inner black spine + 1 apical spur; hind tibiae with 9-10 black spines ventral on both margins + 2 apical spurs on each side; dorsal margins of hind tibiae with many black and yellow black tipped spines + 1 apical spur on each side. Abdomen: styli pointed, ovipositor very short with crenulated dorsal apex. Subgenital plate triangular and short, as long as wide, apically rounded.

Male: unknown.

**Measurements.** See Table 1.

## Catoptropterigini trib. n.

http://zoobank.org/7A9E56A9-2D0C-41C7-88F1-A6E836D84276

**Type genus.** *Catoptropteryx* Karsch, 1890.

Currently the genus *Catoptropteryx* Karsch, 1890 belongs to the species group Ephippithytae Brunner von Wattenwyl, 1878, together with another eleven genera found in Australia and Papua New Guinea. This group of species is very heterogeneous and probably the sole character that brings them together is the reduction of the female ovipositor, even if its structure is much different in some of them. To include the African genus *Catoptropteryx* in this heterogeneous group of Australasian genera seems like a biogeographical nonsense. As a first step, the comparison of the African species *P. mukonja* described by Griffini (1908) was carried out on the type species *Polichne parvicauda* (Stål, 1861) (♀ from Australia, NMW), originally described as *Phaneroptera*, and the following differences were noticed (Fig. 8): presence of fronto-genal carinae, eyes oval, fastigium sulcate, short ovipositor, but not as reduced as in *mukonja*, pronotum with a deep humeral excision, just longer than high, of different shape compared to *mukonja*. Then, the type species of the genus *Ephippitytha*[1] Serville, 1838 [*E. trigintiduoguttata* (Serville, 1838)] was examined (6 specimens of both sexes from Australia, NMW). It has clear fronto-genal carinae, large spines on both margins of the hind femora, one spine on both apices of fore, mid and hind femur knees, pronotum centrally narrowed, similar to

[1] *Ephippithyta* Brunner von Wattenwyl, 1878 is a synonym.

a saddle, ovipositor much reduced, but slender and pointed. In addition, the ovipositor of the other nine genera in the Ephippithytae group is heterogeneous even if reduced, eyes may be round or elongate and fronto-genal carinae may be both present or absent.

When the first species of *Catoptropteryx* were discovered, they were described within the Australian genus *Caedicia* Stål, 1874 (e.g.: *afra*: Karsch 1888; *apicalis*: Bolívar 1893), also included in the Ephippithytae group. Thus, when Karsch (1890) erected for them the genus *Catoptropteryx* it was considered logical at the time to include this genus in the Ephippithytae group, erected by Brunner von Wattenwyl in 1878. However, also *Caedicia* is evidently different from *Catoptropteryx* (examined 6♂ of the type species of the genus, *Caedicia pictipes* Stål, 1874, and a few specimens of the other six species, *C. marginata* Brunner von Wattenwyl, 1878, *C. concisa* Brunner von Wattenwyl, 1878, *C. septentrionalis* Brunner von Wattenwyl, 1878, *C. simplex* (Walker, 1869), *C. inermis* Brunner von Wattenwyl, 1878, and *C. scalaris* Brunner von Wattenwyl, 1878, all from Australia, NMW, coll. Brunner von Wattenwyl). The characteristics of this genus are: eyes round, small spines on femur knees, presence of spines on lower margins of femora, fronto-genal carinae. While these characters are evident in the type species, they are not always present in other species (e.g.: eyes may be oval, spines in femur knees may be absent). Overall, it may be confirmed that the Ephippithytae group is very heterogeneous and therefore it cannot be considered as a tribe.

Presently, in the light of the revision of the genus *Catoptropteryx* by Huxley (1970) and the discovery of the identity of the African *Polichne mukonja* Griffini, 1908 (now *Griffinipteryx mukonja*), the new tribe Catoptropterigini seems a logical taxonomical consequence.

Characters of the tribe are the following. Fastigium narrower than first antennal segment, furrowed, face smooth without fronto-genal carinae, eyes round, very small spines or unarmed lower margins of fore and mid femora, hind femora with few small spines or unarmed, tegmina longer than wings, ovipositor very reduced.

## Concluding remarks

In 1908 the Italian entomologist Achille Griffini described the katydid *Polichne mukonja* from Cameroon. Incomprehensibly he described this taxon within the Australian genus *Polichne*, which does not show any morphological affinities with it. Only the holotype was known (specimen preserved at the Royal Belgian Institute of Natural Sciences, Brussels), and later on this taxon was no longer cited. When an opportunity arose to study the African material preserved in the Naturhistorisches Museum of Vienna, during a Synthesys project, two other specimens of this taxon were discovered and it was possible to understand its identity. *Polichne mukonja* resulted as belonging to a newly established genus (*Griffinipteryx*) and is rather related to the tropical African genus *Catoptropteryx*, for which the new tribe Catoptropterigini is here proposed. This present work continues to demonstrate that Natural History museums preserve interesting treasures that are still waiting to be discovered.

## Acknowledgements

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# Description of *Rhodnius marabaensis* sp. n. (Hemiptera, Reduviidade, Triatominae) from Pará State, Brazil

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## Abstract

*Rhodnius marabaensis* **sp. n.** was collected on 12 May 2014 in the Murumurú Environmental Reserve in the city of Marabá, Pará State, Brazil. This study was based on previous consultation of morphological descriptions of 19 *Rhodnius* species and compared to the identification key for the genus *Rhodnius*. The examination included specimens from 18 *Rhodnius* species held in the Brazilian National and International Triatomine Taxonomy Reference Laboratory in the Oswaldo Cruz Institute in Rio de Janeiro, Brazil. The morphological characteristics of the head, thorax, abdomen, genitalia, and eggs have been determined. *Rhodnius prolixus* and *R. robustus* were examined in more detail because the BLAST analysis of a cyt-b sequence shows they are closely related to the new species, which also occurs in the northern region of Brazil. The most notable morphological features that distinguish *R. marabaensis* **sp. n.** are the keel-shaped apex of the head, the length of the second segment of the antennae, the shapes of the prosternum, mesosternum and metasternum, the set of spots on the abdomen, the male genitalia, the posterior and ventral surfaces of the external female genitalia, and the morphological characteristics of the eggs. *Rhodnius jacundaensis* Serra, Serra and Von Atzingen (1980) *nomen nudum* specimens deposited at the Maraba Cultural Center Foundation - MCCF were examined and considered as a synonym of *R. marabaensis* **sp. n.**

**Keywords**
Triatominae, *Rhodnius marabaensis* sp. n., new species, Amazon

## Introduction

Vectors of the protozoan *Trypanosoma cruzi*, the etiological agent of Chagas disease, include 151 species distributed into 18 genera belonging to the subfamily Triatominae (Galvão 2014, Mendonça et al. 2016). The genus *Rhodnius* includes 19 species (Alevi et al. 2015), of which six were described after the publication of the Lent and Wygodzinsky review (1979): *R. stali* Lent, Jurberg & Galvão, 1993; *R. colombiensis* Mejia, Galvão & Jurberg, 1999; *R. milesi* (Carcavallo, Rocha, Galvão & Jurberg, 2001); *R. zeledoni* Jurberg, Rocha & Galvão, 2009; *R. montenegrensis* Rosa et al., 2012, and *R. barretti* Abad-Franch, Palomeque & Monteiro, 2013. *R. amazonicus* Almeida, Santos & Sposina, 1973 was synonymized with *R. pictipes* by Lent and Wygodzinsky (1979) according a photograph of the holotype, but subsequently it was validated by Bérenger and Pluot-Sigwalt (2002) by morphological study of 19 characters with of the two species.

Among the *Rhodnius* species, only nine are found in the northern region of Brazil: *R. amazonicus*, *R. brethesi*, *R. milesi*, *R. montenegrensis*, *R. neglectus*, *R. paraensis*, *R. pictipes*, *R. robustus*, and *R. stali* (Galvão 2014, Meneguetti et al. 2015).

In May 2014, two *Rhodnius* spp. specimens were collected in Marabá, Pará, Brazil, and compared to the key described by Lent and Wygodzinsky (1979), as well as to previously described *Rhodnius* species, without success. These samples were compared and identified as the same species as *Rhodnius jacundaensis* Serra, Serra & Von Atzingen, 1980 which had been deposited at the Marabá Cultural Center in Pará. *Rhodnius jacundaensis* was mentioned in an abstract presented at the Fourth Annual Brazilian Parasitology Conference in Rio de Janeiro in 1980. According to Article 9 of the International Code of Zoological Nomenclature, however, this new species was not confirmed. As a result, Carcavallo et al. (1998) and Galvão et al. (2003) considered it to be *R. jacundaensis* Serra, Serra & Von Atzingen, 1980) *nomen nudum*. This article describes *Rhodnius marabaensis* sp. n. as the tenth species found in northern Brazil and the twentieth member of this genus (Abad Franch et al. 2013, Galvão 2014, Meneguetti et al. 2014, Alevi et al. 2015).

## Materials and methods

### Morphological identification and description

The specific description was based on the observation of two adult specimens (one female and one male) collected in a residence in the Murumuru Environmental Reserve in the city of Marabá, Pará, Brazil (coordinates: 10°10'05.1"S and 63°24'09.1"W)


**Figure 1.** Localization of Marabá- PA where *R. marabaensis* sp. n. specimens were collected (05°21'54"S, 49°07'24"W).

(Fig. 1). The description included 14 males and 14 females deposited at the MCCF and previously characterized as *R. jacundaensis* [*nomen nudum*].

The identification of samples was performed using the dichotomous key by Lent and Wygodzinsky (1979). The study also considered descriptions of *R. amazonicus*, *R. stali*, *R. colombiensis*, *R. milesi*, *R. zeledoni*, *R. montenegrensis*, and *R. barretti* (Almeida et al. 1973, Lent et al. 1999, Mejia et al. 1999, Valente et al. 2001, Jurberg et al. 2009, Rosa et al. 2012, Abad-Franch et al. 2013). *Rhodnius marabaensis* was also compared to specimens of 18 *Rhodnius* species held at the Brazilian National and International Triatomine Taxonomy Reference Laboratory at the Oswaldo Cruz Institute in Rio de Janeiro, Brazil. The only species that was compared only by description was *R. amazonicus*, which is held at the Brazilian National Institute of Amazon Research (INPA).

## Genetic identification

After the identification, the mitochondrial gene fragment cytochrome b (cyt-b) was amplified by using suggested primers by Monteiro et al. (2003). The amplified fragments were purified and sequenced in duplicate (forward and reverse). The same haplotype was shown with 693 base pairs (bp). This sequence was evaluated by BLAST (http://www.blast.ncbi.nlm.nih.gov/Blast.cgi) to diagnose the homologous sequences in GenBank. In view of this and of the fact that all three species occur in Northern Brazil (Galvão et al. 2003, Galvão 2014), *R. robustus* and *R. prolixus* were morphologically examined and compared in more detail.

## Morphological study

For the comparative morphological study, *R. prolixus* specimens from Araraquara Triatominae Colony (CTA) 074 were used, as were *R. robustus* specimens from CTA085. The specimens were kept in these colonies at the Triatominae Insectarium at the School of Pharmaceutical Sciences of São Paulo State University (UNESP), Araraquara, São Paulo, Brazil. The *R. prolixus* colony had been originally collected in a sylvatic environment in Venezuela on 23 May 1983. The *R. robustus* colony has been maintained since February 1972 using specimens from Peru (Fig. 2).

Optical microscopy and scanning electron microscopy (SEM) were used to compare the morphology of *R. marabaensis* sp. n., *R. prolixus*, and *R. robustus.* The head, the ventral portion of the thorax, the scutellum, and the pygophore were studied using SEM (Figs 3–6, 8). A female of *R. marabaensis* sp. n. that had been collected in May 2014 was used to study the female genitalia, and 13 eggs obtained from its uterus were also analyzed by SEM (Figs 9–13).

## Morphometric study

A Leica MZ APO stereoscope and the Motic Images Advanced System version 3.2 were used for the measurements, as well as for the study of *R. marabaensis* sp. n. male genitalia. For the comparative study of the male genitalia of *R. marabaensis* sp. n. and *R. prolixus* and *R. robustus*, the descriptions by Lent and Jurberg (1969) and by Rosa et al. (2012) were used.

The following parameters of both females (15) and males (15) were measured: total length (TL); head length (HL); the length of the four antennal segments ($A_1$, $A_2$, $A_3$, and $A_4$); the three segments of the proboscis ($R_1$, $R_2$, and $R_3$); the inner distance between the eyes (IE); the outer distance between the eyes (OE); the diameter of the eyes (DE); the maximum width of the abdomen (MWA); the maximum width of the thorax (MWT); and the length, width, and diameter of the opercular opening of the eggs (Lent and Wygodzinsky 1979, Dujardin et al. 1999, Rosa et al. 2000).

## Taxonomy

**Family Reduviidae Latreille, 1807**
**Subfamily Triatominae Jeannel, 1919**
**Genus *Rhodnius* Stål, 1859**

***Rhodnius marabaensis* sp. n.**
http://zoobank.org/883B9B62-9E78-4AFF-9518-021593A308A4

**Holotype ♂. BRAZIL: Pará**: Marabá: Reserva Ambiental Murumurú, 10°10'05.1"S, 63°24'09.1"W, 12 May 2014, N. C. B. Von Atzingen, M. B. Furtado, UNESP.

**Paratypes.** 1 ♀: same data as holotype (UNESP). 14 ♀, 14 ♂ **BRAZIL:** Pará: Jacundá/Jatobal/Marabá,N.C.B. Von Atzingen, Maraba Cultural Center Foundation – MCCF.

**Synonym.** *Rhodnius jacundaensis* Serra, Serra and Von Atzingen (1980) [*nomen nudum*].

**Etymology.** The name *Rhodnius marabaensis* was chosen because this species was found in the city of Marabá, Pará, Brazil.

**Diagnosis.** The most notable morphological features that distinguish *R. marabaensis* sp. n. are the keel-shaped apex of the head, this feature is not accentuated in *R. prolixus* or *R. robustus* ; the second antennal segment of *R. marabaensis* sp. n. is 10.3 times larger than the first; in *R. prolixus*, it is 6.2 times larger, and in *R. robustus* it is 8.3 times larger. The prosternum has a longer and more clearly shaped stridulatory sulcus relative to those of *R. prolixus* and *R. robustus*. In *R. marabaensis* sp. n. the transverse carinae that border the mesosternum and the metasternum are elevated and prominent, and possess convex curvature in the central portion. In *R. prolixus*, they are less elevated and prominent, and in *R. robustus* they are interrupted in the central portion. The set of dark brown spots presents in the ventral abdomen of *R. marabaensis* sp. n. does not appear in *R. prolixus* or *R. robustus*. The ventral connective is also distinct among the three species: the black spots are smaller and, on the sixth segment, much smaller in *R. marabaensis* sp. n. The apex of the endosoma of male genitalia of *R. marabaensis* sp. n. was found to be long and straight, in *R. prolixus*, the apex is long and convex, and in *R. robustus* it is shorter, wide, and convex. The posterior surface and the ventral surface of the ninth and tenth segments of external female genitalia are distinct in the three species. *R. marabaensis* sp. n. eggs possess chorion rims, whereas those of *R. prolixus* and *R. robustus* do not (Figs 1, 3, 5, 6, 7, 10, 11, 12, 13).

**Description.** Measurements of 15 females and 15 males of *R. marabaensis* sp. n., *R. prolixus,* and *R. robustus* are detailed in the Table 1.

Head with apex (central longitudinal dorsal portion), which is elevated, straw yellow, and keel shaped. This keel-shaped section presents the same shape from the beginning of the clypeus to the posterior portion of the ocelli; thus, the border of the clypeus is visible around/from the gena and the jugum (1+1), which are located laterally. However, the gena begin before the beginning of the clypeus. Thus, the gena go toward the anteclypeus which are rounded. The species presents crystalline ocelli and eyes with black and yel-

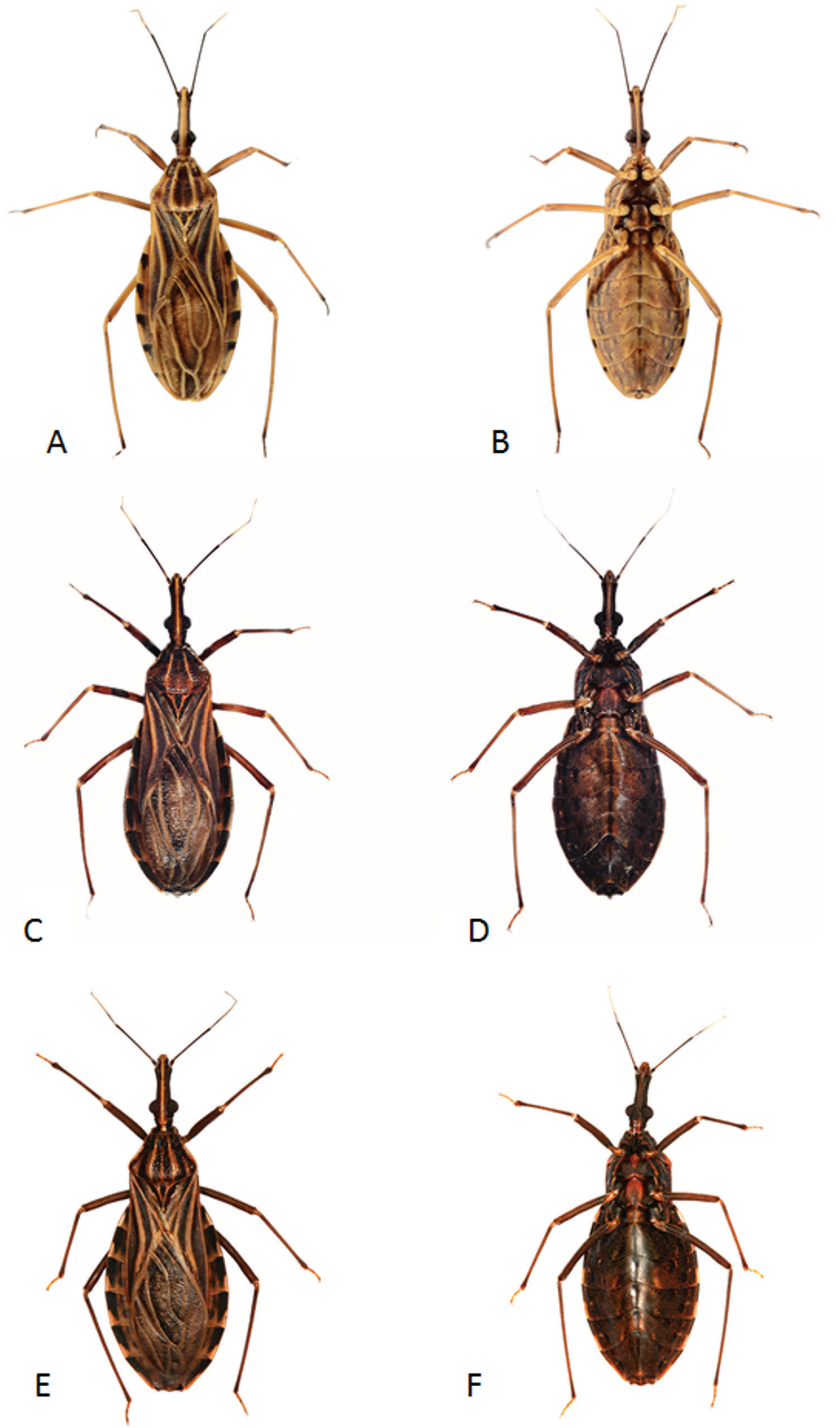


**Figure 2.** *R. marabaensis* sp. n. female (**A** dorsal side **B** ventral side); *R. prolixus* female (**C** dorsal side **D** ventral side); *R. robustus* female (**E** dorsal side **F** ventral side).

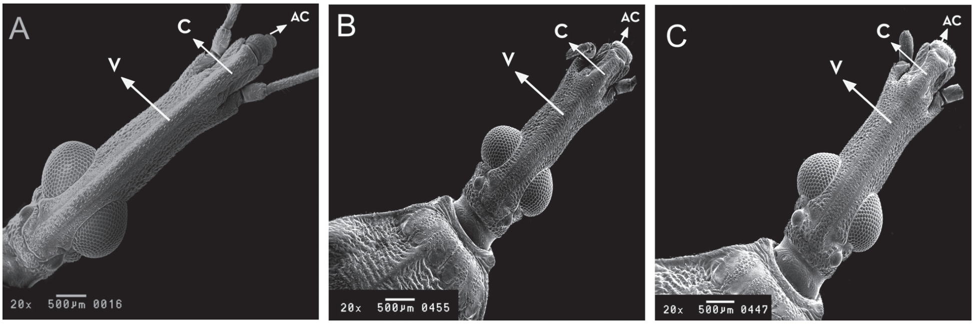


**Figure 3.** Head of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). V: vertice; C: clypeus; AC: anteclypeus.

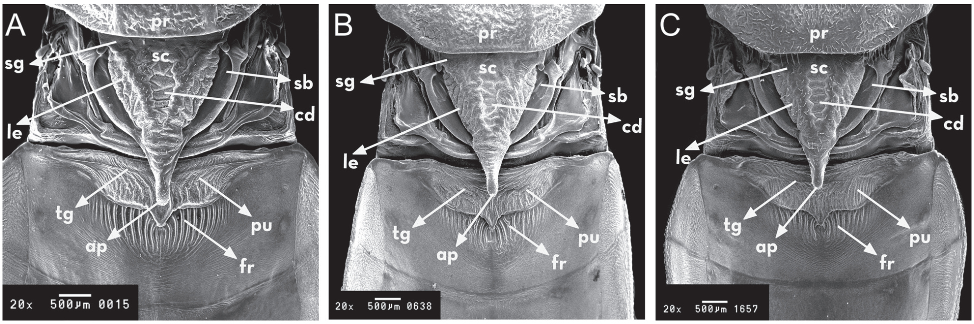


**Figure 4.** Escutellum and process of I urotergit of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). pr: pronotum; sc: escutelum; sb: semi- circular base; sg: glabrous space; cd: central depression; le: lateral edge; ap: apex of escutelum; pu: process of I urotergit; tg: transverse groove; fr: fringe.

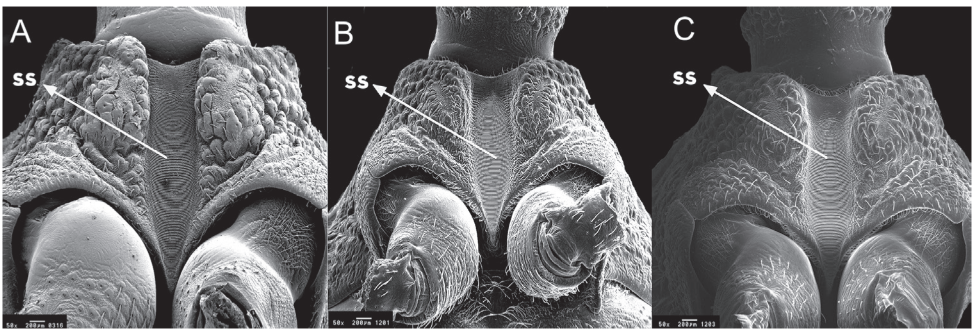


**Figure 5.** Thorax ventral of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). SS: Stridulatory sulcus.

low ommatidia. The first and second segments of the antennae are yellow, whereas the posterior two thirds of the third segment are white, and the fourth segment is completely white. The species presents a second antennal segment that is significantly larger than the others (10.3 times larger than the first; 1.65 times larger than the third, and 4.3 times larger than the fourth) (Table 1).

**Table 1.** Mean of measurement (mm) of 15 females and males of *R. marabaensis* sp. n., *R. prolixus*, and *R. robustus*.

| | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | ***R. marabaensis*** | ***R. prolixus*** | ***R. robustus*** | ***R. marabaensis*** | ***R. prolixus*** | ***R. robustus*** |
| HL | **4.90** a | 3.87 b | 3.82 c | **5.32** a | 3.90 b | 4.06 c |
| IE | 0.62 a | 0.53 b | 0.64 a | 0.59 a | 0.56 b | 0.67 c |
| AO | 2.21 a | 2.05 b | 2.23 c | 3.04 a | 2.26 b | 2.38 c |
| PO | 0.98 a | 0.92 b | 0.72 c | 1.06 a | 0.77 b | 0.78 c |
| DE | 1.72 a | 1.94 b | 1.00 c | 1.91 a | 1.68 b | 1.64 c |
| R1 | 0.97 a | 0.55 b | 0.91 c | 0.93 a | 0.57 b | 0.97 c |
| R2 | **3.87** a | 3.25 b | 3.02 c | **3.77** a | 3.32 b | 3.30 c |
| R3 | 0.87 a | 0.33 b | 0.92 c | 0.77 a | 0.39 b | 0.96 c |
| TL | **20.41** a | 19.98 b | 20.20 c | **22.35** a | 20.98 b | 21.28 c |
| MWT | 4.25 a | 4.62 b | 4.06 c | 4.88 a | 4.82 b | 4.12 c |
| MWA | **6.22** a | 5.93 b | 6.03 c | **6.92** a | 6.75 b | 6.56 c |
| A1 | 0.48 a | 0.38 b | 0.37 c | 0.45 a | 0.37 b | 0.38 c |
| A2 | **4.72** a | 3.04 b | 3.28 c | **4.47** a | 2.88 b | 3.18 c |
| A3 | 2.68 a | 2.25 b | 2.32 c | 3.05 a | 1.94 b | 2.41 c |
| A4 | 1.05 a | 0.98 b | 1.54 c | 1.15 a | 0.94 b | 1.64 c |

HL: head length; IE: inner distance between eyes; AO: anteocular distance; PO: postocular distance (excluding neck); DE: diameter of the eye; R1, R2 and R3: lengths of first, second and third rostral; TL: total length of the triatomine; MWT: maximum width of the thorax; MWA: maximum width of the abdomen; A1, A2, A3 and A4: 1st, 2st, 3st, e 4st antennal segments, respectively; a,b,c: Lower case letters indicate significant differences between specimens with Tukey's test: p < 0,05. Values in bold indicate the main findings.

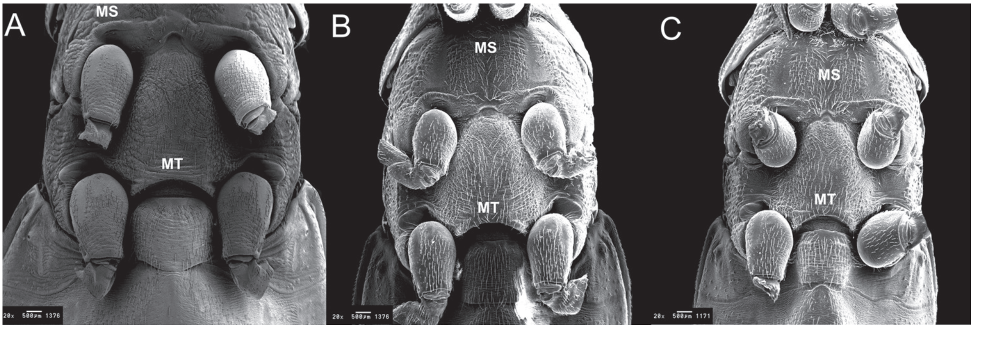


**Figure 6.** Thorax ventral of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). ms: mesosternum; mt: metasternum.

At the juncture between the neck and the thorax, there is a ring that is anteriorly black and posteriorly yellow; the anterolateral angles (1+1) are yellow. The dorsal thorax (pronotum) is shaped like a trapezoid and surrounded by a yellow carina. There are two yellow submedian carinae running lengthwise around the pronotum, from the anterior portion to the posterior one. The submedian carina border three anterior

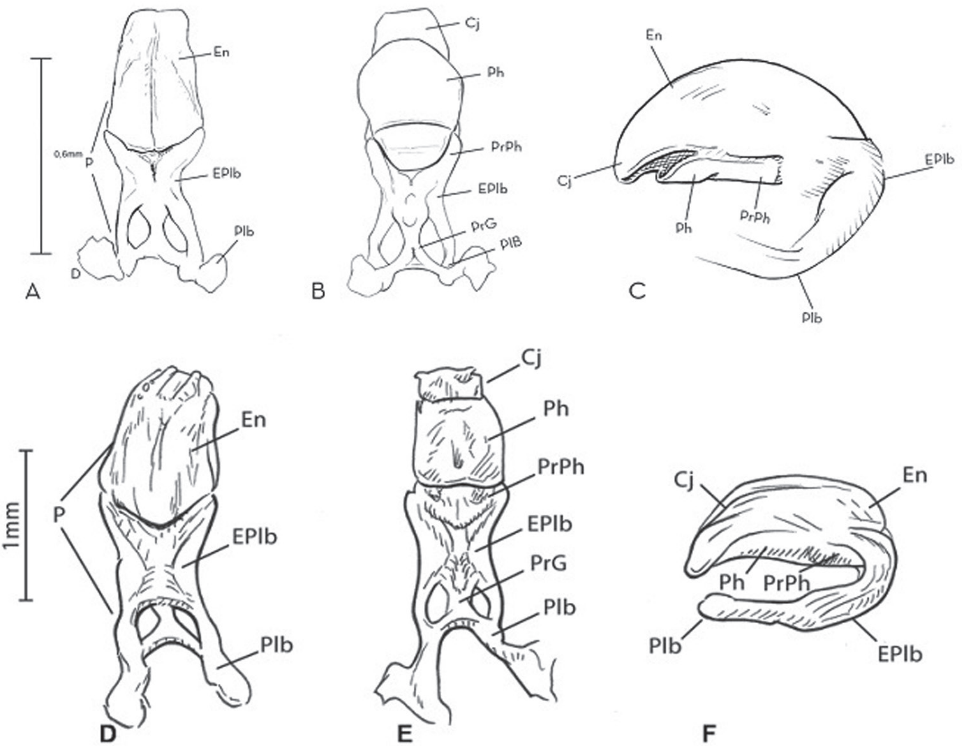


**Figure 7.** Phallus of *R. marabaensis* sp. n. (**A** dorsal view **B** ventral view **C** lateral view) and *R. robustus* (**D** dorsal view **E** ventral view **F** lateral view). Cj: conjunctive; En: endosome; EPlb; median extencion of basal plate; P: phallus; Plb: basal plate; PrG: gonopore process; PrPh: phallossoma process; Ph: phallosoma.

lobes, each of which has a set of black spots, and three posterior lobes with two parallel black stripes on each that are connected to the set of black spots on the anterior lobes. The triangular scutellum is marked laterally and is very clear because of its black color. The internal portion is also triangular and yellow, and it is bordered by thick and obvious carina. When the wings are removed, the posterior portion (tip) of the scutellum covers 2/3 of the I urotergite process (Figs 4, 5).

From the ventral surface of the thorax, a prosternum with deep, well-defined stridulatory black sulcus is visible; in the posterior portion, it takes on a funnel shape and ends as a tip between the anterior pair of legs (Fig. 5). The mesosternum has two elevated black areas that are separated by a yellow depression. The border between the mesosternum and the metasternum is formed by a set of three elevated and prominent carinae. The two lateral carinae are black, and the central carina is yellow. These three carinae are curved backward. The central carina, which is elevated and prominent, possesses a semicircular depression in the central portion at the border with the metasternum. The metasternum is slightly rectangular in shape. The central portion is black and outlined by two yellow carinae (Fig. 6).

The legs have an overall yellowish tone. The coxae have yellow and black spots; the trochanters are yellow and do not have spots; the femurs are yellow with black spots running lengthwise; the tibias are yellow except for the posterior sixth segment, which continues the black pattern of the tarsi (Fig. 2).

The ventral surface of the abdomen is predominantly yellow, with three sets of black stripes: one on the central longitudinal portion and (2+2) on the side portions above the connectives (Fig. 2). The first abdominal segment has a longitudinal black spot between the two larger yellow spots. The second, third, fourth, and fifth ventral abdominal segments possess (1+1) curved sets of dark brown spots. These spots begin at the anterior dividing line and extend diagonally along the central portion of the segments (Fig. 2). The dorsal connective includes yellow and black spots that cover half of each segment. They are wide in the anterior portion and become thinner in the inner posterior portion. The black spot of the connective of the sixth segment is smaller than those of the fifth, fourth, third, and second segments (Fig. 2). The first tergite, which is visible when the wings are removed, is essentially formed by two parts. The anterior portion has a striated cuticula that contrasts with the surrounding smooth cuticula and which is triangular in shape on its upper level. It possesses a clearly defined transverse sulcus. The second portion is posterior to the first and is at a lower level. It consists of a set of transverse and straight fringes (Fig. 5).

When the male genitalia is seen from the dorsal surface, it is clear that the phallus (P) is formed by an endosoma (En), by the median extension of the basal plate (EPlb), and by the basal piece itself (Plb). When seen from the ventral surface, the phallus (P) is formed by the conjunctiva (Cj), the phallosoma (ph), the phallosoma process (PrPh), the median extension of the basal piece (EPlb), the gonopore process (PrG), and the basal piece (Plb). When seen from the lateral surface, the phallus is formed by the conjunctiva (Cj), the endosoma (En), the median extension of the basal piece (EPlb), the basal piece itself (Plb), the phallosoma (Ph), and the phallosoma process (PrPh) (Fig. 8).

The dorsal surface of the external female genitalia was examined using scanning electron microscopy (SEM), which showed that the seventh segment is separated from the eighth segment by a slightly irregular line and forms (1+1) triangular tips at the border between the connective and the eighth segment. The eighth segment is trapezoid shaped. The ninth segment appears as a protrusion. The tenth segment appears as a small curve in the central portion where it delimits with the eighth segment (Fig. 9)

From the posterior surface, (1+1) appendages can be seen on the border between the eighth and ninth segments. The tenth segment is semicircular in shape with a pronounced central slit in the shape of an upside-down V and with (1+1) protrusions at the posterior edge of the gonocoxite 8. Display is also a (1+1) gonocoxite 8 and a (1+1) gonapophysis 8 (Fig. 10).

From the ventral surface, the lateral portions of the line that divides the seventh segment and the gonocoxites 8 and the gonapophysis 8 are curved, and the line then forms small (1+1) ascending curves and a slight depression in the central portion. The ninth segment forms (1+1) lateral flaps at the border with the tenth segment and presents transverse slits at the sub-intermediate position (1+1). The transverse slits then

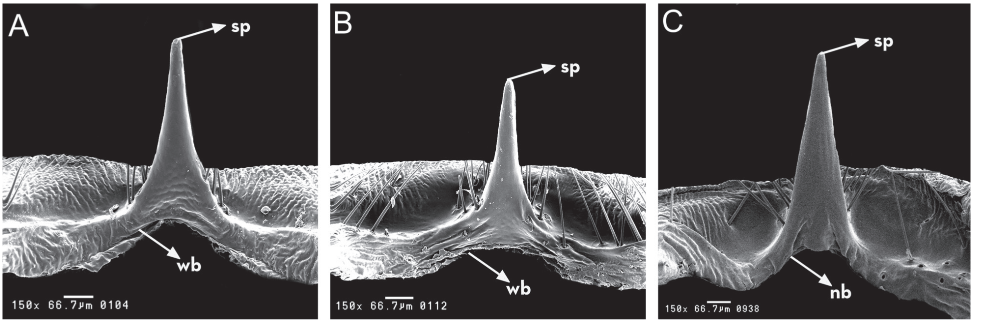


**Figure 8.** Median process of the pygophore of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). gp: gross point: nb: narrow triangular base; sp: slender point; wb: wide triangular base.

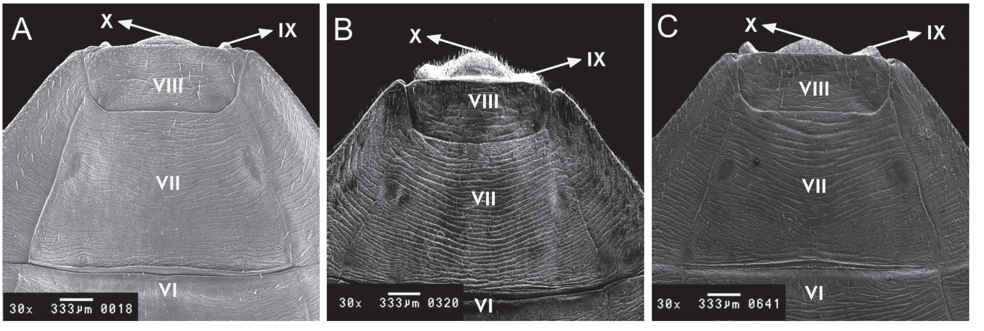


**Figure 9.** Female external genitalia, dorsal side of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). VI, VII, VIII, IX, X, tergites.

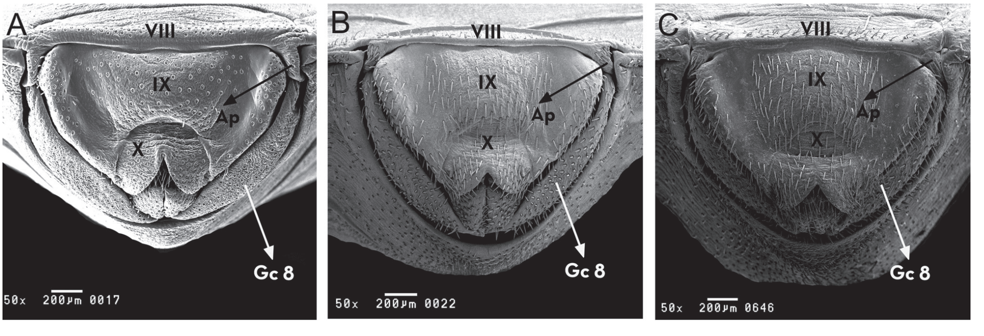


**Figure 10.** Female external genitalia, posterior side of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). Ap: appendices; Gc 8: gonocoxite VIII; Gp 8: gonaphofyse VIII; VII, VIII, IX: tergites; X: segment.

form into two triangles, whose tips are separated in the central portion. The tenth segment is the outer edge of the external female genitalia and is presented as a narrow curved and convex band (Fig. 11).

The egg shells measure 1.59 mm in length and 0.71 mm in width. They present prominent collar and chorial rim (Fig. 12 and Table 2). The exochorion cells are clear-

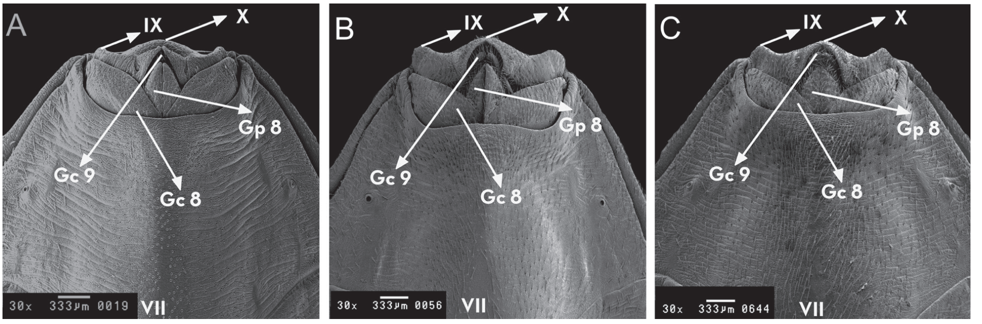


**Figure 11.** Female external genitalia, ventral side of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). Gc 8: gonocoxite VIII; Gc 9: gonocoxite IX; Gp 8: gonapofhyse VIII; VII, IX: esternites; X: segment.

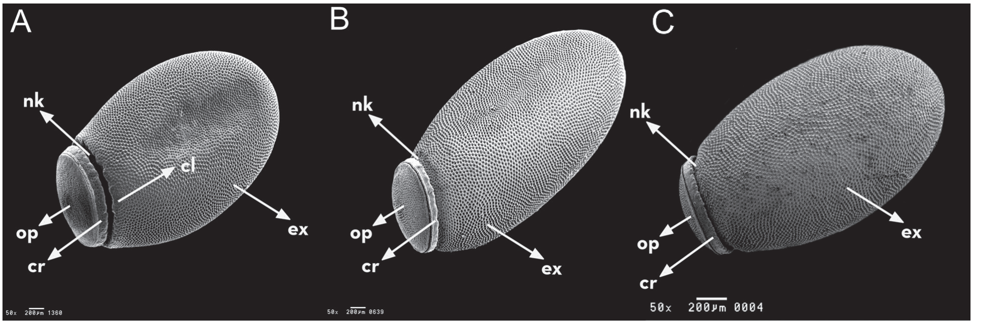


**Figure 12.** Eggs general vision of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). cl: colar; cr: chorial rim; ex: exochorium; nk: neck; op: operculum.

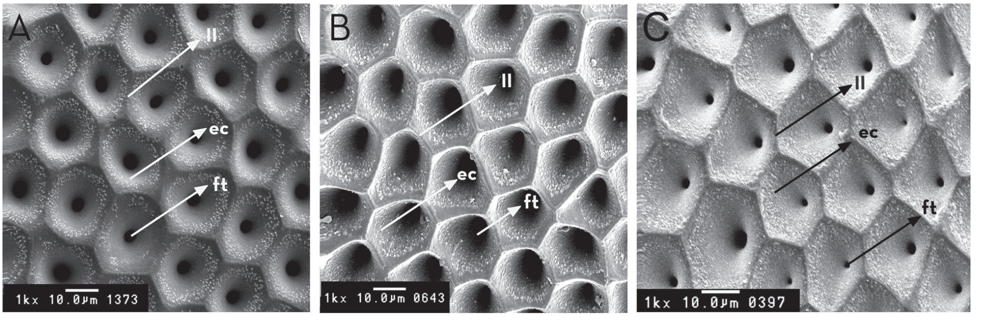


**Figure 13.** Egg exochorium detail of *R. marabaensis* sp. n. (**A**), *R. prolixus* (**B**), *R. robustus* (**C**). ec: exochorium cell; ft: follicular tubes; ll: limiting line.

**Table 2.** Mean of measurements (mm) of 13 eggs of *R. marabaensis* sp. n., *R. prolixus*, and *R. robustus*.

| Measurement | *R. marabaensis* | *R. prolixus* | *R. robustus* |
|---|---|---|---|
| L (mm) | 1.54 ± 0.04 [a] | 1.73 ± 0.02 [b] | 1.61 ± 0.04 [c] |
| W (mm) | 0.87 ± 0.01 [a] | 0.71 ± 0.06 [b] | 0.93 ± 0.01 [c] |
| Oo (mm) | 0.49 ± 0.01 [a] | 0.67 ± 0.01 [b] | 0.73 ± 0.01 [c] |

L: length (40×); L: width (40×); Oo: opening of operculum (80×); a,b,c: Lower case letters indicate significant differences between specimens with Tukey's test: $p < 0,05$.

ly demarcated, with internal granulations organized into a circle. The follicular tubes of each exochorion cell do not differ in diameter (Fig. 13).

The molecular study shown the same haplotype for the find sequences of the cyt-b (693 bp) and the evaluation by BLAST have shown that *R. marabaensis* sp. n. is closely related to *R. robustus* and *R. prolixus* (until 99% and 94% of identity, respectively).

## Discussion

In epidemiological terms (i.e., considering the role of the species as vectors of *T. cruzi*), the three main Triatominae genera are *Panstrongylus*, *Rhodnius*, and *Triatoma*. Distinguishing among these three genera is not difficult because they can be characterized macroscopically based on the format of the head and the position of the antenniferous tubercle, as described by Pinto (1931). However, distinguishing among *Rhodnius* species requires a more detailed examination through optical microscopy. The difficulty in identifying *Rhodnius* species was first noted by Neiva and Pinto (1923). At the time, there were five known species: *R. nasutus*, *R. prolixus*, *R. pictipes*, *R. brethesi*, and *R. domesticus* (Lent and Wygodzinsky 1979). Including this description of *R. marabaensis* sp. n., there are currently 20 species (Rosa et al 2012, Abad Franch 2013); therefore, specific distinction is even more difficult and requires more characteristics to be considered. As a result, the characterization of *R. marabaensis* sp. n. is discussed comparatively using *R. prolixus* and *R. robustus*. *R. marabaensis* is closely related to *R. robustus* and *R. prolixus* (until 99% and 94% of identity, respectively). In view of this and of the fact that all three species occur in Northern Brazil (Galvão 2014), *R. robustus* and *R. prolixus* were morphologically examined and compared in more detail (Table 3).

*Rhodnius marabaensis* sp. n. is predominantly yellow, whereas *R. prolixus* is black and *R. robustus* is brown. The legs of the three species are also consistent in these color schemes (Fig. 2). Another very clear characteristic of *R. marabaensis* sp. n. is that it is larger than *R. prolixus* and *R. robustus* (Figs 3–5 and Table 1).

The head of *R. marabaensis* sp. n. has four very clear characteristics that help to distinguish it from the others:

1) It possesses a keel-shaped longitudinal dorsal portion (apex) running from the clypeus to the ocelli. This feature is not accentuated in *R. prolixus* or *R. robustus* (Fig. 3);
2) It possesses a rounded anteclypeus. In *R. prolixus* and *R. robustus*, the anteclypeus is flat (Fig. 3);
3) It possesses an indistinguishable clypeus. In *R. prolixus*, it is narrow in the anterior portion and wide in the posterior one. In *R. robustus* it is wide in the anterior portion, narrow in the medial portion, and wide in the posterior one (Fig. 3);
4) The second segment of the antenna is significantly larger than the other three, with the following length ratio among the four antennal segments: 2nd > 3rd > 4th > 1st. This relative length pattern of the four antennal segments is the same as the pattern observed by Rosa et al. (2010) in *R. neglectus* and *R. prolixus* adults; however, the

**Table 3.** Triatominae species found in the Amazon region.

| Species | Descriptors | Distribution | References |
|---|---|---|---|
| *R. amazonicus* | Almeida, Santos & Sposina, 1973 | Brazil (Amazonas), French Guiana (Cacao, Saul) | Galvão 2014 |
| *R. barretti* | Abad-Franch, Palomeque & Monteiro, 2013 | Colombia (Puerto de Assís), Ecuador (Lagro Ágrio) | Abad-Franch et al. 2013 |
| *R. brethesi* | Matta, 1919 | Brazil (Amazonas), Venezuela (Aragua) | Galvão 2014 |
| *R. colombiensis* | Mejia, Galvão, Jurberg, 2009 | Colombia (Tolima) | Guhl et al. 2007 |
| *R. dalessandroi* | Carcavallo & Barreto, 1976 | Colombia (Meta) | Guhl et al. 2007 |
| *R. ecuadoriensis* | Lent & Leon, 1958 | Ecuador ( Manabi, Eujias, Loja), Peru (Amazonas, Tumbis, Piura, Cojamarca, La libertad, Lambayeque e San Martin) | Galvão et al. 2003 |
| *R. neivai* | Lent, 1953 | Colombia (Cesar), Venezuela (Lara, Falcón, Zulia) | Galvão et al. 2003 |
| *R. milesi* | Carcavallo et al., 2001 | Brazil (Pará) | Galvão 2014 |
| *R. montenegrensis* | Rosa et al., 2012 | Brazil (Rondônia, Acre) | Galvão 2014 |
| *R. pallescens* | Barber, 1932 | Colombia (Bolívar, Sucre) | Arboleda et al. 2009 |
| *R. paraensis* | Sherlock, Guitton & Miles, 1977 | Brazil (Amazonas,Pará), French Guiana | Galvão 2014 |
| *R. pictipes* | Stal, 1872 | Brazil, French Guiana, Colombia, Peru, Suriname, Venezuela | Galvão 2014 |
| *R. prolixus* | Stal, 1859 | Brazil, Bolivia, Colombia, Guatemala | Galvão et al. 2003 |
| *R. robustus* | Larousse, 1927 | Brazil, Bolivia, Colombia, Venezuela, French Guiana | Galvão 2014 |
| *R. stali* | Lent, Jurberg & Galvão, 1993 | Brazil (Mato Grosso do Sul, Acre), Bolivia (Santa Cruz, La Paz) | Matias et al. 2003 |

Source: Galvão 2014; Galvão et al. 2003; Matias et al. 2003.

differences in size between the largest and the smallest segments are distinct: the second antennal segment of *R. marabaensis* sp. n. is 10.3 times larger than the first; in *R. prolixus*, it is 6.2 times larger, and in *R. robustus* it is 8.3 times larger (Table 1).

For the description of *R. marabaensis* sp. n. five features of the thorax allow for its distinction:

1) The scutellum is larger and includes two prominent internal lateral carinae. It is therefore distinct from *R. prolixus* and *R. robustus*, which present smaller scutellum and whose carinae are not pronounced (Fig. 4);
2) The first urotergite has a pronounced transverse groove and inferior fringe consisting of long and straight filaments. In *R. prolixus*, the transverse groove does not appear and the fringe possesses short and irregular filaments. On the other hand, in *R. robustus* the transverse groove is not accentuated, and the fringe possesses short and straight filaments, as shown in (Fig. 5).

3) It possesses a longer and more clearly shaped stridulatory sulcus relative to those of *R. prolixus* and *R. robustus* (Fig. 5). This specific differentiation among these three *Rhodnius* species adds to the observations by Lent and Wygodzinsky (1979), who verified that the stridulatory sulcus in six species from different genera presented characteristics that allowed for species identification;
4) The transverse carinae that border the mesosternum and the metasternum differ among the three species. In *R. marabaensis* sp. n., they are elevated and prominent, and possess convex curvature in the central portion. In *R. prolixus*, they are less elevated and prominent, and in *R. robustus* they are interrupted in the central portion (Fig. 6);
5) The metasternum is slightly rectangular in shape in *R. marabaensis* sp. n., whereas in *R. prolixus* and *R. robustus* they are slightly triangular (Fig. 6).

From the view of the ventral surface, the abdomen of *R. marabaensis* sp. n. is distinct because of its yellow colouring; this area is brown in *R. prolixus* and black in *R. robustus* (Fig. 11). The set of dark brown spots does not appear in *R. prolixus* or *R. robustus*, and the ventral connective is also distinct among the three species: the black spots are smaller and, on the sixth segment, much smaller in *R. marabaensis* sp. n. (Fig. 2).

When the male genitalia was examined from the dorsal surface, the apex of the endosoma of *R. marabaensis* sp. n. was found to be long and straight; in *R. prolixus*, the apex is long and convex, and in *R. robustus* it is shorter, wide, and convex (Lent and Jurberg, 1969) (Fig. 7). The analysis also revealed that the two final portions of the basal piece are turned to the side in *R. marabaensis* sp. n., whereas in *R. robustus* they face the posterior region. From the ventral surface, the phallosoma of *R. marabaensis* sp. n. is rounded, whereas in *R. prolixus* the anterior portion is convex and in *R. robustus* it is square (Fig. 7). The pygophore of *R. marabaensis* sp. n., *R. prolixus*, and *R. robustus* are all in the shape of an isosceles triangle. However, the sides of the pygophores are straight in *R. robustus* and curved in *R. prolixus* and *R. marabaensis* sp. n. The pygophore of *R. marabaensis* sp. n. is also larger at the tip, thicker, and circular (Fig. 8).

The external female genitalia was also considered. From the dorsal surface, *R. marabaensis* sp. n. and *R. robustus* show no differences; however, the format of the ninth segment of the dorsal surface in *R. prolixus* presents different characteristics (Fig. 9). The posterior surface and the ventral surface of the ninth and tenth segments are distinct in the three species (Fig. 10). These characteristics are also distinct from 12 other *Rhodnius* species, as described by Rosa et al. (2014).

*Rhodnius marabaensis* sp. n. eggs possess chorion rims, whereas those of *R. prolixus* and *R. robustus* do not. The diameter of the follicular tubes of the exochorion cells in *R. prolixus* are larger than those of *R. marabaensis* sp. n. and *R. robustus*; however, they are regular in *R. marabaensis* sp. n. and varied in *R. robustus* (Figs 12, 13 and Table 2).

The data obtained corroborate the status of *R. marabaensis* sp. n. as a new species and indicates that the use of morphology for the description of Triatominae species offers phenotypic information (morphological and morphometric) to define the status of species. It is also important to note that molecular analysis generates data that can help phylogenetic relationships and taxonomic studies of Triatominae (Abad-Franch and Monteiro 2005, Justi et al. 2014). BLAST analysis of cyt-b sequence shows *R. marabaensis* sp. n. as closely related to *R. robustus* and *R. prolixus*, so this new species must be included in the *R. prolixus* complex (Carcavallo et al. 2000). Complementary approaches using molecular data must be encouraged to establish the phylogenetic placement of this new species based on the evaluation of other gene fragments and a more robust assessment.

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CHECKLIST

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# Checklist and identification key of Anomalini (Coleoptera, Scarabaeidae, Rutelinae) of Costa Rica

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## Abstract

A checklist and identification key for the species of the tribe Anomalini in Costa Rica are presented. The Anomalini species are important economically, as they have larvae that are or can become agricultural pests, as well as ecologically, having potential as bioindicators. In spite of their importance and richness, identification tools for the group in the Neotropics remain scarce. The Costa Rican fauna comprises six genera (*Anomala*, *Anomalorhina*, *Callistethus*, *Epectinaspis*, *Moroniella*, and *Strigoderma*) and a total of 120 species. *Anomala contusa* Filippini, Micó, Galante, 2015 is proposed as a synonym of *A. inbio* (Ramírez-Ponce, Bitar, Curoe 2014); *Anomala limon* **nom. n.** is proposed as a new name for *A. inbio* Filippini, Galante, Micó, 2015, a homonym of *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014); *Anomala cinaedias* **nom. n.** is proposed as a new name for *A. chloropyga* Ohaus, 1897, a homonym of *A. chloropyga* Burmeister, 1844; and *Anomala chrysomelina* is moved to the genus *Callistethus.*

## Resumen

Presentamos el listado y la clave de identificación de las especies de la tribu Anomalini de Costa Rica. Las especies de Anomalini son importantes económica, con larvas que son o pueden ser plagas agrícolas, y ecológicamente, con un potencial como bioindicadores. A pesar de su importancia y riqueza, los instrumentos de identificación para el grupo para el Neoptrópico son todavía escasos. La fauna de Costa Rica está compuesta por seis géneros (*Anomala*, *Anomalorhina*, *Callistethus*, *Epectinaspis*, *Moroniella* y *Strigoderma*) y un total de 120 especies. *Anomala contusa* Filippini, Micó, Galante, 2015 se propone como sinónimo de *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014); *Anomala limon* se propone como nuevo nombre de *A. inbio* Filippini, Galante, Micó, 2015, homónimo de *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014); *Anomala cinaedias* se propone como nuevo nombre de *A. chloropyga* Ohaus, 1897, homónimo de *A. chloropyga* Burmeister, 1844; *Anomala chrysomelina* se mueve al género *Callistethus*.

**Keywords**
Identification key, new species, *Anomala*, *Callistethus*, *Strigoderma*, *Anomalorhina*, *Moroniella*, aedeagus, endophallus

## Introduction

One reason for the "taxonomic neglect" (Jameson et al. 2003) of the genus *Anomala* over the past centuries is due to the inverse relationship between the number of species in that genus and the available taxonomic information about them. Most descriptions date to the early 20$^{th}$ century and earlier, and the brevity of these descriptions makes reliable identification impossible without consulting the type material. The largest contribution to the study of the Anomalini in Central America was made by H. W. Bates, with his collaboration on the volumes of *Biologia Centrali-Americana* (1888 for the volume on Anomalini).

For the Neotropics, only a few national checklists that include Anomalini are available, such as Ratcliffe's (2002) for Panama and Paucar-Cabrera's (2005) for Ecuador. Species-level keys are available only for local fauna (e.g., Neita et al. 2006; Reyes Novelo and Morón 2005; Carrillo Ruiz and Morón 2003; Alcazar Ruiz et al. 2003).

Adults of most Anomalini species are nocturnal and are easily captured by light traps. Although they may serve as bioindicators for ecosystem conservation, the lack of proper identification tools makes such a role difficult (Morón 1997). The larvae of Anomalini are subterranean feeders, consuming roots and organic material (Ritcher 1966), and are considered ecologically important for their role in the airing of soil and decomposition of organic material (Morón and Aragón 2003). Some species are known to cause damage to crops, and some have become invasive agricultural pests in countries where they are adventive. While no invasive species of Anomalini have been recorded in Costa Rica (I3N Costa Rica http://invasoras.acebio.org), a few species of *Anomala* have been found to be associated with different crops, together with the scarab beetles *Phyllophaga* (Melolonthinae) and *Cyclocephala* species (Dynastinae). The lack of knowledge about the species' larval morphology, however, makes it difficult to identify which species are associated with crop damage, and identification is usually done on adults collected nearby (Abarca and Quesada 1997). Larval descriptions are available for only four of the species recorded in Costa Rica (*Anomala discoidalis*, *A. undulata*, *A. ludoviciana*, *A. cupricollis*; Micó et al. 2003).

In this paper, a checklist for the Anomalini of Costa Rica is presented, which comprise 120 species, including photographs of the habitus and drawings of male genitalia for nearly all species, and a comprehensive key for use in identification. This work is the final part of the of a three year taxonomic study on Costa Rican Anomalini performed by the authors, which has resulted in the description of more than 50 new species of *Anomala* and *Callistethus* (Filippini et al. 2013, 2014, 2015a–e)

*Anomala contusa* Filippini, Micó Galante 2015 is proposed as a synonym of *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014); *Anomala limon* is proposed as a new name for *A. inbio* Filippini, Galante, Micó, 2015, a homonym of *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014); *Anomala cinaedias* is proposed as a new name for *A. chloropyga* Ohaus, 1897, homonym of *A. chloropyga* Burmeister, 1844; and *Anomala chrysomelina* is moved to the genus *Callistethus*.

## Methods

Specimens cited in this publication are deposited in the following collections:

| | |
|---|---|
| **BMNH** | Natural History Museum, London, United Kingdom |
| **CEUA** | CIBIO Research Institute, Entomological Collection of the University of Alicante, Spain |
| **MNCR** | National Museum of Costa Rica, Costa Rica |
| **MNHUB** | Natural History Museum of Humboldt University, Germany |
| **MUCR** | Insect Museum, University of Costa Rica, Costa Rica |

Procedures for the preparation of endophalli, measurements, definitions, and morphological terminology follow Filippini et al. (2013, 2014). In contrast to Ramírez-Ponce and Morón (2009), who group New World *Anomala* species into a new genus (*Paranomala*) we follow the traditional inclusion in the genus *Anomala* (Jameson et al. 2003) as a more conservative classification, while waiting for a more extensive study at global scale. We use the phylogenetic species concept described by Wheeler and Platnick (2000), which defines species as the smallest aggregation of sexual populations that are diagnosable by a unique combination of character states.

Line drawings were traced using a GNU image manipulation program (GIMP version 2.8, www.gimp.org). Original drawings were produced with the aid of a camera lucida attached to a stereo microscope (Leica M80) for endophalli, or from photographs for aedeagi (taken with a Leica DFC450 camera mounted on a Leica M205C stereo microscope).

For each species in the checklist, the provinces where it is located are given in Figure 1. The distribution data were gathered using labels from identified specimens in the MNCR and CEUA collections, and the Atta database (http:// http://atta.inbio.ac.cr/) of INBio, Costa Rica.

Species identification was undertaken by consulting original species descriptions and, when possible, by type comparison. For a list of the types consulted, see Filippini et al. (2015b). Nomenclatural changes are suggested in accordance with the International Code of Zoological Nomenclature.

## Data resources

The data from specimens deposited at CEUA are deposited at GBIF, the Global Biodiversity Information Facility, http://www.gbif.es/ic_colecciones.php?ID_Coleccion=9709

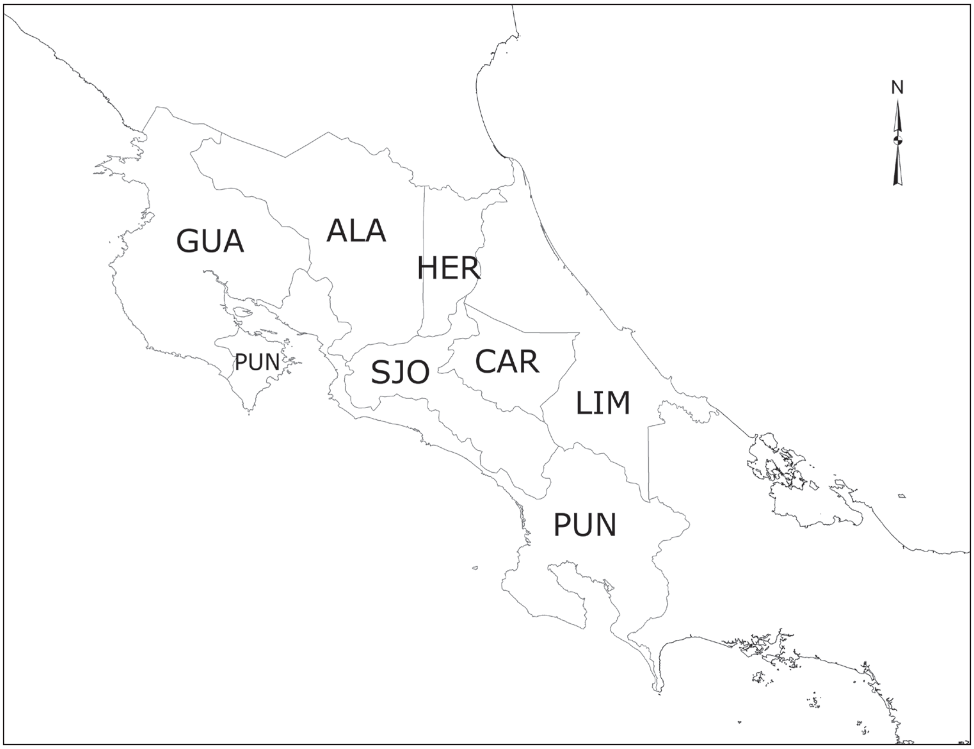


**Figure 1.** Map of Costa Rica showing provinces. ALA: Alajuela; CAR: Cartago; GUA: Guanacaste; HER: Heredia; LIM: Limón; PUN: Puntarenas; SJO: San José.

## Results

In the last three years, new species descriptions have led to a 49% increase in the known Costa Rican fauna of the tribe (Filippini et al. 2013, 2014, 2015a-e; Ramírez-Ponce et al. 2014; Ramírez-Ponce and Curoe 2014). The lack of taxonomical and faunistic studies in other Neotropical countries, however, makes it difficult to make comparisons with similar regions, or even to determine which species are endemic. For example, only 42 Anomalini species are registered for Panama (Ratcliffe 2002), and only 79 for Ecuador (which has a surface area five times that of Costa Rica) (Paucar-Cabrera 2005). It is safe to say that most of the Anomalini diversity in the Neotropical region is yet to be described.

The present work does not exhaust the actual diversity of Costa Rican Anomalini; there were at least a few species that, for reasons such as the scarcity of specimens, were not included in the descriptive work.

Based on the data gathered from the studied specimens, the richest habitats for the species were various types of evergreen tropical forests located on the slopes of the country's main mountain ranges (unpublished material).

## Nomenclatural changes

### *Anomala inbio* (Ramírez-Ponce, Bitar, Curoe, 2014), comb. n.

*Anomala contusa* Filippini, Micó, Galante, 2015, **syn. n.**

The comparison between specimens of *A. contusa* and the description and illustrations of *A. inbio* lead to the conclusion that they are the same species. In particular, the diagnostic characteristics that include the species in the *trapezifera* species group (pronotum bronze with an irregular shaped macula, elytra with ochre background covered by small numerous flecks, tridentate protibia, tectum shorter than or similar in size to the basal piece) (Filippini et al. 2015), the particular texture of the pronotum of this species (not shared by other Costa Rican species), and the peculiar shape of aedeagus, are coincident.

*A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014) was originally described in the genus *Paranomala*. For the reasons explained in Methods it is here placed in the genus *Anomala*.

### *Anomala limon* Filippini, Micó, Galante, nom. n.

For *Anomala inbio* Filippini, Galante, Micó, 2015 [not *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014)]

Due to the homonymy of *Anomala inbio* Filippini, Galante, Micó, 2015 with *A. inbio* (Ramírez-Ponce, Bitar, Curoe, 2014) (Figs 32, 145, 258), a replacement name is proposed here for the first species: *A. limon* (Figs 37, 150, 262). The comparison between images of the habitus and male genitalia of the two species leaves no doubt that the same name was given to very different species.

**Etymology.** this species is specific to the Costa Rican Province of Limón, where most of the type material was collected. To be used as a name in apposition.

### *Anomala cinaedias* Filippini, Micó, Galante, nom. n.

For *Anomala chloropyga* Ohaus, 1897 (not *A. chloropyga* Burmeister 1844).

*Anomala chloropyga* Ohaus, 1897 is a homonym for *A. chloropyga* Burmeister, 1844, a species from the Philippines, so a replacement name is necessary.

**Etymology.** from the Greek κιναιδίας, a precious stone, for the smooth and shiny appearance of this species. To be used as a noun in apposition.

### *Callistethus chrysomelinus* (Bates, 1888), comb. n.

*Anomala chrysomelina* Bates, 1888 is moved to the genus *Callistethus*, as it presents the following diagnostic characteristics of this genus, as described in Filippini et al. (2015):

wide interocular space and small elongated eyes; posterior margin of the pronotum is smooth, without bead, and directly opposite to the scutellum; presence of a mesosternal process produced slightly beyond the apex of the mesocoxae.

## Checklist of Anomalini of Costa Rica

The three figure numbers for each species refer to the habitus, aedeagus and endophallus, respectively.

*ANOMALA* Samouelle, 1819

1 *Anomala aereiventris* Filippini, Micó, Galante, 2015d (Figs 2, 115, 228)
Distribution: Cartago, San José.

2 *Anomala aglaos* Filippini, Galante, Micó, 2015b (Figs 3, 116, 229)
Distribution: Alajuela, San José.

3 *Anomala antica* Ohaus, 1897 (Figs 4, 117, 230)
Note: type specimens (Colombia, MNHUB) have aedeagus with longer and thinner parameres than specimens from Costa Rica.
Distribution: Alajuela, Guanacaste, Limón, Puntarenas, San José.

4 *Anomala arara* Ohaus, 1897 (Figs 5, 118, 231)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas, San José.

5 *Anomala arthuri* Filippini, Micó, Galante, 2014 (Figs 6, 119, 232)
Distribution: Guanacaste.

6 *Anomala aspersa* Filippini, Micó, Galante, 2015d (Figs 7, 120, 233)
Distribution: Cartago, San José.

7 *Anomala atrivillosa* Filippini, Micó, Galante, 2015d (Figs 8, 121, 234)
Distribution: Heredia.

8 *Anomala balzapambae* Ohaus, 1897 (Figs 9, 122, 235)
Distribution: Alajuela, Guanacaste, Heredia, Limón, Puntarenas, San José.

9 *Anomala calligrapha* Bates, 1888 (Figs 10, 123, 236)
Distribution: Alajuela, Cartago, Guanacaste, Limón, Puntarenas, San José.

10 *Anomala chiriquina* Bates, 1888 (Figs 11, 124, 237)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas, San José.

11 *Anomala cinaedias* **nom. n.** (Figs 12, 125, 238)
Distribution: San José.

12 *Anomala clarivillosa* Filippini, Micó, Galante, 2015d (Figs 13, 126, 239)
Distribution: Cartago.

13 *Anomala clathrata* Ohaus, 1930 (Figs 14, 127, 240)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas.

14 *Anomala coffea* Filippini, Galante, Micó, 2015c (Figs 15, 128, 241)
Distribution: Guanacaste.

15 *Anomala cupreovariolosa* Filippini, Micó, Galante, 2014 (Figs 16, 129, 242)
Distribution: Puntarenas.

16 *Anomala cupricollis* Chevrolat, 1834 (Figs 17, 130, 243)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas.
17 *Anomala cyclops* Filippini, Galante, Micó, 2015c (Figs 18, 131, 244)
Distribution: Guanacaste.
18 *Anomala discoidalis* Bates, 1888 (Figs 19, 132, 245)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
19 *Anomala divisa* Filippini, Galante, Micó, 2015c (Figs 20, 133, 246)
Distribution: Alajuela, Puntarenas.
20 *Anomala estrella* Filippini, Galante, Micó, 2015b (Figs 21, 134, 247)
Distribution: Guanacaste, Puntarenas.
21 *Anomala eucoma* Bates, 1888 (Figs 22, 135, 248)
Distribution: Guanacaste, Limón, Puntarenas.
22 *Anomala eulissa* Bates, 1888 (Figs 23, 136, 249)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas.
23 *Anomala eusticta* Filippini, Micó, Galante, 2015d (Figs 24, 137, 250)
Distribution: Guanacaste, Puntarenas.
24 *Anomala ferrea* Filippini, Micó, Galante, 2014 (Figs 25, 138, 251)
Distribution: Puntarenas.
25 *Anomala flavacoma* Filippini, Micó, Galante, 2013 (Figs 26, 139, 252)
Distribution: Alajuela, Guanacaste, Limón.
26 *Anomala foraminosa* Bates, 1888 (Figs 27, 140, 253)
Distribution: Guanacaste, Heredia, Limón, Puntarenas, San José.
27 *Anomala globulata* Filippini, Micó, Galante, 2015d (Figs 28, 141, 254)
Distribution: Cartago, San José.
28 *Anomala hiata* Filippini, Micó, Galante, 2015d (Figs 29, 142, 255)
Distribution: Puntarenas.
29 *Anomala histrionella* Bates, 1888 (Figs 30, 143, 256)
Distribution: Alajuela, Guanacaste, Puntarenas.
30 *Anomala hoppi* Ohaus, 1928 (Figs 31, 144, 257)
Distribution: Alajuela, Cartago, Guanacaste, Limón, Puntarenas.
31 *Anomala inbio* (Ramírez-Ponce, Bitar, Curoe, 2014) (Figs 32, 145, 258)
Distribution: Guanacaste, San José.
32 *Anomala jansoni* Ohaus, 1897 (Figs 33, 146)
Note: no specimens apart from the type series are known.
Distribution: "Monte Rotondo, Costa Rica".
33 *Anomala latifalculata* Filippini, Micó, Galante, 2015d (Figs 34, 147, 259)
Distribution: Cartago.
34 *Anomala leopardina* Filippini, Micó, Galante, 2015d (Figs 35, 148, 260)
Distribution: Puntarenas.
35 *Anomala levicollis* Filippini, Micó, Galante, 2015d (Figs 36, 149, 261)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas.
36 *Anomala limon* **nom. n.** (Figs 37, 150, 262)
Distribution: Heredia, Limón.

37 *Anomala longisacculata* Filippini, Micó, Galante, 2015d (Figs 38, 151, 263)
Distribution: Alajuela, Cartago, Guanacaste, Limón, San José.
38 *Anomala ludoviciana* Schaeffer, 1906 (Figs 39, 152, 264)
Distribution: Guanacaste, Puntarenas.
39 *Anomala megalia* Bates, 1888 (Figs 40, 153, 265)
Distribution: Limón, San José.
40 *Anomala megaparamera* Filippini, Micó, Galante, 2013 (Figs 41, 154, 266)
Distribution: Limón.
41 *Anomala mersa* Filippini, Galante, Micó, 2015c (Figs 42, 155, 267)
Distribution: Guanacaste.
42 *Anomala mesosticta* Filippini, Galante, Micó, 2015c (Figs 43, 156, 268)
Distribution: Heredia, Limón.
43 *Anomala m-fuscum* Filippini, Micó, Galante, 2015d (Figs 44, 157, 269)
Distribution: Cartago.
44 *Anomala moroni* Filippini, Micó, Galante, 2015e (Figs 45, 158, 270)
Distribution: Guanacaste.
45 *Anomala nigroflava* Filippini, Micó, Galante, 2014 (Figs 46, 159, 271)
Distribution: Puntarenas.
46 *Anomala obovata* Ohaus, 1933 (Figs 47, 160, 272)
Distribution: Cartago, Heredia, Limón.
47 *Anomala ochrogastra* Bates, 1888 (Figs 48, 161, 273)
Distribution: Guanacaste, Heredia, Limón, Puntarenas.
48 *Anomala ochroptera* Bates, 1888 (Figs 49, 162, 274)
Distribution: Guanacaste, Puntarenas.
49 *Anomala parvaeucoma* Filippini, Micó, Galante, 2015e (Figs 50, 163, 275)
Distribution: Puntarenas.
50 *Anomala perspicax* Filippini, Micó, Galante, 2015d (Figs 51, 164, 276)
Distribution: Cartago, Puntarenas.
51 *Anomala piccolina* Filippini, Micó, Galante, 2015d (Figs 52, 165, 277)
Distribution: Puntarenas.
52 *Anomala pincelada* Filippini, Galante, Micó, 2015b (Figs 53, 166, 278)
Distribution: Guanacaste.
53 *Anomala polygona* Bates, 1888 (Figs 54, 167)
Note: apart from the type specimen, only one recent specimen with dubious identification is known.
Distribution: "Costa Rica" (holotype, MNHN); San José (1 specimen at MNHUB); Limón (see Filippini et al. 2014).
54 *Anomala popayana* Ohaus, 1897 (Figs 55, 168, 279)
Distribution: Guanacaste, Heredia, Limón, Puntarenas.
55 *Anomala praecellens* Bates, 1888 (Figs 56, 169, 280)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
56 *Anomala pseudoeucoma* Filippini, Micó, Galante, 2013 (Figs 57, 170, 281)
Distribution: Alajuela, Limón, Puntarenas.

57 *Anomala quiche* Ohaus, 1897 (Figs 58, 171, 282)
Note: specimens from Costa Rica differ from the type specimen (Guatemala, MN-HUB) in that they have two defined maculae on the pronotum instead of one. Aedeagus is identical.
Distribution: Alajuela, Guanacaste, Heredia, Limón, Puntarenas.
58 *Anomala robiginosa* Filippini, Galante, Micó, 2015c (Figs 59, 172, 283)
Distribution: Alajuela, Guanacaste.
59 *Anomala ruatana* Bates, 1888 (Figs 60, 173, 284)
Distribution: Guanacaste.
60 *Anomala semicincta* Bates, 1888 (Figs 61, 174, 285)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas.
61 *Anomala semilla* Filippini, Micó, Galante, 2014 (Figs 62, 175, 286)
Distribution: Alajuela, Guanacaste.
62 *Anomala solisi* Filippini, Micó, Galante, 2014 (Figs 63, 176, 287)
Distribution: Alajuela, Guanacaste, Limón.
63 *Anomala stillaticia* Filippini, Micó, Galante, 2015d (Figs 64, 177, 288)
Distribution: Cartago.
64 *Anomala strigodermoides* Filippini, Galante, Micó, 2015c (Figs 65, 178, 289)
Distribution: Alajuela, Cartago.
65 *Anomala subaenea* (Nonfried, 1893) (Figs 66, 179, 290)
Distribution: Guanacaste.
66 *Anomala subridens* Filippini, Micó, Galante, 2015d (Figs 67, 180, 291)
Distribution: Cartago.
67 *Anomala subusta* Filippini, Micó, Galante, 2015d (Figs 68, 181, 292)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas.
68 *Anomala tenoriensis* Filippini, Micó, Galante, 2015d (Figs 69, 182, 293)
Distribution: Alajuela, Guanacaste.
69 *Anomala testaceipennis* Blanchard, 1851 (Figs 70, 183, 294)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
70 *Anomala trapezifera* Bates, 1888 (Figs 71, 184, 295)
Distribution: Cartago, Limón.
71 *Anomala tuberculata* Filippini, Micó, Galante, 2015d (Figs 72, 185, 296)
Distribution: Alajuela, Cartago, San José.
72 *Anomala undulata* Melsheimer, 1844 (Figs 73, 186, 297)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
73 *Anomala unilineata* Filippini, Galante, Micó, 2015c (Figs 74, 187, 298)
Distribution: Guanacaste.
74 *Anomala valida* Burmeister, 1844 (Figs 75, 188, 299)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
75 *Anomala vallisneria* Filippini, Micó, Galante, 2015d (Figs 76, 189, 300)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas.
76 *Anomala veraecrucis* Bates, 1888 (Figs 77, 190, 301)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas.

77 *Anomala volsellata* Filippini, Micó, Galante, 2014 (Figs 78, 191, 302)
Distribution: Puntarenas, San José.
78 *Anomala vulcanicola* Ohaus, 1897 (Figs 79, 192, 303)
Distribution: San José.
79 *Anomala zumbadoi* Filippini, Micó, Galante, 2014 (Figs 80, 193, 304)
Distribution: Puntarenas.

*ANOMALORHINA* Jameson, Paucar-Cabrera, Solís, 2003
1 *Anomalorhina osaensis* Jameson, Paucar-Cabrera, Solís, 2003
Distribution: Puntarenas.
2 *Anomalorhina turrialbana* (Ohaus, 1928) (Figs 81, 194, 305)
Distribution: Alajuela, Cartago.

*CALLISTETHUS* Blanchard, 1851
1 *Callistethus calonotus* (Bates, 1888) (Figs 82, 195, 306)
Distribution: Puntarenas.
2 *Callistethus carbo* Filippini, Galante, Micó, 2015a (Figs 83, 196, 307)
Distribution: Guanacaste.
3 *Callistethus chlorotoides* (Bates, 1888) (Figs 84, 197, 308)
Distribution: Alajuela, Cartago, Limón, Puntarenas, San José.
4 *Callistethus chontalensis* (Bates, 1888) (Figs 85, 198, 309)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas.
5 *Callistethus chrysanthe* (Bates, 1888) (Figs 86, 199)
Note: no specimens apart from the type series are known.
Distribution: "Costa Rica".
6 *Callistethus chrysomelinus* (Bates, 1888) (Figs 87, 200, 310)
Distribution: Puntarenas.
7 *Callistethus flavodorsalis* Filippini, Galante, Micó, 2015a (Figs 88, 201, 311)
Distribution: Puntarenas.
8 *Callistethus fuscorubens* Filippini, Galante, Micó, 2015a (Figs 89, 202, 312)
Distribution: Puntarenas.
9 *Callistethus granulipygus* (Bates, 1888) (Figs 90, 203, 313)
Distribution: Alajuela, Guanacaste, Heredia, Limón, Puntarenas, San José.
10 *Callistethus jordani* (Ohaus, 1902) (Figs 91, 204, 314)
Distribution: Guanacaste, Puntarenas.
11 *Callistethus lativittis* Filippini, Galante, Micó, 2015a (Figs 92, 205, 315)
Distribution: Alajuela, Guanacaste.
12 *Callistethus levigatus* Filippini, Galante, Micó, 2015a (Figs 93, 206, 316)
Distribution: Alajuela, Cartago, Guanacaste, Puntarenas.

13 *Callistethus macroxantholeus* Filippini, Galante, Micó, 2015a (Figs 94, 207, 317)
Distribution: Alajuela, Limón, Guanacaste.
14 *Callistethus microxantholeus* Filippini, Galante, Micó, 2015a (Figs 95, 208, 318)
Distribution: Alajuela, Guanacaste, Heredia, Limón, Puntarenas.
15 *Callistethus mimeloides* (Ohaus, 1902) (Figs 96, 209, 319)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.
16 *Callistethus multiplicatus* Filippini, Galante, Micó, 2015a (Figs 97, 210, 320)
Distribution: Alajuela, Guanacaste, Limón.
17 *Callistethus nicoya* (Ohaus, 1928) (Figs 98, 211, 321)
Distribution: Alajuela, Heredia, Puntarenas, San José.
18 *Callistethus parapulcher* Filippini, Galante, Micó, 2015a (Figs 99, 212, 322)
Distribution: Guanacaste, Puntarenas, San José.
19 *Callistethus pseudocollaris* Filippini, Galante, Micó, 2015a (Figs 100, 213, 323)
Distribution: Puntarenas.
20 *Callistethus ruteloides* Filippini, Galante, Micó, 2015b (Figs 101, 214, 324)
Distribution: Alajuela, Cartago, Puntarenas.
21 *Callistethus schneideri* (Ohaus, 1905) (Figs 102, 215, 325)
Distribution: Alajuela, Guanacaste, Heredia, Limón, Puntarenas, San José.
22 *Callistethus specularis* (Bates, 1888) (Figs 103, 216, 326)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Puntarenas, San José.
23 *Callistethus stannibractea* Filippini, Galante, Micó, 2015a (Figs 104, 217, 327)
Distribution: Heredia.
24 *Callistethus sulcans* (Bates, 1888) (Figs 105, 218, 328)
Distribution: Alajuela, Guanacaste, Limón.
25 *Callistethus valdecostatus* (Bates, 1888) (Figs 106, 219, 329)
Distribution: Puntarenas, San José.
26 *Callistethus vanpatteni* (Bates, 1888) (Figs 107, 220, 330)
Distribution: Alajuela, Guanacaste, Heredia, Puntarenas.
27 *Callistethus xiphostethus* (Bates, 1888) (Figs 108, 221, 331)
Distribution: Alajuela, Guanacaste, Heredia, San José.
28 *Callistethus yalizo* Filippini, Galante, Micó, 2015b (Figs 109, 222, 332)
Distribution: Alajuela, Cartago, Heredia.

*EPECTINASPIS* Blanchard, 1851

1 *Epectinaspis costaricensis* Ramírez-Ponce and Curoe, 2014
Distribution: Heredia.

*MORONIELLA* Ramírez-Ponce, 2015

1 *Moroniella nitidula* (Blanchard, 1851) (Figs 110, 223, 333)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, San José.

*STRIGODERMA* Burmeister, 1844

1 *Strigoderma angulicollis* Ohaus, 1915
Distribution: Limón.

2 *Strigoderma auriventris* Bates, 1888 (Figs 111, 224, 334)
Distribution: Alajuela, Guanacaste, Limón.

3 *Strigoderma biolleyi* Ohaus, 1908 (Figs 112, 225, 335)
Distribution: Cartago, Puntarenas, San José.

4 *Strigoderma castor* (Newman, 1838)
Distribution: Heredia, San José.

5 *Strigoderma marginata* (Olivier, 1789)
Distribution: Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas, San José.

6 *Strigoderma micans* Nonfried, 1893
Distribution: Guanacaste.

7 *Strigoderma nodulosa* Ohaus, 1902 (Figs 113, 226, 336)
Distribution: Heredia, Limón, Puntarenas.

8 *Strigoderma orbicularis* Burmeister, 1855
Distribution: Cartago, Guanacaste, Heredia, Limón, Puntarenas.

9 *Strigoderma rutelina* Bates, 1888
Distribution: Alajuela, Puntarenas.

10 *Strigoderma sulcipennis* Burmeister, 1844 (Figs 114, 227, 337)
Distribution: Guanacaste, Puntarenas, San José.

11 *Strigoderma vestita* Burmeister, 1844
Distribution: Alajuela, Guanacaste, Puntarenas, San José.

## Key to Anomalini species of Costa Rica

Partly modified from: Jameson, Paucar-Cabrera and Solís (2003), Filippini et al. (2013, 2015a, d).

1 Mesepimeron is well-exposed anterior to base of elytron in dorsal view (Fig. 338B); body shape elongated ........................................................................ **2**

– Mesepimeron is concealed by base of elytron or weakly exposed (Fig. 338A); body shape oval or elongated ........................................................................ **3**

2 Mesosternal intercoxal region subequal in width to base of mesofemur; mesepimeron subrectangular and well-exposed; clypeus of male narrowly reflexed at apex; dorsal surface of elytron flat; pronotum narrower than base of elytra (except in *S. orbicularis*) ................ ***STRIGODERMA* Burmeister, 1844**...7

– Mesosternal intercoxal region less than 1/4 width of base of mesofemur; mesepimeron subtriangular and partially exposed; clypeus of male broadly reflexed at apex; dorsal surface of elytron evenly rounded; pronotum as wide as base of elytra.....................***Epectinaspis costaricensis* Ramírez-Ponce & Curoe, 2014**

3 Frontoclypeal suture incomplete, sides of clypeus elevated at base of canthus; males with pronotal disc with depression; females with apical bead of pronotum produced posteriorly at middle ............................................................... ***ANOMALORHINA* Jameson, Paucar-Cabrera, Solís, 2003...17**

– Frontoclypeal suture complete, sides of clypeus weakly elevated or flat at base of canthus; males with pronotal disc evenly convex; females with apical bead of pronotum not produced posteriorly ...................................................... **4**

4 Surface between mesocoxae not produced beyond mesotrochanters; pronotum with basal bead complete or obsolete at middle ........................................................................................ ***ANOMALA* Samouelle, 1819...18**

– Surface between mesocoxae possessing a mesosternal process and produced beyond mesotrochanters; pronotum with basal bead or lacking basal bead. **5**

5 Parameres perpendicular to the phallobase; metatarsi 1-4 together similar in length to the 5th, excluding claws; small size.............................................................................. ***Moroniella nitidula* (Blanchard, 1851)**

– Parameres in line with the phallobase; metatarsi 1-4 together longer than the 5th, excluding claws; size varies...................................................................... **.6**

6 Mesosternal process short, either not or slightly produced beyond the mesocoxae, apex seen as a bump in lateral view............................................................... ...***ANOMALA* Samouelle, 1819** and ***CALLISTETHUS* Blanchard, 1851...96**

– Mesosternal process long, produced beyond the mesocoxae for more than half the width of mesocoxa, apex free in lateral view .................................................................... ***CALLISTETHUS* Blanchard, 1851...112**

7 Pronotum with irregular surface, granulate or with concavities .................. **8**

– Pronotum homogeneously convex ........................................................... **10**

8 Pronotum with granulate surface ........***Strigoderma nodulosa* Ohaus, 1902**

– Pronotum with concavities ...................................................................... **9**

9 Body length 11–13 mm; pronotum homogeneously black or copper; elongated shape (elytra > 2 times longer than wide)................................................................. ***Strigoderma sulcipennis* Burmeister, 1844**

– Body length 7–9 mm; pronotum green or reddish brown with white sides; rounded shape (elytra < 2 times longer than wide) ............................................................ ***Strigoderma castor* (Newman, 1838)**

10 Elytra smooth; venter with metallic colors ........................................................................................ ***Strigoderma auriventris* Bates, 1888**

– Elytra striated; venter not with metallic colors .......................................... **11**

11 Pronotum with green metallic color........................................................ **12**

– Pronotum brown to black, without metallic luster .................................. **14**

12 Elytra black with a ochre circle near base .................................................................................................. ***Strigoderma rutelina* Bates, 1888**

– Elytra with uniform color ...................................................................... **13**

13 Pronotum with one central macula or uniformly colored; elytra black or brown ........................................... ***Strigoderma biolleyi*** **Ohaus, 1908**
– Pronotum with two lateral light colored bands; elytra brown .......................................................................***Strigoderma micans*** **Nonfried, 1893**
14 Elytra homogeneously brown.......... ***Strigoderma vestita*** **Burmeister, 1844**
– Elytra black or brown with black maculae............................................... **15**
15 Body length 11–12 mm.................***Strigoderma angulicollis*** **Ohaus, 1915**
– Body length < 8 mm.................................................................................. **16**
16 Rounded shape; pronotum strongly convex, as wide as base of elytra; body length 7–8 mm ....................... ***Strigoderma orbicularis*** **Burmeister, 1855**
– Elongated shape; pronotum slightly convex, narrower than base of elytra; body length 5–7 mm ...................***Strigoderma marginata*** **(Olivier, 1789)**
17 Head and pronotum rufous, elytra black or reddish brown; male with two tubercles on base of frons; clypeus with apex acute in frontal view; females with subsutural interstice twice as wide as first costa, frontal disc slightly concave ..............................................***Anomalorhina turrialbana*** **(Ohaus, 1928)**
– Head, pronotum and elytra castaneous; male without tubercles on frons; clypeus with apex quadrate in frontal view; females with subsutural interstice as wide as first costa, frontal disc slightly convex ........................................ ................***Anomalorhina osaensis*** **Jameson, Paucar-Cabrera, Solís, 2003**
18 Protibia tridentate..................................................................................... **19**
– Protibia bidentate ...................................................................................... **49**
19 Elytra of homogeneous color..................................................................... **20**
– Elytra with darker maculae ....................................................................... **22**
20 Body color dark brown .....***Anomala coffea*** **Filippini, Galante, Micó, 2015**
– Pronotum dark brown or green, elytra ochre........................................... **21**
21 Pronotum of homogeneous color, green or brown; body length 11.0–13.0 mm; aedeagus Fig. 183 .............. ***Anomala testaceipennis*** **Blanchard, 1851**
– Pronotum dark brown with ochre sides; body length 8.5–9.5 mm; aedeagus Fig. 190 ..............................................***Anomala veraecrucis*** **Bates, 1888**
22 Head and pronotum entirely black; elytra ochre with large irregular black maculae developing longitudinally (Fig. 53)............................................... .................................***Anomala pincelada*** **Filippini, Galante, Micó, 2015**
– Head and pronotum metallic green or brown, pronotum usually with light colored margins; elytra with small maculae on transversal bands or sparse flecks on entire surface ......................................................................... **23**
23 Pattern on elytra consists of one central macula or median transversal band....**24**
– Pattern on elytra consists of various bands of maculae or sparse flecks...... **25**
24 Pronotum mainly dark brown with narrow ochre sides; body length 10–12 mm; aedeagus Fig. 156...........***Anomala mesosticta*** **Filippini, Galante, Micó, 2015**
– Pronotum with pentagonal central dark macula, less than half the pronotum width; body length 8–10 mm; aedeagus Fig. 131 ........................................ ......................................***Anomala cyclops*** **Filippini, Galante, Micó, 2015**

25 Pronotum with deep concavities ................................................................ ...............................***Anomala inbio* (Ramírez-Ponce, Bitar, Curoe, 2014)**
– Pronotum with convex surface ................................................................ **26**
26 Presence of setae on pronotum and elytra ................................................ **27**
– Pronotum and elytra glabrous, pronotum may have a row of a few setae.....**29**
27 Body length 10.0–11.5 mm; pronotum with dense punctation; elytra with two regular rows of maculae; aedeagus in Fig. 148 ...................................... ...............................***Anomala leopardina* Filippini, Micó, Galante, 2015**
– Body length 12.0–14.0 mm; pronotum with sparse and coarse punctation; elytra irregularly covered with maculae and flecks; aedeagus with different shape................................................................................................... **28**
28 Light color; pronotum with evident sinuate lateral margins; aedeagus Fig. 126 .........................***Anomala clarivillosa* Filippini, Micó, Galante, 2015**
– Dark color; pronotum with slightly sinuate lateral margins; aedeagus Fig. 121 ..........................***Anomala atrivillosa* Filippini, Micó, Galante, 2015**
29 Lateral margins of pronotum sinuate ...................................................... **30**
– Lateral margins of pronotum regularly convex or angulated ..................... **37**
30 Side of pronotum deeply sinuate (crosses an imaginary line from apical to basal angle); pronotum almost completely dark in color; aedeagus Fig. 167 . ..................................................................***Anomala polygona* Bates, 1888**
– Lateral margins of pronotum weakly sinuate (do not cross an imaginary line from apical to basal angle); pronotum with an irregular macula on disc or ochre margins; aedeagus with different shape .......................................... **31**
31 Pronotum dark with ochre margins; elytra with regular maculae; aedeagus Fig. 142 ...........................***Anomala hiata* Filippini, Micó, Galante, 2015**
– Pronotum with an irregular macula on its disc; elytra with several small flecks; aedeagus with different shape ................................................................... **32**
32 Pronotum with a narrow sinuate macula; elytra with few flecks; body length less than 11.5 mm; parameres long with an acute apex and protruding ventral angle in lateral view (Fig. 157) ........................................................... ................................***Anomala m-fuscum* Filippini, Micó, Galante, 2015**
– Pronotum with larger maculae; elytra with abundant flecks; body length 10.2–13.4 mm; different aedeagus ......................................................... **33**
33 Ventral plate with elongated apical corners; short parameres, less than half the length of the tectum (Fig. 192) ......***Anomala vulcanicola* Ohaus, 1897**
– Ventral plate with a curved apex in ventral view; parameres longer than half the length of the tectum................................................................... **34**
34 Ventral plate with apical side curved in lateral view................................. **35**
– Ventral plate with apical side flat ........................................................... **36**
35 Parameres short with blunt apex in lateral view (Fig. 120) ......................... ....................................***Anomala aspersa* Filippini, Micó, Galante, 2015**
– Parameres long with acute apex in lateral view (Fig. 184)............................ ............................................................***Anomala trapezifera* Bates, 1888**

36 Parameres long and narrow, dorsal margin curved, ventral angle obtuse (Fig. 180) ........ ***Anomala subridens*** **Filippini, Micó, Galante, 2015**

– Parameres short and wide, dorsal margin sinuate, ventral angle pointing backwards in a lateral view (Fig. 189) ........ ***Anomala vallisneria*** **Filippini, Micó, Galante, 2015**

37 Elytra light colored with sparse flecks; body length > 14.1 mm ........ **38**

– Elytra light colored and body length < 13.5 mm; or dark elytra and body length > 14.1 mm ........ **40**

38 Presence of protuberance on clypeus; aedeagus Fig. 185 ........ ***Anomala tuberculata*** **Filippini, Micó, Galante, 2015**

– Clypeus with even surface; aedeagus with different shape ........ **39**

39 Pronotum with irregular macula on its disc; elytra with large maculae; aedeagus Fig. 137 ........ ***Anomala eusticta*** **Filippini, Micó, Galante, 2015**

– Pronotum completely dark; elytra with small flecks; aedeagus Fig. 115 ........ ***Anomala aereiventris*** **Filippini, Micó, Galante, 2015**

40 Pronotum surface smooth ........ **41**

– Pronotum surface with evident punctures ........ **42**

41 Pronotum completely dark; venter homogeneously bronze brown, metallic; third tooth of protibia weakly developed; body length > 13.2 mm; aedeagus Fig. 115 ........ ***Anomala aereiventris*** **Filippini, Micó, Galante 2015**

– Pronotum with ochre sides; venter brown with yellowish parts, without metallic luster; third tooth of protibia well developed; body length < 13.0 mm; aedeagus Fig. 149 ........ ***Anomala levicollis*** **Filippini, Micó, Galante, 2015**

42 Male with large eyes (interocular ratio < 1.8); medium size ........ **43**

– Male with small eyes (interocular ratio > 2.2); medium and large size ........ **44**

43 Pronotum with coarse punctures, basal half of lateral margins parallel; elytra with small irregularly placed flecks; aedeagus Fig. 164 ........ ***Anomala perspicax*** **Filippini, Micó, Galante, 2015**

– Pronotum with fine punctures, basal half of lateral margins oblique to the base; elytra with large maculae organized in three rows; aedeagus Fig. 177 ........ ***Anomala stillaticia*** **Filippini, Micó, Galante, 2015**

44 Body length > 13.0 mm, body width > 7 mm; elytra nearly completely dark ........ **45**

– Body length < 12.6 mm, body width < 6.8 mm; elytra usually with abundant light flecks ........ **46**

45 Green pronotum; elongated ochre maculae on elytra; light colored pygidium; aedeagus Fig. 182 ........ ***Anomala tenoriensis*** **Filippini, Micó, Galante, 2015**

– Brown pronotum; diffuse ochre flecks on elytra; pygidium with large dark maculae; aedeagus Fig. 181 ........ ***Anomala subusta*** **Filippini, Micó, Galante, 2015**

46 Basal half of lateral margins of pronotum parallel; body length ≤ 10.0 mm, body width < 5.2 mm ........ **47**

– Basal half of lateral margins of pronotum oblique to the base; body length generally > 11.0 mm, body width > 5.9 mm ........ **48**

47 Presence of concavity on frons; dark venter; micropunctation on elytra surface; male internal protarsal claw wide (upper branch 1/4 the width of the lower one); aedeagus Fig. 147 ...... ***Anomala latifalculata*** **Filippini, Micó, Galante, 2015**

– Frons with even surface; light venter; punctation on elytra surface simple; male internal protarsal claw narrow (upper branch 2/3 the width of the lower one); aedeagus Fig. 165 ......... ***Anomala piccolina*** **Filippini, Micó, Galante, 2015**

48 Clypeus with a straight apical side; pronotum green with ochre sides, surface homogeneous; aedeagus Fig. 151 ............................................................... .......................... ***Anomala longisacculata*** **Filippini, Micó, Galante, 2015**

– Clypeus with a sinuate apical side; pronotum with an irregular brown macula on disc, surface with wrinkles; aedeagus Fig. 141 ........................................ ................................. ***Anomala globulata*** **Filippini, Micó, Galante, 2015**

49 Pronotum and elytra covered with dense setae ......................................... **50**

– Pronotum and elytra glabrous or with very few setae................................ **56**

50 Body shape rounded, with widest point at mid length of elytra; two transversal bands on elytra: a median transversal wavy band, hind band usually not reaching the posterior margin of elytra ........ ***Anomala balzapambae*** **Ohaus, 1897**

– Body shape elongated, with widest point in last third of elytra; elytra with uniform color, or with 1 or more continuous transversal bands, hind band covering apical third of elytra; when bands are defined by maculae, they are arranged in 3 rows ......................................................................................... **51**

51 Elytra uniformly light brown or with one transversal dark band, apical third of elytra light colored; size approximately 11 mm ...................................... ................................ ***Anomala flavacoma*** **Filippini, Micó, Galante, 2013**

– Elytra uniformly dark brown or with two bands, apical third of elytra always dark; size varies ........................................................................................... **52**

52 Body length > 11.0 mm ................................................................................ **53**

– Body length < 10.1 mm ................................................................................ **54**

53 Elytra uniformly dark or with a lighter posthumeral band (and rarely, a second light band on disc); male protibia upper tooth short (less than 1/4 of total length) and almost straight; parameres with wide apex and strongly sinuate ventral margin (Fig. 170)................................................................... ......................... ***Anomala pseudoeucoma*** **Filippini, Micó, Galante, 2013**

– Two darker transversal bands visible on elytra; male protibia upper tooth long (greater than 1/4 of total length) and oblique; parameres with short rounded apex and slightly sinuate ventral margin (Fig. 135) ....................... ............................................................................ ***Anomala eucoma*** **Bates, 1888**

54 Pronotum with irregular surface due to small depressions at sides of median sulcus; parameres wide, with blunt and wide apex, length of parameres 3/4 of tectum length, basal ventral margin longer than dorsal joint of parameres.... ........................ ***Anomala megaparamera*** **Filippini, Micó, Galante, 2013**

– Pronotum with uniform surface, sometimes a median sulcus is present; parameres slender, with defined narrow apex, length of parameres not reaching

3/4 of tectum length, basal ventral margin as long as dorsal joint of parameres ........................................................................................ **55**
55 Ventral margin of parameres slightly sinuous, parameres long, more than half the length of the tectum (Fig. 163) ........................................................... ............................***Anomala parvaeucoma*** **Filippini, Micó, Galante, 2015**
– Ventral margin of parameres straight, parameres short, less than half the length of the tectum (Fig. 158).....***Anomala moroni*** **Filippini, Micó, Galante, 2015**
56 Both pronotum and elytra ochre.................***Anomala megalia*** **Bates, 1888**
– Either pronotum, elytra or both of darker color ....................................... **57**
57 Elytra with homogeneous color.................................................................. **58**
– Elytra with pattern of maculae or bands.................................................... **75**
58 Dark colored elytra .................................................................................. **59**
– Light colored elytra................................................................................... **65**
59 Small size, body length < 9.5 mm ............................................................. **60**
– Medium and large size, body length > 12.0 mm ........................................ **62**
60 Elytra regularly striated ....................***Anomala subaenea*** **(Nonfried, 1893)**
– Elytra with rows of punctures ................................................................... **61**
61 Elytra metallic green or coppery; large head (about 2/3 of pronotum width); elytra with rows of coalescing punctures.........***Anomala hoppi*** **Ohaus, 1928**
– Elytra brown; small head (about 1/2 of pronotum width); elytra with shallow isolated punctures ................................***Anomala cinaedias*** **nomen novum**
62 Elytra with costae defined by regular rows of punctures, and interstices with rows of punctures............***Anomala ferrea*** **Filippini, Micó, Galante, 2014**
– Elytra with costae not defined, irregular surface due to coalescing punctures ...**63**
63 Absence of metallic luster***Anomala semilla*** **Filippini, Micó, Galante, 2014**
– Presence of metallic luster ......................................................................... **64**
64 Large size (body length > 17 mm); oblong shape; clypeus with sinuate anterior margin ..............................................***Anomala obovata*** **Ohaus, 1933**
– Medium size (body length < 14 mm); oval shaped; clypeus with straight anterior margin....***Anomala cupreovariolosa*** **Filippini, Micó, Galante, 2014**
65 Pronotum of dark homogeneous color....................................................... **66**
– Pronotum with light colored sides ............................................................. **68**
66 Pronotum black........***Anomala nigroflava*** **Filippini, Micó, Galante, 2014**
– Pronotum dark brown ............................................................................... **67**
67 Pygidium and abdominal sternites ochre; body length > 16 mm; aedeagus Fig. 161 ..............................................***Anomala ochrogastra*** **Bates, 1888**
– Pygidium and abdominal sternites brown; body length < 14 mm; aedeagus Fig. 162 ..............................................***Anomala ochroptera*** **Bates, 1888**
68 Pronotum and wide elytral suture green..................................................... **69**
– Pronotum and narrow elytral suture brown ............................................... **70**
69 Pronotum with one green macula .................***Anomala arara*** **Ohaus, 1897**
– Pronotum with two maculae.......................................................................... ....................................***Anomala arthuri*** **Filippini, Micó, Galante, 2015**

70 Elytra regularly striated; size < 7.5 mm ....................................................
.......................................................***Anomala subaenea* (Nonfried, 1893)**

– Elytra with primary costae and punctured interstices; size > 8.5 mm........ **71**

71 Pronotum with two small dark maculae, not reaching half the length of pronotum and narrower than 1/4 of pronotum width; aedeagus Fig. 146 .........
..............................................................***Anomala jansoni* Ohaus, 1897**

– Pronotum with one or two maculae, larger than 1/2 the length and 1/4 the width of pronotum; different aedeagus.................................................... **72**

72 Pronotum with one pentagonal central macula not reaching basal margin; aedeagus Fig. 117.........................................***Anomala antica* Ohaus, 1897**

– Pronotum with large irregular macula, reaching basal margin at least at sides; different aedeagus ........................................................................... **73**

73 Body length >14.4 mm; aedeagus Fig. 134 ................................................
.....................................***Anomala estrella* Filippini, Galante, Micó, 2015**

– Body length < 14.0 mm; different aedeagus ............................................ **74**

74 Body length > 12 mm; pronotum usually with median ochre line; males with dark brown abdominal sternites; aedeagus Fig. 133.....................................
......................................***Anomala divisa* Filippini, Galante, Micó, 2015**

– Body length < 10 mm; pronotum without median ochre line; males with ochre abdominal sternites; aedeagus Fig. 173 ............................................
..............................................................***Anomala ruatana* Bates, 1888**

75 Elytral pattern consisting of maculae or lines arranged in at least one median transversal band ........................................................................... **76**

– Other elytral pattern, not forming transversal bands ................................ **88**

76 Elytra pattern consisting of one median transversal band ......................... 77

– Elytra pattern consisting of two or more transversal bands, or presence of maculae at base and apex of elytra........................................................... **80**

77 Small size (body length < 8.5 mm); elytral transversal band simple, elytral base color ochre ........***Anomala unilineata* Filippini, Galante, Micó, 2015**

– Medium size (body length > 10.5 mm); elytral transversal band crossed by vertical lines, elytral base color ochre or orangish yellow .......................... **78**

78 Pronotum with shallow sparse punctures, surface appearing polished to the naked eye; aedeagus Fig. 168 ..................***Anomala popayana* Ohaus, 1897**

– Pronotum with deep dense punctures, visible to naked eye; aedeagus different ...................................................................................................... **79**

79 Elytral transversal row narrow (less than 1/8 of elytra length), with long vertical lines; aedeagus Fig. 127 ......................***Anomala clathrata* Ohaus, 1930**

– Elytral transversal row wide (about 1/4 of elytra length), with faint vertical lines; aedeagus Fig. 193.........................................................................
.................................***Anomala zumbadoi* Filippini, Micó, Galante, 2014**

80 Medium size (body length 10–12 mm, body width 6–7 mm) .................. **81**

– Small size (body length 6–9 mm, body width < 5 mm)............................ **82**

81 Macula on pronotum not reaching basal margin; elytra without maculae at sides of scutellum; aedeagus Fig. 191 ........................................................ .................................*Anomala volsellata* **Filippini, Micó, Galante, 2014**
– Macula on pronotum reaching basal margin; elytra with maculae at sides of scutellum; aedeagus Fig. 176.................................................................... ........................................*Anomala solisi* **Filippini, Micó, Galante, 2014**
82 Macula on pronotal disc irregular, consisting of a longitudinal median bar with two 3-shaped maculae at sides; elytra light brown with ochre short longitudinal lines (Fig. 30).........................*Anomala histrionella* **Bates, 1888**
– Macula on pronotal disc large or pronotum entirely dark; elytra ochre and dark brown ........................................................................................ **83**
83 Pronotum of homogeneous dark color..................................................... **84**
– Pronotum with ochre sides ..................................................................... **86**
84 Body shape rounded; apical third of elytra dark in color; head width less than half the basal width of pronotum..................*Anomala eulissa* **Bates, 1888**
– Body shape elongated; apical third of elytra light colored with maculae; head width more than half the basal width of pronotum................................. **85**
85 Elytra regularly striated; pronotum long (ratio width/length < 1.3), with coalescing coarse punctures.......*Anomala strigodermoides* **Filippini, Galante, Micó, 2015**
– Elytra with punctured interstices; pronotum short (ratio width/length > 1.6) with isolated fine punctures ..................*Anomala calligrapha* **Bates, 1888**
86 Body length < 6.0 mm; apical portion of elytra mainly dark; aedeagus Fig. 124 .....................................................*Anomala chiriquina* **Bates, 1888**
– Body length > 7.5 mm; apical portion of elytra light colored; aedeagus different ............................................................................................... **87**
87 Pronotum metallic green with narrow ochre sides; elytra with two wavy bands, usually complete .................*Anomala undulata* **Melsheimer, 1844**
– Pronotum brown with wide ochre sides (metallic luster present on some specimens); elytra with bands usually composed of isolated maculae........... ..........................................................*Anomala discoidalis* **Bates, 1888**
88 Elytral pattern made up of pigmented punctures on striae ....................... **89**
– Elytral pattern not linked to punctures ................................................... **92**
89 Body length ≥ 15 mm, body width ≥ 9 mm.............................................. ........................................................*Anomala valida* **Burmeister, 1844**
– Body length ≤ 11 mm, body width ≤ 6.5 mm .......................................... **90**
90 Body length < 8.5 mm; first elytral costa defined by a sulcus....................... ...................................................*Anomala ludoviciana* **Schaeffer, 1906**
– Body length >10.5 mm; first elytral costa defined by scattered punctures. **91**
91 First interstice on elytra with 4–5 irregular rows of punctures; elytral suture not pigmented; pygidium covered with dense short setae; males with first tooth of protibia longer than width of protibia .......................................... ......................................................... *Anomala foraminosa* **Bates, 1888**
– First interstice on elytra with 2–3 irregular rows of punctures; elytral suture dark brown; pygidial disc glabrous; males with first tooth of protibia shorter

than width of protibia ................................................................................
................................***Anomala robiginosa* Filippini, Galante, Micó, 2015**
92 Elytra metallic green ........................................................................ **93**
– Elytra black and ochre ........................................................................ **94**
93 Elytra with branched yellow lines at apex; pronotum entirely metallic green
.......................................***Anomala aglaos* Filippini, Galante, Micó, 2015**
– Elytra with ochre apex; pronotum with ochre sides .....................................
..........................................................***Anomala semicincta* Bates, 1888**
94 Elytra black with ochre base....***Anomala mersa* Filippini, Galante, Micó, 2015**
– Elytra ochre with dark maculae ............................................................ **95**
95 Pronotum with two dark maculae; elytra with black maculae on humeral calli .........................................................***Anomala quiche* Ohaus, 1897**
– Pronotum entirely black; elytra with irregular black maculae mainly on sides .......................................................***Anomala limon* nomen novum**
96 Pronotum with basal bead, complete or obliterated at the middle ............ **97**
– Pronotum without basal bead, margin smooth....................................... **100**
97 Elytra regularly sulcated, homogeneously dark colored............................ **98**
– Elytra punctate; pronotum with brown-reddish color and lighter colored elytra...................................................................................................... **99**
98 Dark green color with bronze luster; elytra surface with irregular aspect due to presence of secondary rows of punctures on costae.................................
......................................................... ***Callistethus nicoya* (Ohaus, 1928)**
– Bluish black color, no metallic luster; elytra surface with smooth costae.......
......................................................... ***Callistethus sulcans* (Bates, 1888)**
99 Elytra nearly smooth, homogeneously orange-reddish in color....................
........................................................***Anomala praecellens* Bates, 1888**
– Elytra with rows of coalescing sparse punctures, ochre in color ...................
.....................................................***Anomala cupricollis* Chevrolat, 1834**
100 Elytra with pattern of regular maculae and stripes in yellowish white and red or black..................................... ***Callistethus chrysomelinus* (Bates, 1888)**
– Elytra of homogeneous color, green or brown ...................................... **101**
101 Stout body, wider at 2/3 elytra length; body surface convex; interocular space narrow (less than 3.5 times the width of eye); elytra with defined costae and punctate interstices ....................................................................... **102**
– Body rhomboidal shaped, pronotum long and with anterior margin narrow, end of body narrowing steadily from half of elytra length; body surface flattened; wide interocular space (more than 3.8 times the width of eye); elytra regularly striated or nearly smooth ...................................................... **110**
102 Elytra metallic green with brown hues and shallow coalescing punctures .....
..................................***Callistethus yalizo* Filippini, Galante, Micó, 2015**
– Elytra brown, metallic luster may be present, costae and punctures well defined ......................................................................................... **103**
103 Elytra light brown, lighter in color than pronotum ............................... **104**
– Elytra dark brown, similar in tone to pronotum.................................... **106**

104 Elytra with bronze luster; first interstice wide with dense punctures; pronotum glabrous............***Callistethus lativittis*** **Filippini, Galante, Micó, 2015**
– Elytra without metallic luster; first interstice narrow with 1–2 rows of punctures; pronotum covered with setae....................................................... **105**
105 Mesosternal process pointed in lateral view, large and slightly tapering at apex in ventral view; parameres with squared apex (Fig. 212).......................
..........................***Callistethus parapulcher*** **Filippini, Galante, Micó, 2015**
– Mesosternal process blunt in lateral view, tapering strongly just above base in ventral view; parameres with acute apex (Fig. 215).....................................
........................................................***Callistethus schneideri*** **(Frey, 1968)**
106 Pronotum with homogeneous color, no ochre margins ................................
..................................................... ***Callistethus chontalensis*** **(Bates, 1888)**
– Pronotum with ochre margins .............................................................. **107**
107 Elytral surface with protruding costae, interstices flat with dense irregular punctures.................................... ***Callistethus valdecostatus*** **(Bates, 1888)**
– Costae not protruding in relation to rest of elytral surface, interstices with rows of punctures........................................................................... **108**
108 Mesosternal process long, slightly protruding beyond mesocoxae; first interstice of elytra with four rows of punctures, other interstices with irregular rows of punctures, flat.........................................................................
...........................***Callistethus fuscorubens*** **Filippini, Galante, Micó, 2015**
– Mesosternal process short, not protruding beyond mesocoxae; first interstice of elytra with three rows of punctures, other interstices with regular rows of punctures forming sulcate striae ........................................................... **109**
109 Secondary small sparse punctures on the whole elytra surface; aedeagus Fig. 203; endophallus Fig. 313 ............***Callistethus granulipygus*** **(Bates, 1888)**
– No secondary punctures on elytra, background surface smooth; aedeagus Fig. 220; endophallus Fig. 330 ............... ***Callistethus vanpatteni*** **(Bates, 1888)**
110 Elytra clearly striated, of variable color ................................................... **111**
– Elytra nearly smooth with very shallow rows of punctures, black color ........
................................... ***Callistethus carbo*** **Filippini, Galante, Micó, 2015**
111 Body length > 9.5 mm; pygidium ochre with green sides; head small in relation to pronotum (head width < 0.45 pronotum width) .............................
.................***Callistethus macroxantholeus*** **Filippini, Galante, Micó, 2015**
– Body length < 8.6 mm; pygidium entirely yellow; head large in relation to pronotum (head width > 0.55 of pronotum width).....................................
..................***Callistethus microxantholeus*** **Filippini, Galante, Micó, 2015**
112 Elytra surface with regular and sulcate striae, normally 14 in number .... **113**
– Elytra surface nearly smooth, or with intercostal spaces with shallow irregular punctures, never forming sulcate striae.................................................. **118**

113 Pronotum with irregular dark macula; clypeus rectangular; elytra with transversal band, yellow, without metallic luster ........................................ ............................***Callistethus ruteloides* Filippini, Galante, Micó, 2015**

– Pronotal disc uniform in color; clypeus subtrapezoidal; elytra with uniform color and presence of metallic luster........................................ **114**

114 Elytra of same color as pronotum; body length < 16.0 mm.................... **115**

– Elytra of lighter color than pronotum; body length > 16.0 mm .................. ........................................***Callistethus specularis* (Bates, 1888)**

115 Elytra and pronotum yellow; aedeagus Fig. 209 ........................................ ........................................ ***Callistethus mimeloides* (Ohaus, 1902)**

– Elytra and pronotum green; different aedeagus ..................................... **116**

116 Body length > 14.0 mm; ochre margins of pronotum concealed by metallic green luster; bright light green color with reddish hues ............................... ........................................ ***Callistethus calonotus* (Bates, 1888)**

– Body length < 14.0 mm; ochre margins evident at wide end of pronotum; dark to brownish metallic green color ................................................... **117**

117 Apex of parameres wide and straight in lateral view (Fig. 213) .................... ......................***Callistethus pseudocollaris* Filippini, Galante, Micó, 2015**

– Apex of parameres narrow and bending upwards in lateral view (Fig. 210) .. .......................***Callistethus multiplicatus* Filippini, Galante, Micó, 2015**

118 Elytra of same color as pronotum, green or purple blackish .................. **119**

– Elytra of lighter color than pronotum, yellowish or light green ............. **120**

119 Elytral surface completely smooth; ventral side brownish, without metallic luster........................................ ***Callistethus chlorotoides* (Bates, 1888)**

– Elytral surface with very shallow punctures, costae visible; ventral side with green metallic luster....***Callistethus levigatus* Filippini, Galante, Micó, 2015**

120 Body length > 20 mm........................................................................ **121**

– Body length < 17 mm........................................................................ **122**

121 Costae on elytra defined by sulcated rows of punctures; aedeagus Fig. 199 .. ........................................ ***Callistethus chrysanthe* (Bates, 1888)**

– Costae poorly defined, not sulcated; aedeagus Fig. 204 ............................... ........................................***Callistethus jordani* (Ohaus, 1902)**

122 Elytral surface irregular with small wrinkles, punctation not clearly visible to the naked eye; body length > 16.5 mm ........................................ ...................... ***Callistethus stannibractea* Filippini, Galante, Micó, 2015**

– Elytral surface with regular, clearly visible costae and punctate interstices; body length < 16 mm ........................................................................ **123**

123 Body length 12–13 mm; deep punctures on elytra; ventral side ochre reddish in color, or only partially with green luster (not on abdominal sternites or legs); flat sixth spiracle ..................***Callistethus xiphostethus* (Bates, 1888)**

– Body length 14–15 mm; shallow punctures on elytra; ventral side completely dark metallic green; tuberculiform sixth spiracle ........................................ ........................***Callistethus flavodorsalis* Filippini, Galante, Micó, 2015**

**Clave taxonómica para especies de la tribu Anomalini de Costa Rica**

Algunas partes han sido modificadas a partir de: Jameson et al. 2003, Filippini et al. 2013, Filippini et al. 2015a, d.

1 Mesoepímero visible anteriormente a la base del élitro en vista dorsal (Fig. 338B); forma del cuerpo alargada .............................................................. **2**

– Mesoepímero oculto por la base de los élitros o ligeramente expuesto (Fig. 338A); forma del cuerpo ovalada o alargada .............................................. **3**

2 Región intercoxal mesoesternal similar en ancho a la base del mesofémur; mesoepímero subrectangular, bien expuesto; clípeo del macho poco doblado al ápice; superficie dorsal de los élitros plana; pronoto más estrecho que la base de los élitros (exceptuado *S. orbicularis*) ............................................... .................................................. ***STRIGODERMA*** **Burmeister, 1844**...7

– Región intercoxal mesoesternal ancha menos de 1/4 de la base del mesofémur; mesoepímero subtriangular, parcialmente expuesto; clípeo del macho ampliamente doblado al ápice; superficie dorsal de los élitros redondeada, pronoto tan ancho como la base de los élitros ......................................................... .......................***Epectinaspis costaricensis*** **Ramírez-Ponce & Curoe, 2014**

3 Sutura frontoclipeal incompleta; lados del clípeo elevados en la base del canto; machos con el disco del pronoto con una depresión; hembras con el margen apical del pronoto con una muesca en la mitad.................................... ..............***ANOMALORHINA*** **Jameson, Paucar-Cabrera, Solís, 2003**...**17**

– Sutura frontoclipeal completa; lados del clípeo ligeramente elevados o planos en la base del canto; machos con el disco del pronoto uniformemente convexo; hembras con el margen apical del pronoto liso ................................. **4**

4 Espacio entre las mesocoxas plano o ligeramente convexo que no se prolonga más allá de los mesotrocanteres; pronoto con margen basal completo o interrumpido en el medio............................***ANOMALA*** **Samouelle, 1819**...**18**

– Presencia de un proceso mesoesternal prolongado más allá de los mesotrocanteres; pronoto con el margen basal presente o liso ..................................... **5**

5 Parámeros perpendiculares a la falobase; quinto metatarso similar en longitud a los metatarsos 1-4 unidos, excluyendo las uñas; pequeño tamaño ............. .................................................. ***Moroniella nitidula*** **(Blanchard, 1851)**

– Parámeros dispuestos en línea con la falobase; quinto metatarso más corto que los metatarsos 1-4 unidos, excluyendo las uñas ................................... **6**

6 Proceso mesoesternal corto, no sobrepasando (o sobrepasando muy levemente) la mesocoxa; ápice del proceso romo en vista lateral ...................................... ***ANOMALA*** **Samouelle, 1819** and ***CALLISTETHUS*** **Blanchard, 1851**...**96**

– Proceso mesoesternal largo, sobrepasando la mesocoxa más de la mitad de la anchura de la misma, ápice libre en vista lateral........................................... ............................................... ***CALLISTETHUS*** **Blanchard, 1851**...**112**

7 Pronoto con superficie irregular, granulada o con impresiones .................. **8**

– Pronoto liso ...................................................................................... **10**

8 Pronoto con superficie granulada ........ ***Strigoderma nodulosa* Ohaus, 1902**

– Pronoto con impresiones ........................................................................ **9**

9 Longitud 11–13 mm; pronoto homogéneamente negro o cobrizo; forma alargada (élitros más de 2 veces más largos que anchos) ............................... ............................................. ***Strigoderma sulcipennis* Burmeister, 1844**

– Longitud 7–9 mm; pronoto verde o marrón rojizo con lados amarillentos; forma redondeada (élitros menos de 2 veces más largos que anchos) ............ ...................................................... ***Strigoderma castor* (Newman, 1838)**

10 Élitros lisos; vientre con colores metálicos brillantes .................................... ...................................................... ***Strigoderma auriventris* Bates, 1888**

– Élitros estriados; vientre sin colores metálicos.......................................... **11**

11 Pronoto de color verde metálico............................................................. **12**

– Pronoto marrón o negro, sin reflejos metálicos......................................... **14**

12 Élitros negros con un círculo amarillo cerca de la base................................ ......................................................... ***Strigoderma rutelina* Bates, 1888**

– Élitros con color uniforme ..................................................................... **13**

13 Pronoto con una mancha central o color uniforme, élitros negros o marrones ..................................................... ***Strigoderma biolleyi* Ohaus, 1908**

– Pronoto con dos bandas claras, élitros marrones......................................... ....................................................... ***Strigoderma micans* Nonfried, 1893**

14 Élitros marrones............................. ***Strigoderma vestita* Burmeister, 1844**

– Élitros negros o marrones con manchas negras ......................................... **15**

15 Longitud 11–12 mm ..................... ***Strigoderma angulicollis* Ohaus, 1915**

– Longitud <8 mm .................................................................................. **16**

16 Forma redondeada; pronoto fuertemente convexo, tan ancho como la base de los élitros; longitud 7–8 mm .... ***Strigoderma orbicularis* Burmeister, 1855**

– Forma alargada; pronoto ligeramente convexo, más estrecho que la base de los élitros; longitud 5–7 mm ......... ***Strigoderma marginata* (Olivier, 1789)**

17 Cabeza y pronoto rojizos, élitros negros o marrones rojizos; macho con dos tubérculos en la base de la frente, clípeo con ápice agudo en vista frontal; hembras con primera interestría de los élitros dos veces más ancho que la primera estría, disco frontal ligeramente cóncavo ....................................... ............................................. ***Anomalorhina turrialbana* (Ohaus, 1928)**

– Cabeza, pronoto y élitros marrones; macho sin tubérculos en la frente, clípeo con ápice cuadrado en vista frontal; hembras con primera interestría de los élitros tan ancho como la primera estría, disco frontal ligeramente convexo . ................ ***Anomalorhina osaensis* Jameson, Paucar-Cabrera, Solís, 2003**

18 Protibia con 3 dientes ............................................................................ **19**

– Protibia con 2 dientes ............................................................................ **49**

19 Élitros de color homogéneo ..................................................................... **20**

– Élitros con manchas oscuras..................................................................... **22**

20 Color del cuerpo mayoritariamente marrón oscuro .................................... ....................................... ***Anomala coffea* Filippini, Galante, Micó, 2015**

– Pronoto marrón oscuro o verde, élitros color ocre .................................... **21**

21 Pronoto de color homogéneo, verde o marrón; longitud corporal 11.0–13.0 mm; edeago en Fig. 183............ ***Anomala testaceipennis*** **Blanchard, 1851**

– Pronoto marrón oscuro con lados amarillentos; longitud 8.5–9.5 mm; edeago en Fig. 190....................................... ***Anomala veraecrucis*** **Bates, 1888**

22 Cabeza y pronoto negros uniformes, élitros ocre con grandes manchas irregulares negras que se desarrollan longitudinalmente (Fig. 53) .......................... .................................***Anomala pincelada*** **Filippini, Galante, Micó, 2015**

– Cabeza y pronoto verdes metálico o marrones, pronoto normalmente con lados amarillentos, élitro con manchas oscuras pequeñas en hileras transversales o pequeñas manchitas en toda la superficie............................................... **23**

23 Patrón de los élitros constituido por una mancha central o una hilera transversal media ........................................................................................ **24**

– Patrón de los élitros constituido por varias hileras de manchas o manchitas dispersas.......................................................................................... **25**

24 Pronoto mayoritariamente marrón oscuro, con sutiles márgenes amarillos; longitud 10–12 mm; edeago en Fig. 156 .................................................... ................................***Anomala mesosticta*** **Filippini, Galante, Micó, 2015**

– Pronoto con una mancha oscura pentagonal central ocupando menos de la mitad de la anchura del pronoto; longitud 8–10 mm; edeago en Fig. 131.... ......................................***Anomala cyclops*** **Filippini, Galante, Micó, 2015**

25 Pronoto con impresiones profundas.......................................................... ..............................***Anomala inbio*** **(Ramírez-Ponce, Bitar, Curoe, 2014)**

– Pronoto con superficie homogéneamente convexa .................................. **26**

26 Presencia de setas en pronoto y élitros...................................................... **27**

– Pronoto y élitros glabros, el pronoto puede tener unas pocas setas............ **29**

27 Longitud 10.0–11.5 mm; pronoto con puntuación densa; élitros con 2 hileras regulares de manchas; edeago en Fig. 148 ........................................... ..............................***Anomala leopardina*** **Filippini, Micó, Galante, 2015**

– Longitud 12.0–14.0 mm; pronoto con puntuación escasa y gruesa; élitros cubiertos irregularmente por manchitas; edeago diferente ........................ **28**

28 Color claro; pronoto con márgenes muy sinuados; edeago en Fig. 126......... ..............................***Anomala clarivillosa*** **Filippini, Micó, Galante, 2015**

– Color oscuro; pronoto con márgenes ligeramente sinuados; edeago en Fig. 121 ..........................***Anomala atrivillosa*** **Filippini, Micó, Galante, 2015**

29 Márgenes laterales del pronoto sinuados ................................................... **30**

– Márgenes laterales del pronoto convexos o formando un ángulo ............. **37**

30 Lados del pronoto profundamente sinuados (cruzando una línea imaginaria que une los ángulos apicales y basales), pronoto casi completamente oscuro; edeago en Fig. 167 .................................... ***Anomala polygona*** **Bates, 1888**

– Lados del pronoto poco sinuados (no cruzan una línea imaginaria que une los ángulos apicales y basales); pronoto con una mancha irregular en el disco o lados amarillentos; edeago diferente ...................................................... **31**

31 Pronoto oscuro con lados amarillentos; élitros con manchas regulares; edeago en Fig. 142 ...................... ***Anomala hiata*** **Filippini, Micó, Galante, 2015**

– Pronoto con una mancha irregular en el disco; élitros con numerosas manchitas; edeago diferente ........................................................................ **32**

32 Pronoto con una mancha sutil y sinuosa; élitros con escasas manchitas; longitud < 11.5 mm; parámeros largos con ápice agudo y ángulo ventral saliente en vista lateral (Fig. 157)........................................................................ ................................ ***Anomala m-fuscum*** **Filippini, Micó, Galante, 2015**

– Pronoto con manchas más grandes; élitros con numerosas manchitas; longitud 10.2–13.4 mm, edeagos diferentes .................................................. **33**

33 Placa ventral con ángulos apicales alargados, parámeros más cortos que la mitad de la longitud del tecto ............. ***Anomala vulcanicola*** **Ohaus, 1897**

– Placa ventral con ápice curvo en vista ventral, parámeros más largos que la mitad de la longitud del tecto ................................................................. **34**

34 Placa ventral con porción apical curva en vista lateral.............................. **35**

– Placa ventral con ápice recto ..................................................................... **36**

35 Parámeros cortos con ápice romo en vista lateral (Fig. 120) ........................ .................................... ***Anomala aspersa*** **Filippini, Micó, Galante, 2015**

– Parámeros largos con ápice agudo en vista lateral (Fig. 184)........................ ........................................................... ***Anomala trapezifera*** **Bates, 1888**

36 Parámeros largos y estrechos, margen dorsal curvo, ángulo ventral obtuso (Fig. 180).................. ***Anomala subridens*** **Filippini, Micó, Galante, 2015**

– Parámeros cortos y anchos, margen dorsal sinuado, ángulo ventral apuntando hacia atrás en vista lateral (Fig. 189)...................................................... ................................ ***Anomala vallisneria*** **Filippini, Micó, Galante, 2015**

37 Élitros de color claro con manchitas esparcidas; longitud > 14.1 mm....... **38**

– Élitros de color claro y longitud < 13.5 mm; o élitro oscuro y longitud > 14.1 mm ............................................................................................................ **40**

38 Presencia de una protuberancia en el clípeo, edeago en Fig. 185 ................. .............................. ***Anomala tuberculata*** **Filippini, Micó, Galante, 2015**

– Superficie del clípeo plana, edeago diferente........................................... **39**

39 Pronoto con una mancha irregular en el disco; élitros con manchas grandes; edeago en Fig. 137 ........ ***Anomala eusticta*** **Filippini, Micó, Galante, 2015**

– Pronoto completamente oscuro; élitros con manchitas pequeñas; edeago en Fig. 115 ................. ***Anomala aereiventris*** **Filippini, Micó, Galante, 2015**

40 Superficie del pronoto lisa......................................................................... **41**

– Superficie del pronoto con puntuación evidente ...................................... **42**

41 Pronoto completamente oscuro; partes inferiores del cuerpo homogéneamente marrón-bronce, metálicas; tercer diente de la protibia desarrollado débilmente; longitud > 13.2 mm; edeago en Fig. 115. ................................... ............................. ***Anomala aereiventris*** **Filippini, Micó, Galante, 2015**

– Pronoto con lados amarillentos; partes inferiores del cuerpo marrones con zonas amarillas; tercer diente de la protibia bien desarrollado; longitud < 13.0

mm; edeago as in Fig. 149 ........................................ *Anomala levicollis* **Filippini, Micó, Galante, 2015**

42 Macho con ojos grandes (proporción espacio interocular/diámetro del ojo < 1.8); tamaño mediano ........................................ **43**

– Macho con ojos pequeños (proporción espacio interocular/diámetro del ojo > 2.2); tamaño medio y grande ........................................ **44**

43 Pronoto con puntuación gruesa, mitad basal de los márgenes laterales paralelos; élitros con manchitas pequeñas esparcidas irregularmente; edeago en Fig. 164 ........................................ ***Anomala perspicax*** **Filippini, Micó, Galante, 2015**

– Pronoto con puntuación fina, mitad basal de los márgenes laterales oblicuos respecto a la base; élitros con manchas grandes organizadas en 3 hileras transversales; edeago en Fig. 177 ........................................ ***Anomala stillaticia*** **Filippini, Micó, Galante, 2015**

44 Longitud > 13.0 mm, anchura >7 mm; élitros casi completamente oscuros.. **45**

– Longitud < 12.6 mm, anchura < 6.8 mm; élitros normalmente con abundantes manchitas claras ........................................ **46**

45 Pronoto verde; élitros con manchas amarillas alargadas; pigidio de color claro; edeago en Fig. 182 ........................................ ***Anomala tenoriensis*** **Filippini, Micó, Galante, 2015**

– Pronoto marrón; élitros con numerosas manchitas pequeñas amarillas; pigidio con una grande mancha oscura; edeago en Fig. 181 ........................................ ***Anomala subusta*** **Filippini, Micó, Galante, 2015**

46 Mitad basal de los lados laterales del pronoto paralelos; longitud <=10.0 mm, anchura < 5.2 mm ........................................ **47**

– Mitad basal de los lados laterales del pronoto oblicuos respecto a la base; longitud generalmente > 11.0 mm, anchura > 5.9 mm ........................................ **48**

47 Frente cóncava; zonas inferiores oscuras; presencia de micropuntuación en la superficie de los élitros; uña protarsal interna del macho ancha (rama superior 1/4 de ancha de la inferior); edeago en Fig. 147 ........................................ ***Anomala latifalculata*** **Filippini, Micó, Galante, 2015**

– Frente con superficie plana; zonas inferiores claras; puntuación de los élitros simple; uña protarsal interna del macho estrecha (rama superior 2/3 de ancha de la inferior); edeago en Fig. 165 ........................................ ***Anomala piccolina*** **Filippini, Micó, Galante, 2015**

48 Clípeo con lado apical recto; pronoto verde con lados amarillentos, con superficie homogénea; edeago en Fig. 151 ........................................ ***Anomala longisacculata*** **Filippini, Micó, Galante, 2015**

– Clípeo con ápice sinuado; pronoto con una mancha marrón irregular en el disco, con superficie irregular; edeago en Fig. 141 ........................................ ***Anomala globulata*** **Filippini, Micó, Galante, 2015**

49 Pronoto y élitros cubiertos densamente por sedas ........................................ **50**

– Pronoto y élitros glabros o con muy pocas sedas ........................................ **56**

50 Forma redondeada, con la máxima anchura a mitad de la longitud de los élitros; 2 bandas transversales en los élitros: una banda mediana ondulada constituida por manchas separadas y otra en el tercio apical, normalmente sin llegar a él........................................***Anomala balzapambae*** **Ohaus, 1897**

– Forma alargada, con la máxima anchura en el último tercio de los élitros; élitros de color uniforme, o con 1 ó más bandas transversales continuas, la banda inferior cubre el tercio apical del élitro, cuando las bandas están definidas por manchas, se organizan en 3 bandas transversales ....................... **51**

51 Élitros uniformemente marrón claro o con 1 banda transversal oscura; longitud aproximadamente 11 mm................................................................. ................................***Anomala flavacoma*** **Filippini, Micó, Galante, 2013**

– Élitros uniformemente marrón oscuros o con 2 bandas transversales, tercio apical del élitro siempre oscuro, longitud variada .................................... **52**

52 Longitud mayor a 11 mm ................................................................... **53**

– Longitud menor a 10.1 mm................................................................. **54**

53 Élitros uniformemente oscuros o con una zona basal clara (raramente está presente una segunda banda clara en el disco); diente superior de la protibia del macho corto (menos de 1/4 de la longitud total de la protibia) y recto; edeago con ápice ancho y margen ventral fuertemente sinuado (Fig. 170).... .........................***Anomala pseudoeucoma*** **Filippini, Micó, Galante, 2013**

– Élitros con 2 bandas oscura transversales; diente superior de la protibia del macho largo (más de 1/4 de la longitud total de la protibia) y oblicuo; parámeros con ápice redondeado y margen ventral débilmente sinuado (Fig. 135)........................................................***Anomala eucoma*** **Bates, 1888**

54 Pronoto con superficie irregular debida a pequeñas depresiones a los lados de un surco mediano; parámeros anchos, longitud máxima 3/4 de la longitud del tecto, con ápice romo y ancho, margen ventral basal más largo que la unión dorsal de los parámeros ............................................................... .........................***Anomala megaparamera*** **Filippini, Micó, Galante, 2013**

– Pronoto con superficie uniforme, a veces está presente un surco mediano; parámeros esbeltos, con ápice definido y estrecho, longitud de los parámeros no llega a 3/4 de la longitud del tecto; margen ventral basal tan largo como la unión dorsal de los parámeros ............................................................ **55**

55 Margen ventral de los parámeros ligeramente sinuada, parámeros largos, más de la mitad de la longitud del tecto (Fig. 163)............................................ ......................................***A. parvaeucoma*** **Filippini, Micó, Galante, 2015**

– Margen ventral de los parámeros recto, parámeros cortos, menos de la mitad de la longitud del tecto (Fig. 158) ............................................................ ..............................................***A. moroni*** **Filippini, Micó, Galante, 2015**

56 Pronoto y élitros amarillo claro ...................***Anomala megalia*** **Bates, 1888**

– Pronoto o élitros o ambos de color oscuro.............................................. **57**

57 Élitros de color homogéneo ............................................................... **58**

– Élitros con manchas o bandas ............................................................. **75**

58 Élitros de color oscuro .......... **59**

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59 Tamaño pequeño (longitud <9.5 mm) .......... **60**

– Tamaño medio y grande (longitud >12 mm) .......... **62**

60 Élitros con surcos regulares .......... ***Anomala subaenea* (Nonfried, 1893)**

– Élitros con hileras de puntos .......... **61**

61 Élitros verde metálico o cobrizos; cabeza ancha (alrededor de 2/3 de la anchura del pronoto); élitros con hilera de puntos coalescentes .......... ***Anomala hoppi* Ohaus, 1928**

– Élitros marrones; cabeza pequeña (alrededor de 1/2 de la anchura del pronoto); élitros con puntos aislados y pocos profundos .......... ***Anomala cinaedias* nomen novum**

62 Élitros con estrías definidas por hileras regulares de puntos, interestrias con hileras de puntos .......... ***Anomala ferrea* Filippini, Micó, Galante, 2014**

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63 Superficie sin reflejos metálicos .......... ***Anomala semilla* Filippini, Micó, Galante, 2014**

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– Tamaño mediano (longitud < 14 mm); forma ovalada; clípeo con margen anterior recto .......... ***Anomala cupreovariolosa* Filippini, Micó, Galante, 2014**

65 Pronoto uniformemente oscuro .......... **66**

– Pronoto con bandas claras a los lados .......... **68**

66 Pronoto negro .......... ***Anomala nigroflava* Filippini, Micó, Galante, 2014**

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67 Pigidio y esternitos abdominales de color ocre; longitud > 16 mm; edeago en Fig. 161 .......... ***Anomala ochrogastra* Bates, 1888**

– Pigidio y esternitos abdominales marrones; longitud <14 mm; edeago en Fig. 162 .......... ***Anomala ochroptera* Bates, 1888**

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– Pronoto y sutura elitral estrecha de color marrón .......... **70**

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– Pronoto con 2 manchas verdes .......... ***Anomala arthuri* Filippini, Micó, Galante, 2015**

70 Élitros estriados regularmente; longitud < 7.5 mm .......... ***Anomala subaenea* (Nonfried, 1893)**

– Élitros con estrias primarias definidas e interestrias punteadas; longitud > 8.5 mm .......... **71**

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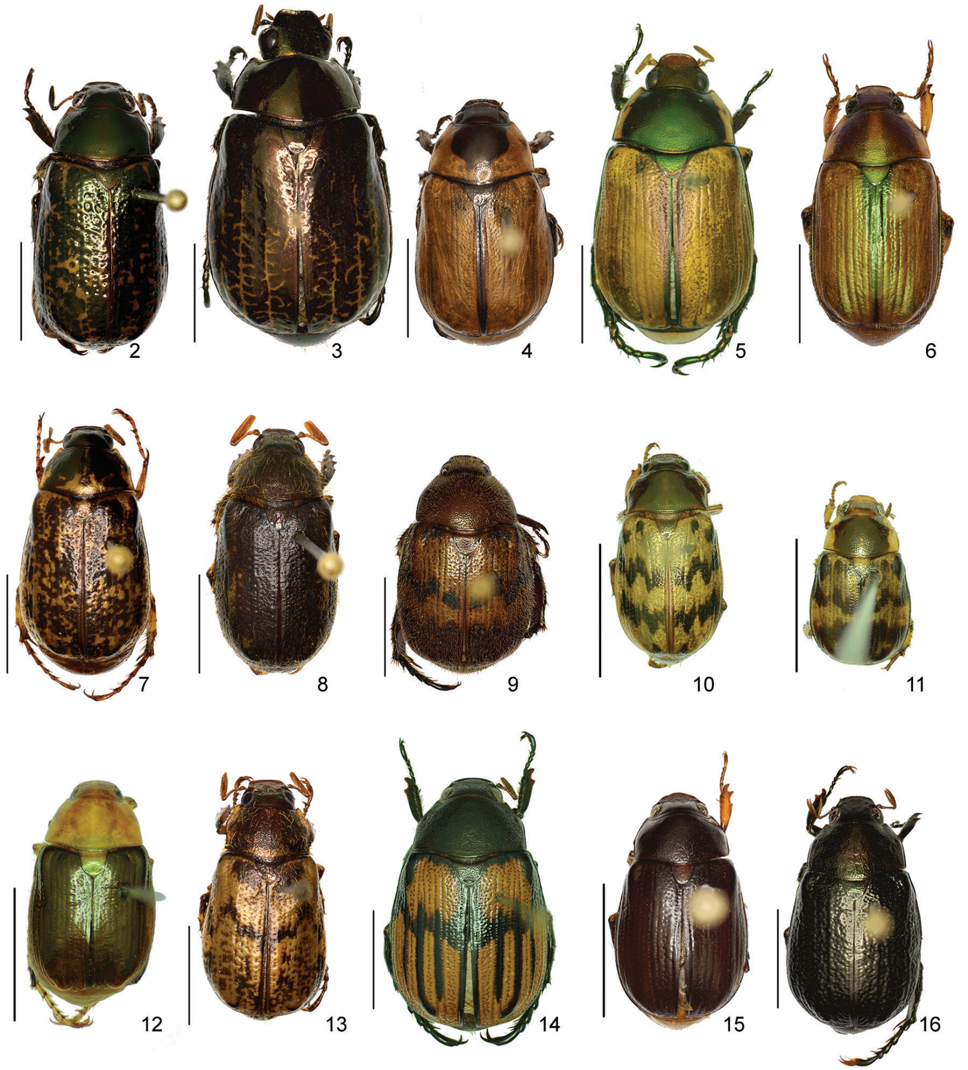
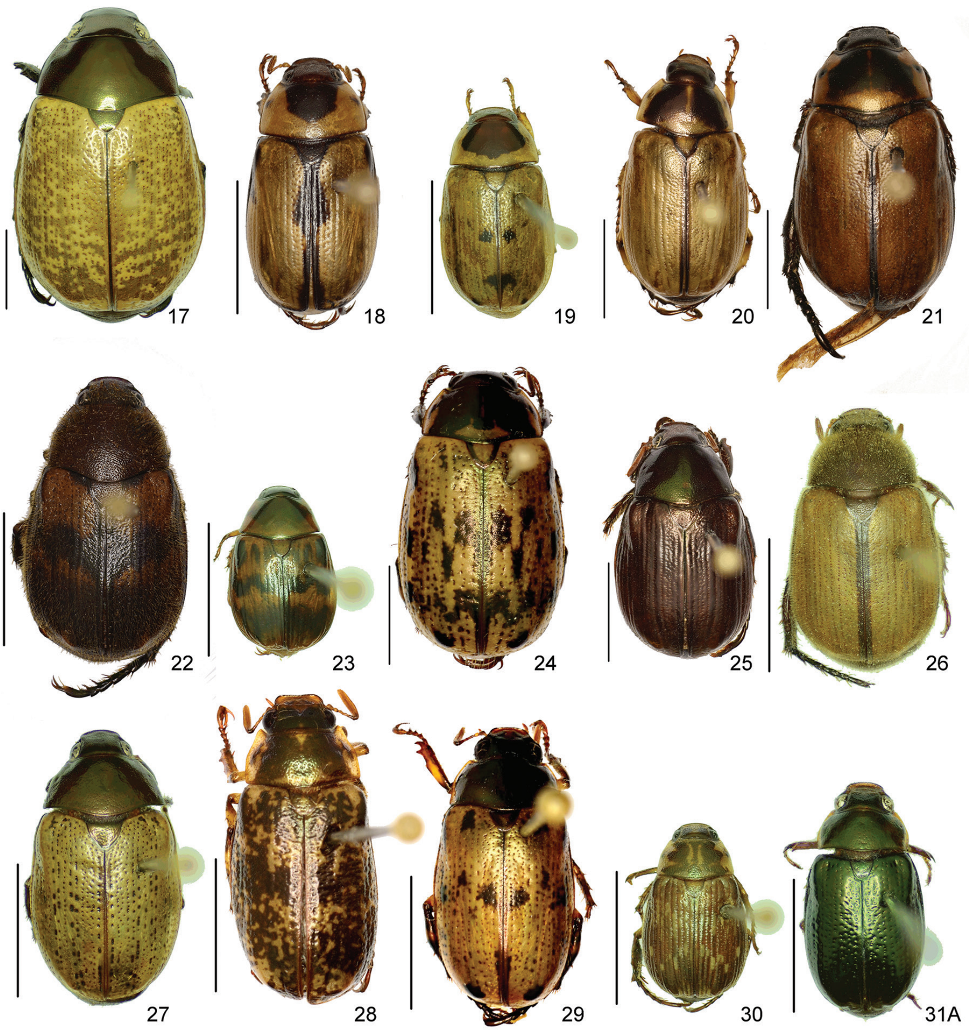
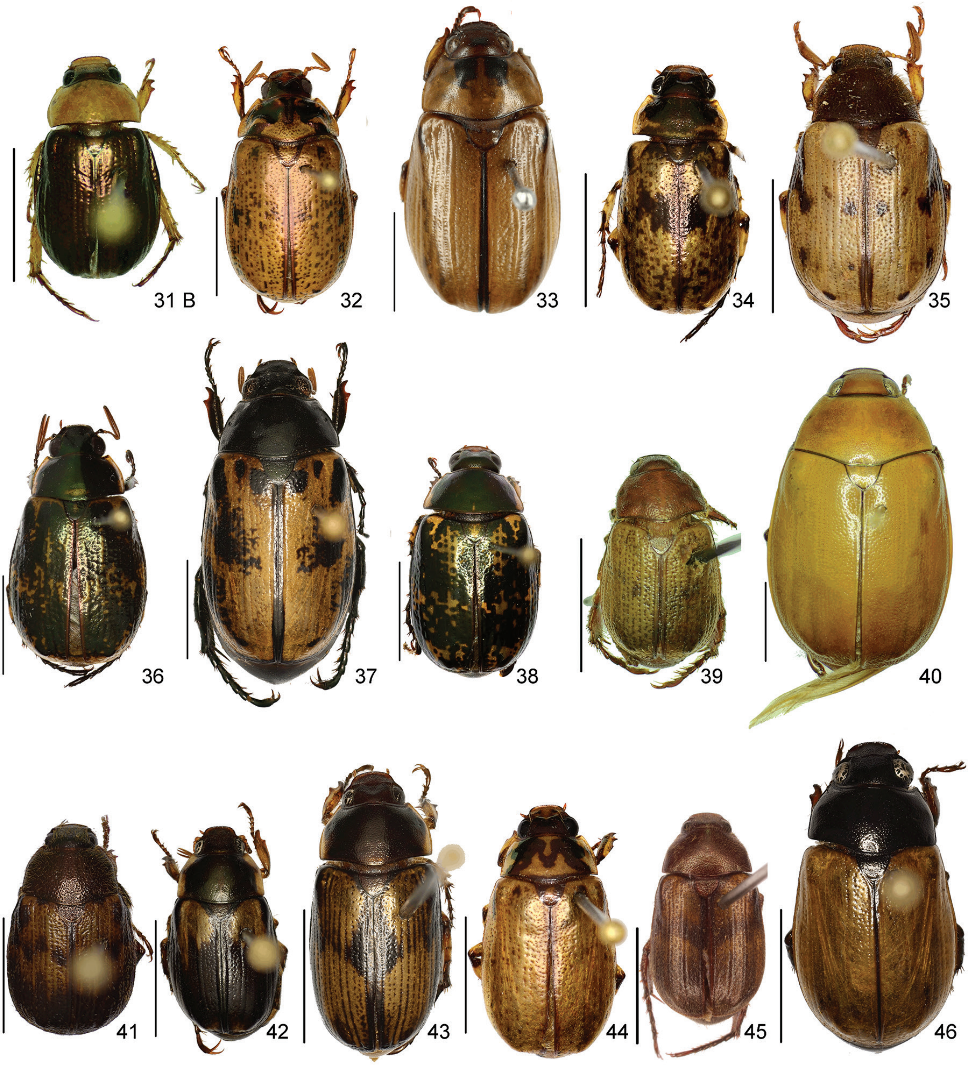
## Plates



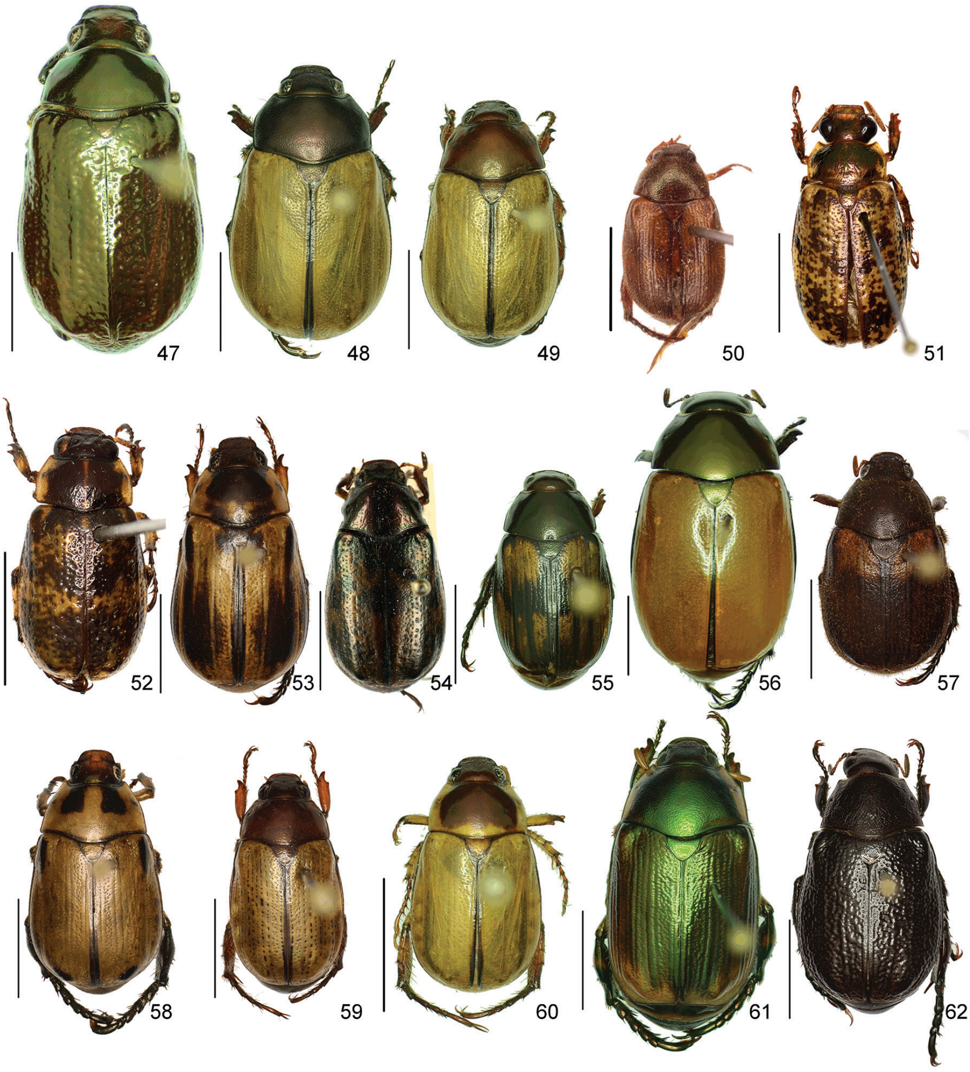

**Figures 2–16.** For each specimen is given the locality and province of recollection, and the collection where it is stored. Habitus. **2** *Anomala aereiventris* (Parque Nacional Tapantí, Cartago, MNCR) **3** *A. aglaos* (La Montura, San José, CEUA) **4** *A. antica* (Estación Palo Verde, Guanacaste, MNCR) **5** *A. arara* (Albergue Heliconias, Alajuela, CEUA) **6** *A. arthuri* (Estación Maritza, Guanacaste, MNCR) **7** *A. aspersa* (Villa Mills, Cartago, MNCR) **8** *A. atrivillosa* (Estación Barva, Heredia, MNCR) **9** *A. balzapambae* (Reserva biológica Hitoy Cerere, Limón, MNCR) **10** *A. calligrapha* (Estación Cabro Muco, Guanacaste, CEUA) **11** *A. chiriquina* (Finca Cafrosa, Puntarenas, MNCR) **12** *A. cinaedias* (San Luis, Puntarenas, MNCR) **13** *A. clarivillosa* (La Esperanza, Cartago, CEUA) **14** *A. clathrata* (Estación Cabro Muco, Guanacaste, CEUA) **15** *A. coffea* (Estación Pitilla, Guanacaste, MNCR) **16** *A. cupreovariolosa* (Las Cruces, Puntarenas, MNCR). Scale bars: 5 mm. Figs 6, 16 from Filippini et al. (2014); Fig. 3 from Filippini et al. (2015b); Fig. 15 from Filippini et al. (2015c); Figs. 2, 7, 8, 13 from Filippini et al. (2015d).



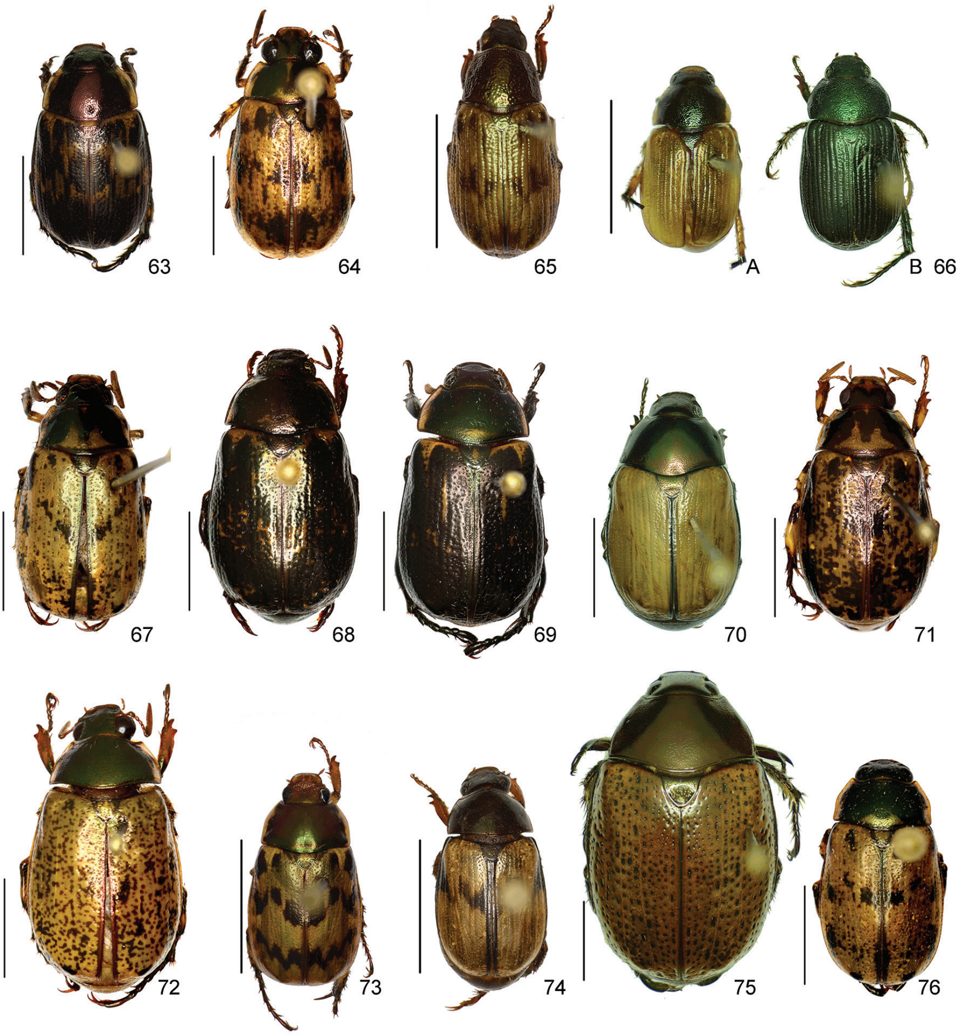

**Figures 17–31.** Habitus. **17** *Anomala cupricollis* (Finca San Gabriel, Alajuela, MNCR) **18** *A. cyclops* (Cerro El Hacha, Guanacaste, MNCR) **19** *A. discoidalis* (Estación Biológica Las Alturas, Puntarenas, MNCR) **20** *A. divisa* (Cinco esquinas de Carrizal, Alajuela, MNCR) **21** *A. estrella* (Estación La Casona, Puntarenas, MNCR) **22** *A. eucoma* (Amubri, Limón, MNCR) **23** *A. eulissa* (Sector Cedrales de la Rita, Limón, MNCR) **24** *A. eusticta* (Estación La Casona, Puntarenas, MNCR) **25** *A. ferrea* (Las Cruces, Puntarenas, MNCR) **26** *A. flavacoma* (Estación Hitoy Cerere, Limón, MNCR) **27** *A. foraminosa* (Estación Hitoy Cerere, Limón, MNCR) **28** *A. globulata* (Macizo de la Muerte, Cartago, MNCR) **29** *A. hiata* (Estación Pittier, Puntarenas, MNCR) **30** *A. histrionella* (Estación Murcielago, Guanacaste, MNCR) **31** *A. hoppi*, showing variable colorations (A: Río San Lorencito, Alajuela, MNCR; B: Las Cruces, Puntarenas, MNCR). Scale bars: 5 mm. Fig. 25 from Filippini et al. (2014); Fig. 21 from Filippini et al. (2015b); Figs 18, 20 from Filippini et al. (2015c); Figs 24, 28–29 from Filippini et al. (2015d).



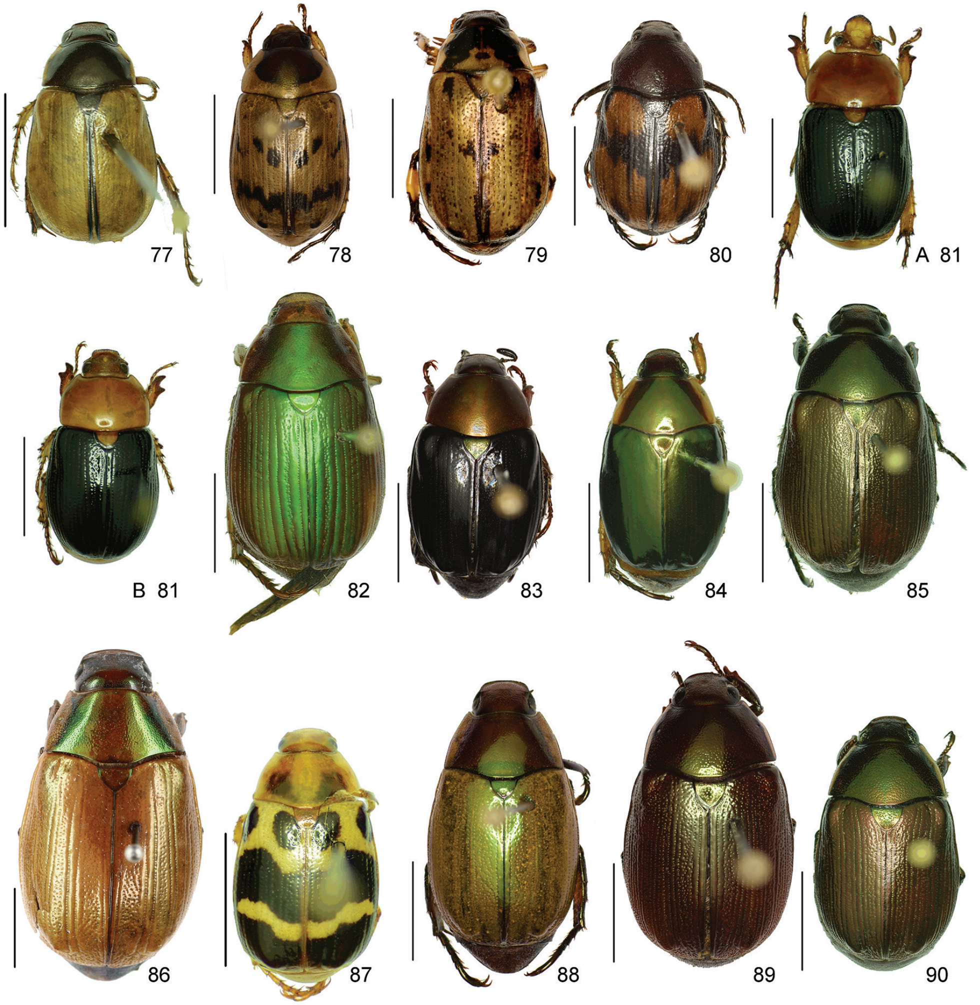

**Figures 32–46.** Habitus. **32** *Anomala inbio* (Volcán Tenorio, Guanacaste, CEUA) **33** *A. jansoni* (Monte Rotondo, Costa Rica, MNHUB) **34** *A. latifalculata* (Zona Protectora Cerros de la Carpintera, Cartago, MNCR) **35** *A. leopardina* (Finca Cafrosa, Puntarenas, MNCR) **36** *A. levicollis* (Cerro Montezuma, Alajuela, CEUA) **37** *A. limon* (Estación Hitoy Cerere, Limón, MNCR) **38** *A. longisacculata* (La Montura, San José, CEUA) **39** *A. ludoviciana* (Parque Nacional Santa Rosa, Guanacaste, MNCR) **40** *A. megalia* (Cerro Tortuguero, Limón, MNCR) **41** *A. megaparamera* (Estación Cuatro Esquinas, Limón , MNCR) **42** *A. mersa* (Sector Palo Verde, Guanacaste, MNCR) **43** *A. mesosticta* (Los Arbolitos, heredia, MNCR) **44** *A. m-fuscum* (Río Grande de Orosí, Cartago, MNCR) **45** *A. moroni* (Estación Palo Verde, Guanacaste, MNCR) **46** *A. nigroflava* (Río Rincon, Puntarenas, MNCR). Scale bars: 5 mm. Fig. 46 from Filippini et al. (2014); Fig. 37 from Filippini et al. (2015b); Figs 42–43 from Filippini et al. (2015c); Figs 32, 34–36, 38, 44 from Filippini et al. (2015d); Fig. 45 from Filippini et al. (2015e).



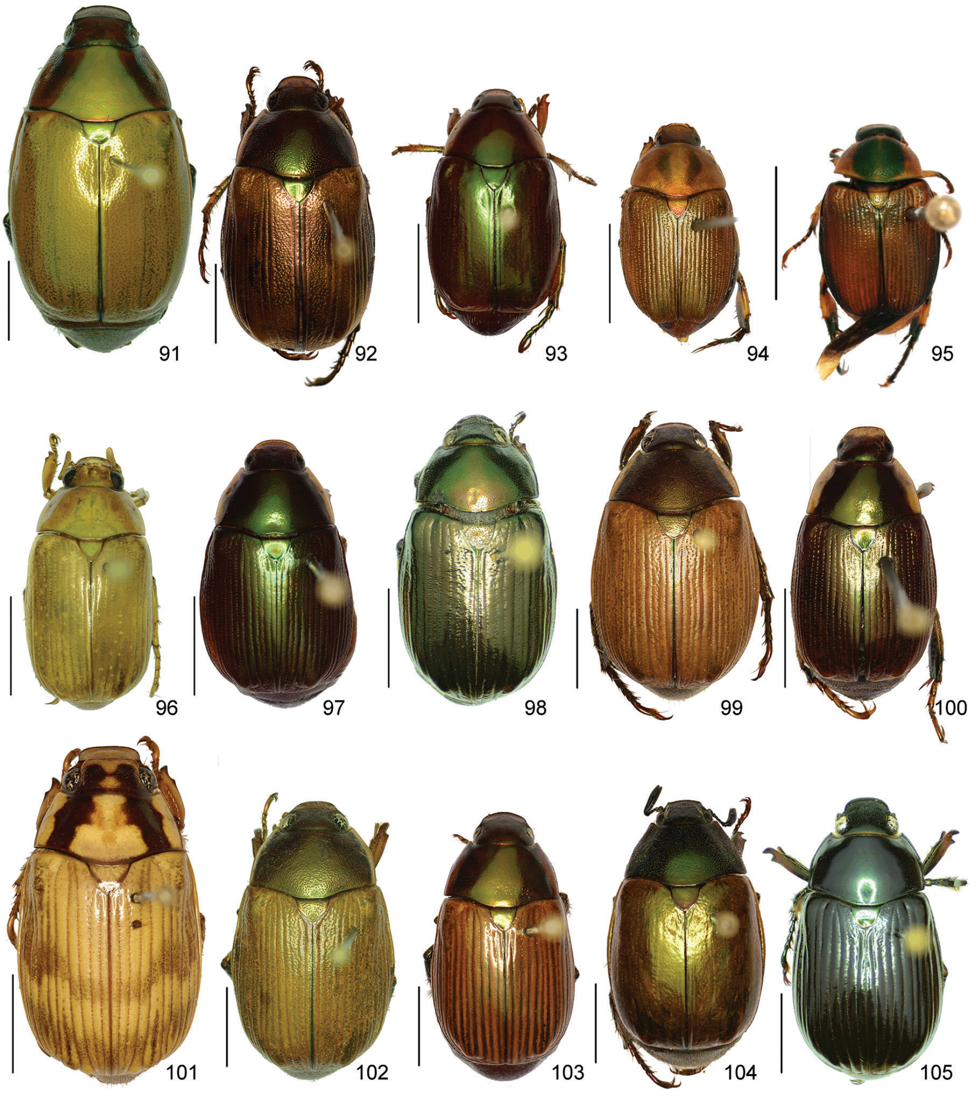

**Figures 47–62.** Habitus. **47** *Anomala obovata* (Cerro Chompipe, Heredia, MNCR) **48** *A. ochrogastra* (Estación Biológica Las Alturas, Puntarenas, MNCR) **49** *A. ochroptera* (La Maritza, Guanacaste, MNCR) **50** *A. parvaeucoma* (Estación Sirena, Puntarenas, MNCR) **51** *A. perspicax* (La Esperanza, Cartago CEUA) **52** *A. piccolina* (Estación Biológica Las Alturas, Puntarenas, MNCR) **53** *A. pincelada* (Finca Jenny, Guanacaste, MNCR) **54** *A. polygona* (Escazu, Costa Rica, MNHUB) **55** *A. popayana* (Reserva Biológica Hitoy Cerere, Limón, MNCR) **56** *A. praecellens* (Orosilito, Guanacaste, CEUA) **57** *A. pseudoeucoma* (Estación Hitoy Cerere, Limón, MNCR) **58** *A. quiche* (Estación Maritza, Guanacaste, MNCR) **59** *A. robiginosa* (Zarcero, Alajuela, MNCR) **60** *A. ruatana* (Playa Naranjo, Guanacaste, MNCR) **61** *A. semicincta* (Estación Cabro Muco, Guanacaste, CEUA) **62** *A. semilla* (Albergue Heliconias, Alajuela, CEUA). Scale bars: 5 mm. Fig. 62 from Filippini et al. (2014); Fig. 53 from Filippini et al. (2015b); Fig. 59 from Filippini et al. (2015c); Figs 51–52, 54 from Filippini et al. (2015d); Fig. 50 from Filippini et al. (2015e).



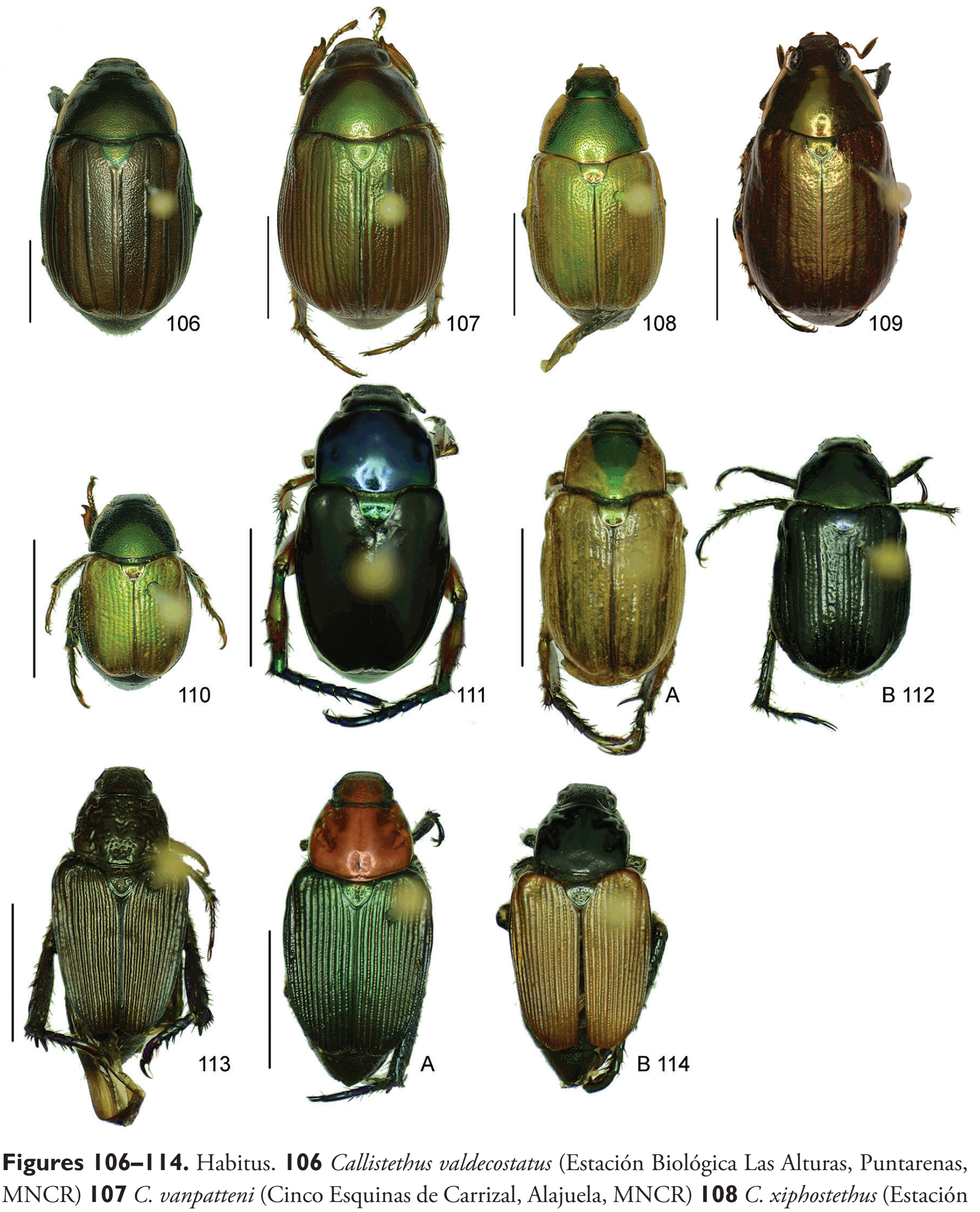

**Figures 63–76.** Habitus. **63** *Anomala solisi* (Amubri, Limón, MNCR) **64** *A. stillaticia* (La Catarata, Cartago, MNCR) **65** *Anomala strigodermoides* (holotype) **66** *A. subaenea*, showing variable colorations (A: Parque Nacional Santa Rosa, Guanacaste, MNCR; B: Estación Maritza, Guanacaste, MNCR) **67** *A. subridens* (Reserva Forestal Río Macho, Cartago, MNCR) **68** *A. subusta* (Estación Cacao, Guanacaste, MNCR) **69** *A. tenoriensis* (Parque Nacional Volcán Tenorio, Alajuela, MNCR) **70** *A. testaceipennis* (Cecafor, Heredia, MNCR) **71** *A. trapezifera* (Parque Nacional Tapantí, Cartago, CEUA) **72** *A. tuberculata* (Isla Bonita, Alajuela, CEUA) **73** *A. undulata* (San Luis, Puntarenas, MNCR) **74** *A. unilineata* (Parque Nacional Santa Rosa, Guanacaste, MNCR) **75** *A. valida* (Reserva Biológica Hitoy Cerere, Limón, MNCR) **76** *A. vallisneria* (Sector Las Pailas, Guanacaste, MNCR). Scale bars: 5 mm. Fig. 63 from Filippini et al. (2014); Figs 65, 74 from Filippini et al. (2015c); Figs 64, 67–69, 71–72, 76 from Filippini et al. (2015d).



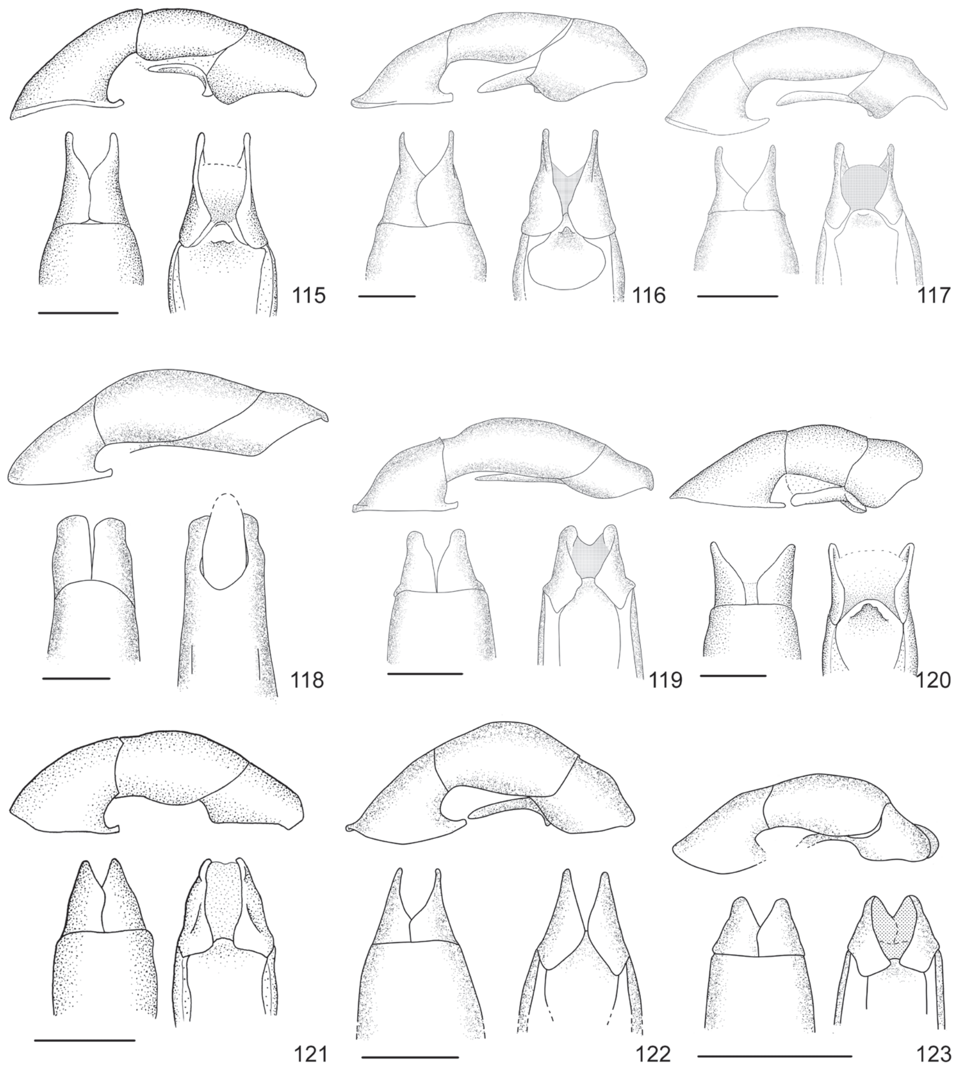

**Figures 77–90.** Habitus. **77** *Anomala veraecrucis* (Finca Jenny, Guanacaste, MNCR) **78** *A. volsellata* (Cerro Brujo, Puntarenas, MNCR) **79** *A. vulcanicola* (San Gerardo de Dota, San José, MNCR) **80** *A. zumbadoi* (Rancho quemado, Puntarenas, MNCR) **81** *Anomalorhina turrialbana*, A: male, B: female (Cabanga, Alajuela, CEUA, both) **82** *Callistethus calonotus* (Alto de Las Moras, Puntarenas, MNCR) **83** *C. carbo* (Río San Lorenzo, Guanacaste, MNCR) **84** *C. chlorotoides* (Reserva Biológica Hitoy Cerere, Limón, MNCR) **85** *C. chontalensis* (El Copal, Cartago, CEUA) **86** *C. chrysanthe* (Chiriqui, MNHUB) **87** *C. chrysomelinus* (San Luis, Puntarenas, MNCR) **88** *C. flavodorsalis* (Finca Cafrosa, Puntarenas, MNCR) **89** *C. fuscorubens* (La Esquadra, Puntarenas, MNCR) **90** *C. granulipygus* (Rancho Quemado, Puntarenas, MNCR). Scale bars: 5 mm. Figs 78, 80 from Filippini et al. (2014); Figs 83, 88–89 from Filippini et al. (2015a); Fig. 79 from Filippini et al. (2015d).



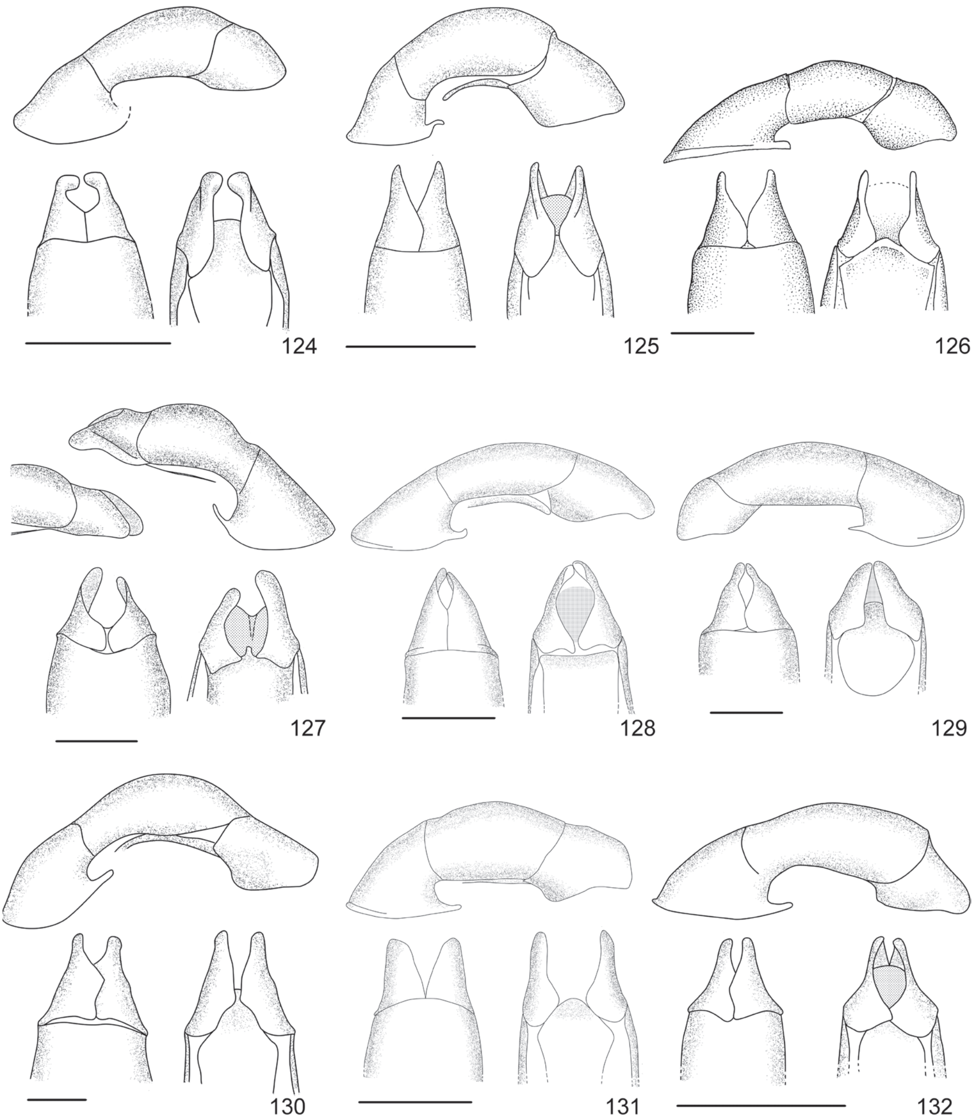

**Figures 91–105.** Habitus. **91** *Callistethus jordani* (Estación Cacao, Guanacaste, MNCR) **92** *C. lativittis* (Río San Lorenzo, Guanacaste, MNCR) **93** *C. levigatus* (Quebrada Segunda, Cartago, MNCR) **94** *C. macroxantholeus* (Estación Pitilla, Guanacaste, MNCR) **95** *C. microxantholeus* (Est. Pitilla, Guanacaste, MNCR) **96** *C. mimeloides* (La Montura, San José, CEUA) **97** *C. multiplicatus* (Sector Cerro Cocori, Limón, MNCR) **98** *C. nicoya* (Estación Quebrada Bonita, Puntarenas, MNCR) **99** *C. parapulcher* (Estación Altamira, Puntarenas, MNCR) **100** *C. pseudocollaris* (Estación La Casona, Puntarenas, MNCR) **101** *C. ruteloides* (holotype) **102** *C. schneideri* ( Estación Pitilla, Guanacaste, MNCR) **103** *C.specularis* (Rio San Lorenzo, Guanacaste, MNCR) **104** *C. stannibractea* (Estación Barva, Heredia, MNCR) **105** *C. sulcans* (Reserva Biológica Hitoy Cerere, Limón). Scale bars: 5 mm. Figs 92–95, 97, 99–100, 103–104 from Filippini et al. (2015a); Fig. 101 from Filippini et al. (2015b).



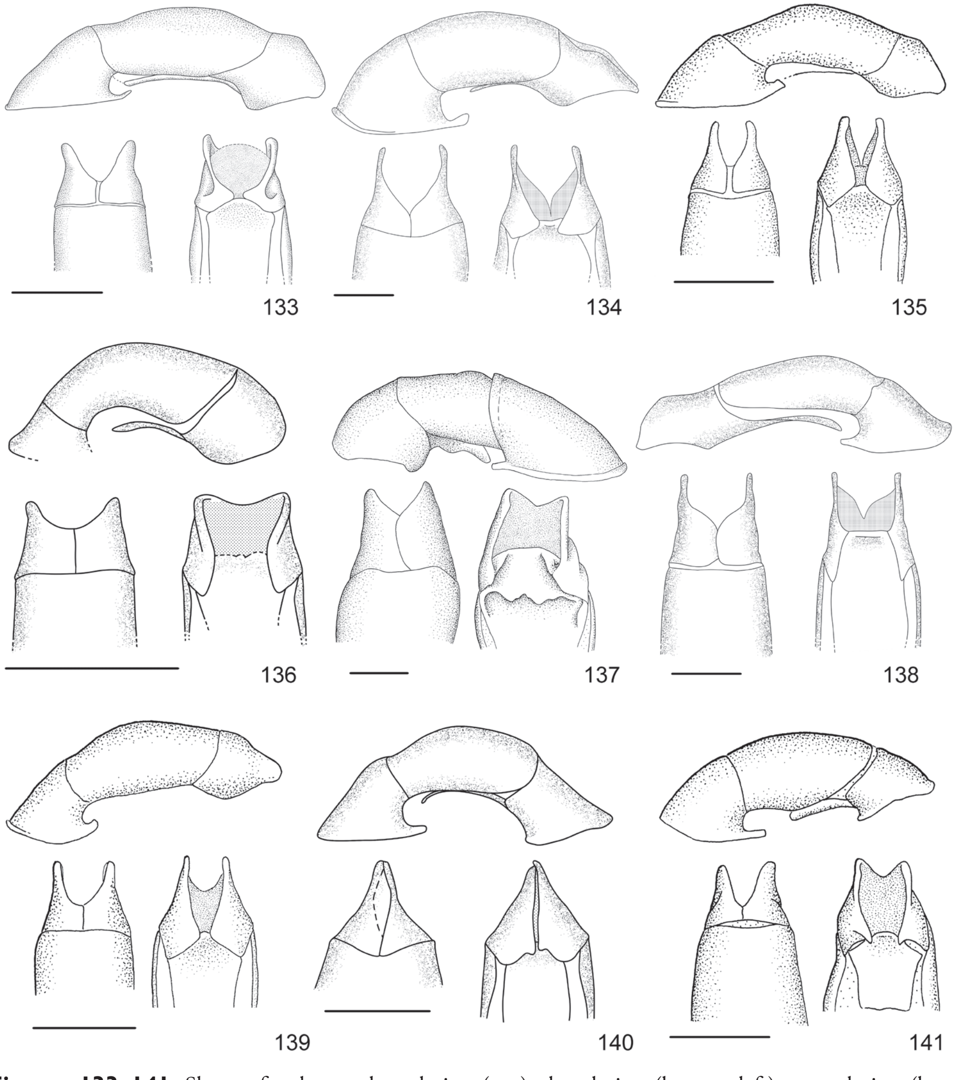

**Figures 106–114.** Habitus. **106** *Callistethus valdecostatus* (Estación Biológica Las Alturas, Puntarenas, MNCR) **107** *C. vanpatteni* (Cinco Esquinas de Carrizal, Alajuela, MNCR) **108** *C. xiphostethus* (Estación Las Pailas, Guanacaste, MNCR) **109** *C. yalizo* (holotype) **110** *Moroniella nitidula* (Zarcero, Alajuela, MNCR) **111** *Strigoderma auriventris* (Sector San Ramón de dos ríos, Alajuela, MNCR) **112** *S. biolleyi*, showing variable colorations (A: Reserva Tapantí, Cartago, MNCR; B: Macizo de la Muerte, Cartago, MNCR) **113** *S. nodulosa* (Urbanización El Colegio, Puntarenas, MNCR) **114** *S. sulcipennis*, showing variable colorations (A: Finca Jenny, Guanacaste, MNCR; B: San Luis, Puntarenas, MNCR). Scale bars: 5 mm. Fig. 106 from Filippini et al. (2015a); Fig. 109 from Filippini et al. (2015b).



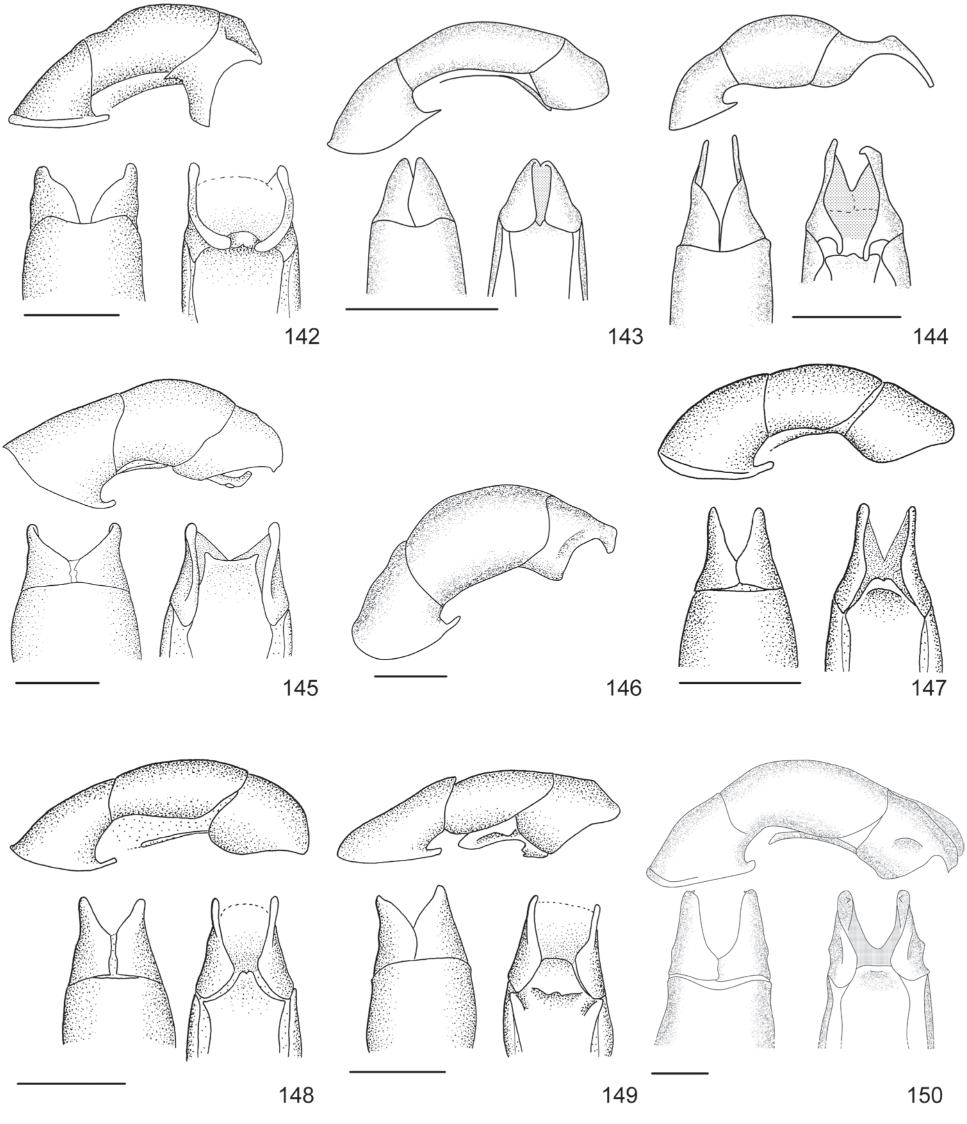

**Figures 115–123.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **115** *Anomala aereiventris* (Parque Nacional Tapantí, Cartago, MNCR) **116** *A. aglaos* (Isla Bonita, Alajuela, CEUA) **117** *A. antica* (Estación Palo Verde, Guanacaste, MNCR) **118** *A. arara* (Estación Cabro Muco, Guanacaste, CEUA) **119** *A. arthuri* (Estación Maritza, Guanacaste, MNCR) **120** *A. aspersa* (Villa Mills, Cartago, MNCR) **121** *A. atrivillosa* (Estación Barva, Heredia, MNCR) **122** *A. balzapambae* (Rancho Quemado, Puntarenas, MNCR) **123** *A. calligrapha* (Cabro Muco, Guanacaste, CEUA). Scale bars: 1 mm. Figs 118–119 modified from Filippini et al. (2014); Figs 116–117 modified from Filippini et al. (2015b); Figs 115, 120–121 from Filippini et al. (2015d).



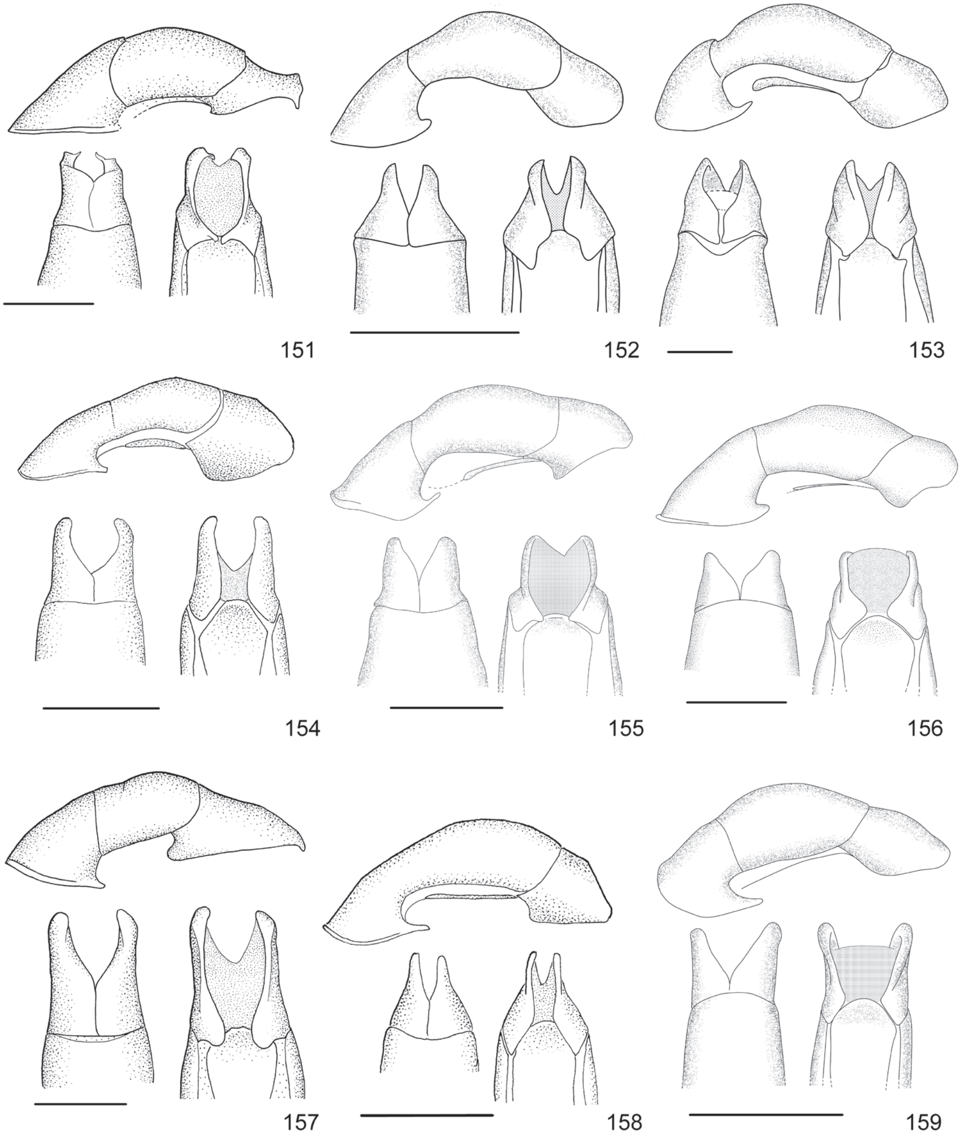

**Figures 124–132.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **124** *Anomala chiriquina* (Finca Cafrosa, Puntarenas, MNCR) **125** *A. cinaedias* (San Luis, Puntarenas, MNCR) **126** *A. clarivillosa* (La Esperanza, Cartago, CEUA) **127** *A. clathrata*, below lateral view: detail of parameres on the other side (Cerro Bitárkara, Limón, CEUA) **128** *A. coffea* (Estación Pitilla, Guanacaste, MNCR) **129** *A. cupreovariolosa* (Las Cruces, Puntarenas, MNCR) **130** *A. cupricollis* (Finca San Gabriel, Alajuela, MNCR) **131** *A. cyclops* (Cerro El Hacha, Guanacaste, MNCR) **132** *A. discoidalis* (Estación Cuatro Esquinas, Limón, MNCR). Scale bars: 1 mm. Figs 127, 129 modified from Filippini et al. (2014); Figs 128, 131 from Filippini et al. (2015c); Fig. 126 from Filippini et al. (2015d).



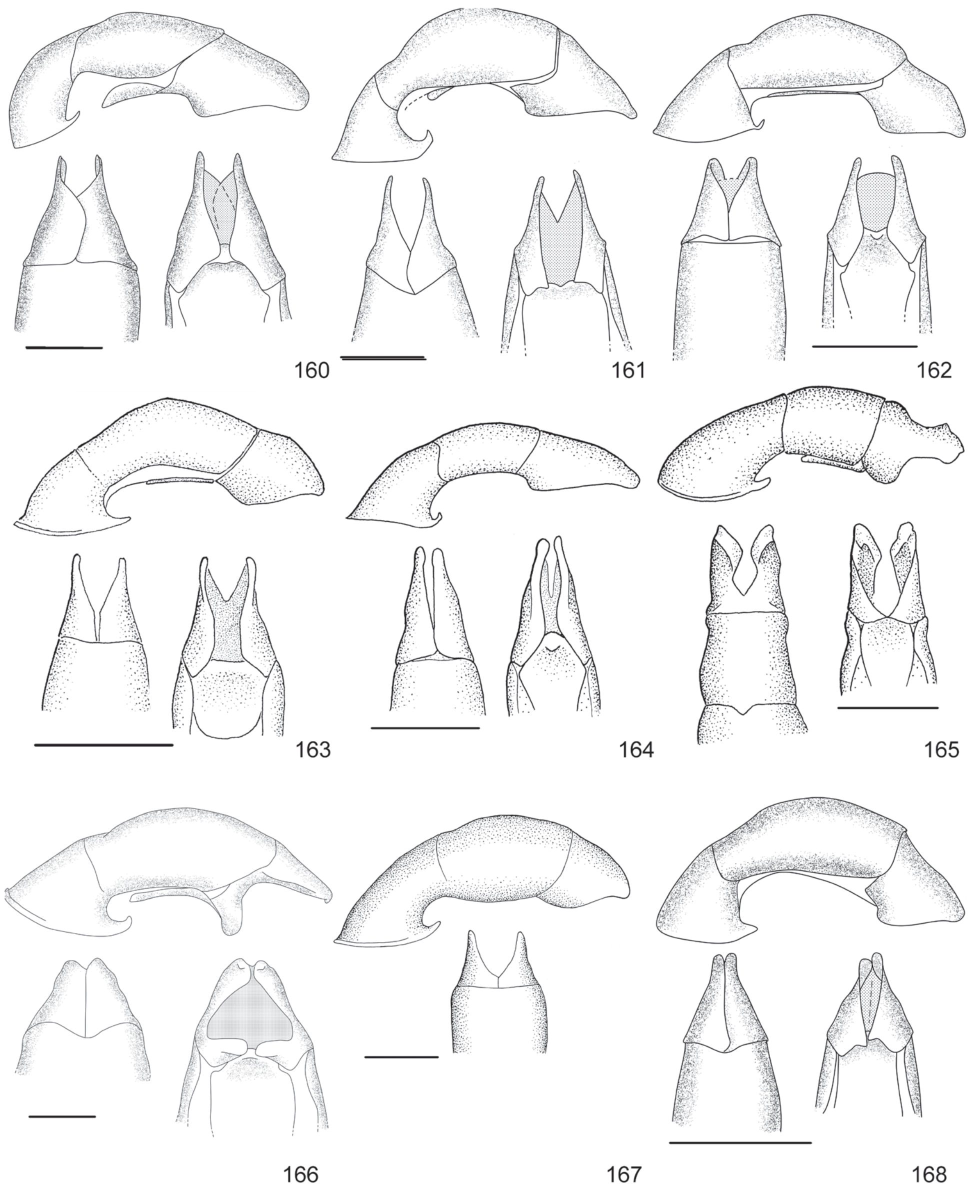

**Figures 133–141.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **133** *Anomala divisa* (Cinco esquinas de Carrizal, Alajuela, MNCR) **134** *A. estrella* (Estación La Casona, Puntarenas, MNCR) **135** *A. eucoma* (San José, San José, MUCR) **136** *A. eulissa* (Estación Biológica La Selva, Heredia, MNCR) **137** *A. eusticta* (Estación La Casona, Puntarenas, MNCR) **138** *A. ferrea* (Las Cruces, Puntarenas, MNCR) **139** *A. flavacoma* (Estación Cabro Muco, Guanacaste, CEUA) **140** *A. foraminosa* (Estación Hitoy Cerere, Limón, MNCR) **141** *A. globulata* (Macizo de la Muerte, Cartago, MNCR). Scale bars: 1 mm. Fig. 139 from Filippini et al. (2013), Fig. 138 from Filippini et al. (2014); Fig. 134 from Filippini et al. (2015b); Fig. 133 from Filippini et al. (2015c); Figs 137, 141 from Filippini et al. (2015d).



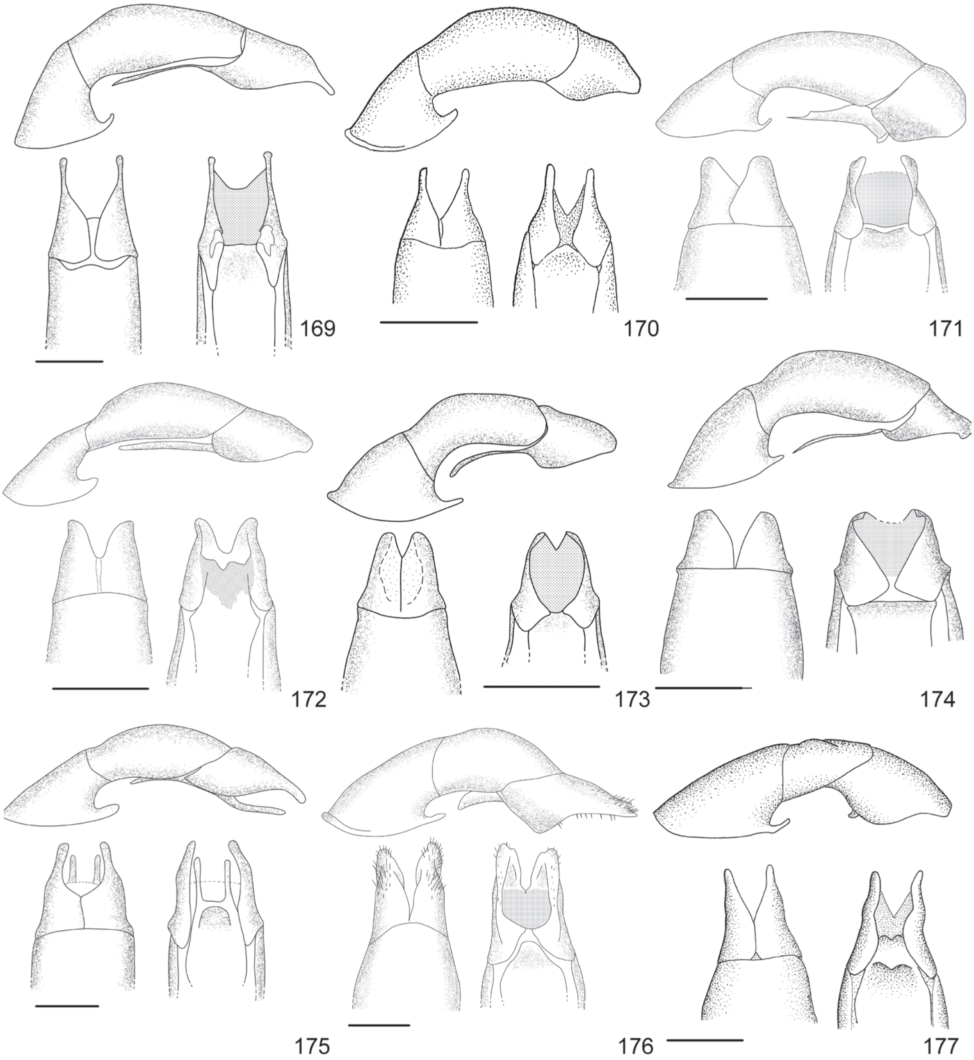

**Figures 142–150.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **142** *Anomala hiata* (Estación Pittier, Puntarenas, MNCR) **143** *A. histrionella* (Bahía Santa Elena, Guanacaste, MNCR) **144** *A. hoppi* (Las Cruces, Puntarenas, MNCR) **145** *A. inbio* (Volcán Tenorio, Guanacaste, CEUA) **146** *A. jansoni* (Monte Rotondo, Costa Rica, MNHUB) **147** *A. latifalculata* (Zona Protectora Cerros de la Carpintera, Cartago, MNCR) **148** *A. leopardina* (Finca Cafrosa, Puntarenas, MNCR) **149** *A. levicollis* (Cerro Montezuma, Alajuela, CEUA) **150** *A. limon* (Estación Hitoy Cerere, Limón, MNCR). Scale bars: 1 mm. Figs 146, 150 modified from Filippini et al. (2015b); Figs 142, 145, 147–149 from Filippini et al. (2015d).



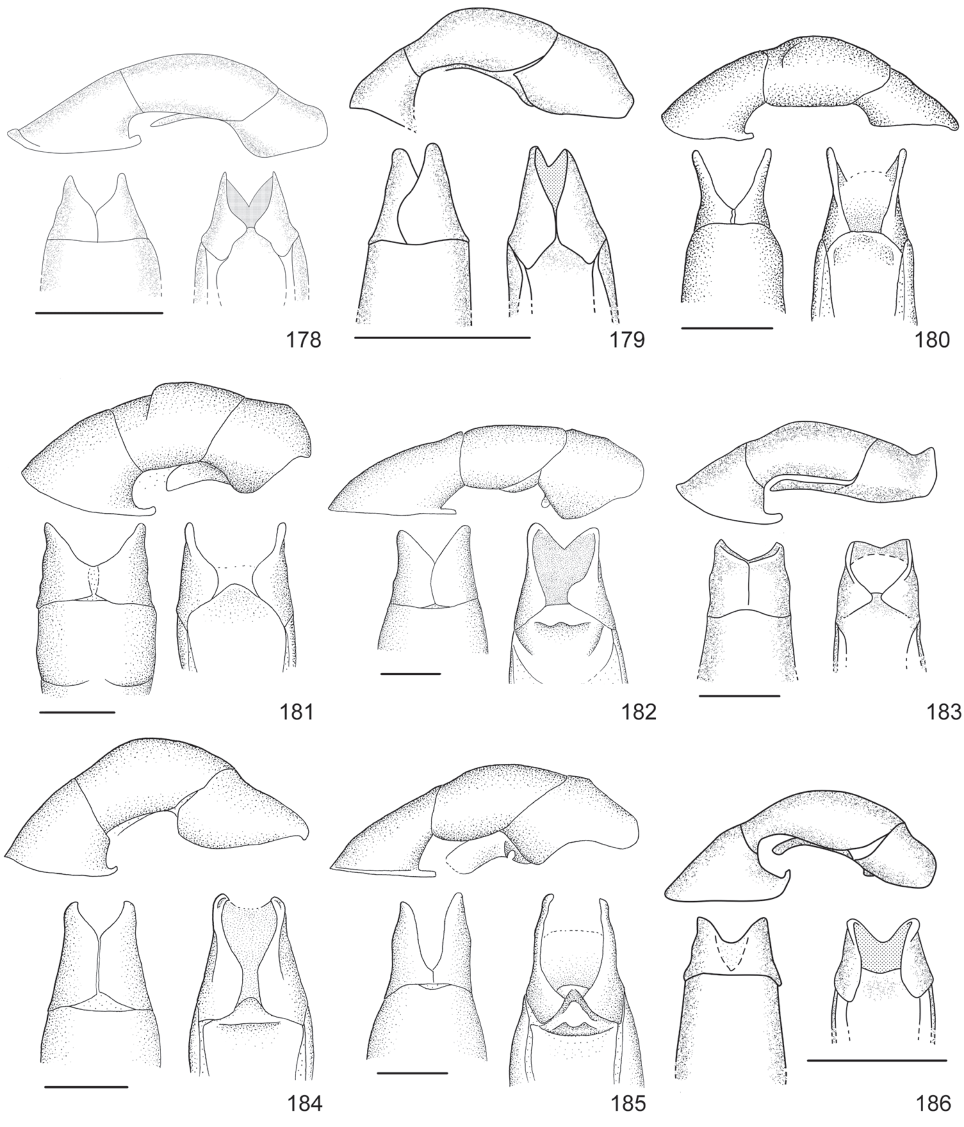

**Figures 151–159.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **151** *Anomala longisacculata* (La Montura, San José, CEUA) **152** *A. ludoviciana* (Finca Jenny, Guanacaste, MNCR) **153** *A. megalia* (Manzanillo, Limón, MNCR) **154** *A. megaparamera* (Estación Cuatro Esquinas, Limón, MNCR) **155** *A. mersa* (Sector Palo Verde, Guanacaste, MNCR) **156** *A. mesosticta* (Los Arbolitos, heredia, MNCR) **157** *A. m-fuscum* (Río Grande de Orosí, Cartago, MNCR) **158** *A. moroni* (Estación Palo Verde, Guanacaste, MNCR) **159** *A. nigroflava* (Río Rincon, Puntarenas, MNCR). Scale bars: 1 mm. Fig. 154 from Filippini et al. (2013), Fig. 159 from Filippini et al. (2014); Figs 155–156 from Filippini et al. (2015c); Figs 151, 157 from Filippini et al. (2015d); Fig. 158 from Filippini et al. (2015e).



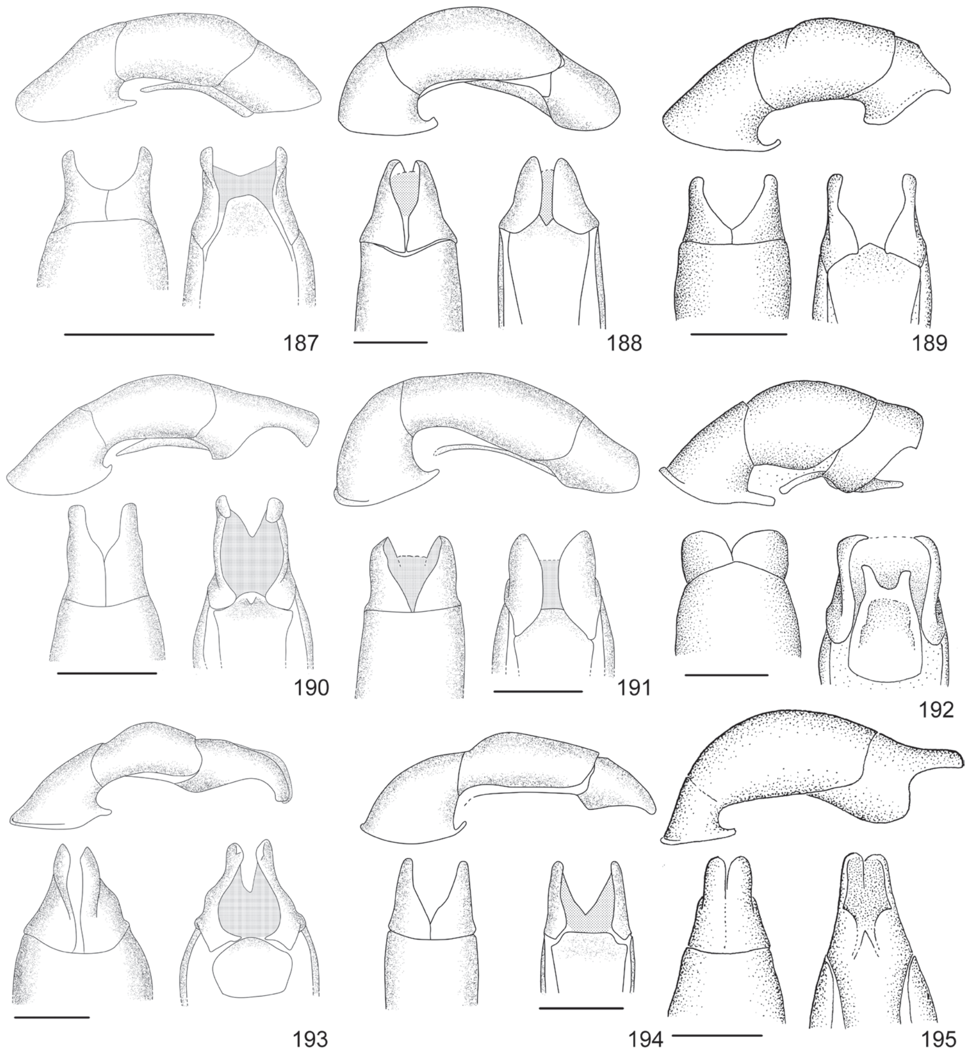

**Figures 160–168.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **160** *Anomala obovata* (Quebrada Kuisa, Limón, MNCR) **161** *ochrogastra* (Finca Cafrosa, Puntarenas, MNCR) **162** *A. ochroptera* (La Maritza, Guanacaste, MNCR) **163** *A. parvaeucoma* (Estación Sirena, Puntarenas, MNCR) **164** *A. perspicax* (La Esperanza, Cartago, CEUA) **165** *A. piccolina* (Estación Biológica Las Alturas, Puntarenas, MNCR) **166** *A. pincelada* (Finca Jenny, Guanacaste, MNCR) **167** *A. polygona* (Escazu, Costa Rica, MNHUB) **168** *A. popayana* (Río Banano, Limón, MNCR). Scale bars: 1 mm. Fig. 168 modified from Filippini et al. (2014); Figs 160, 166 from Filippini et al. (2015b); Figs 164–165, 167 from Filippini et al. (2015d); Fig. 163 from Filippini et al. (2015e).



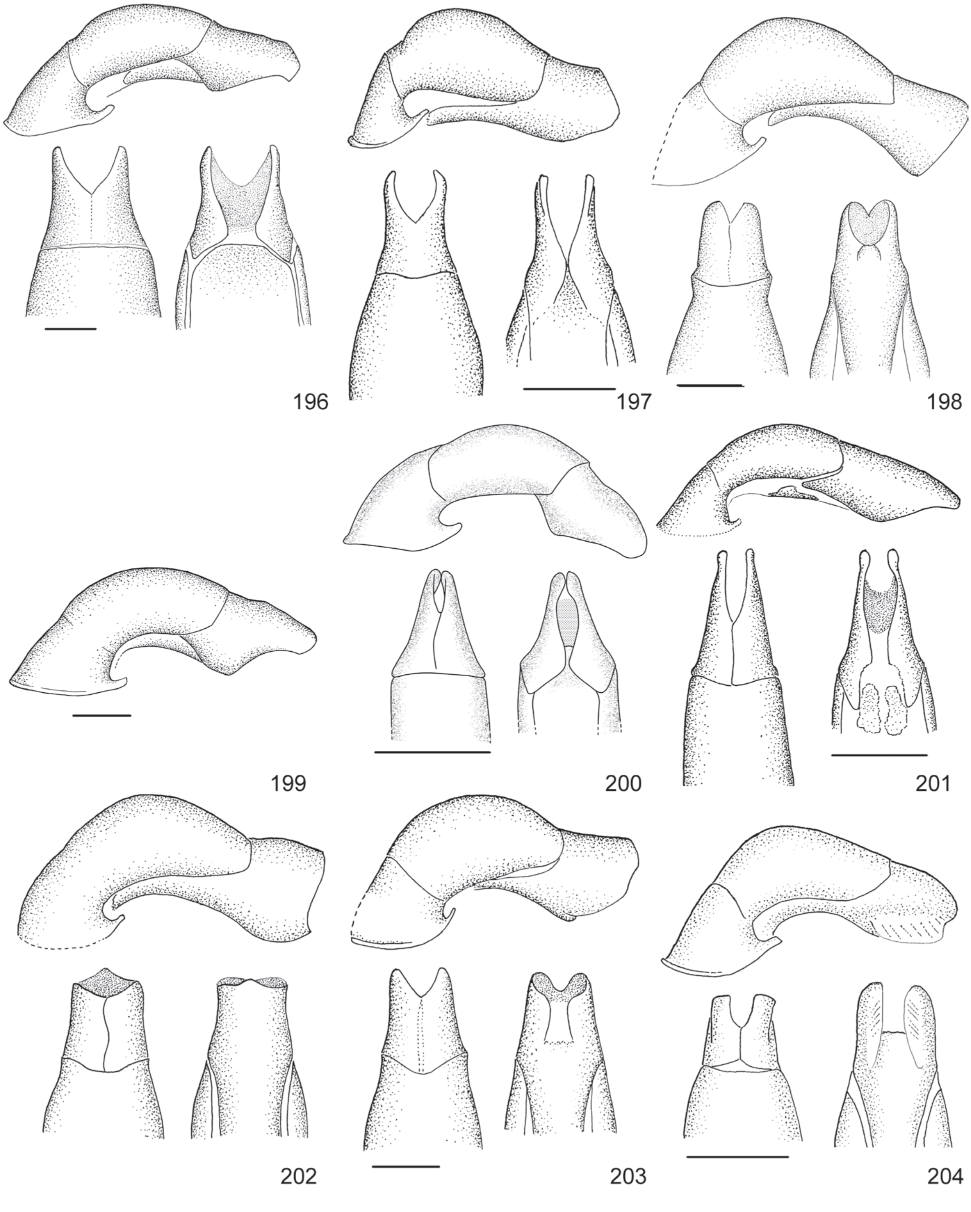

**Figures 169–177.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **169** *Anomala praecellens* (Orosilito, Guanacaste, CEUA) **170** *A. pseudoeucoma* (Estación Hitoy Cerere, Limón, MNCR) **171** *A. quiche* (Estación Maritza, Guanacaste, MNCR) **172** *A. robiginosa* (Zarcero, Alajuela, MNCR) **173** *A. ruatana* (Playa Naranjo, Guanacaste, MNCR) **174** *A. semicincta* (Albergue Heliconias, Alajuela, CEUA) **175** *A. semilla* (Albergue Heliconias, Alajuela, CEUA) **176** *A. solisi* (Amubri, Limón, MNCR) **177** *A. stillaticia* (La Catarata, Cartago, MNCR). Scale bars: 1 mm. Fig. 170 from Filippini et al. (2013); Figs 174–176 modified from Filippini et al. (2014); Fig. 171 modified from Filippini et al. (2015b); Fig. 172 from Filippini et al. (2015c); Fig. 177 from Filippini et al. (2015d).



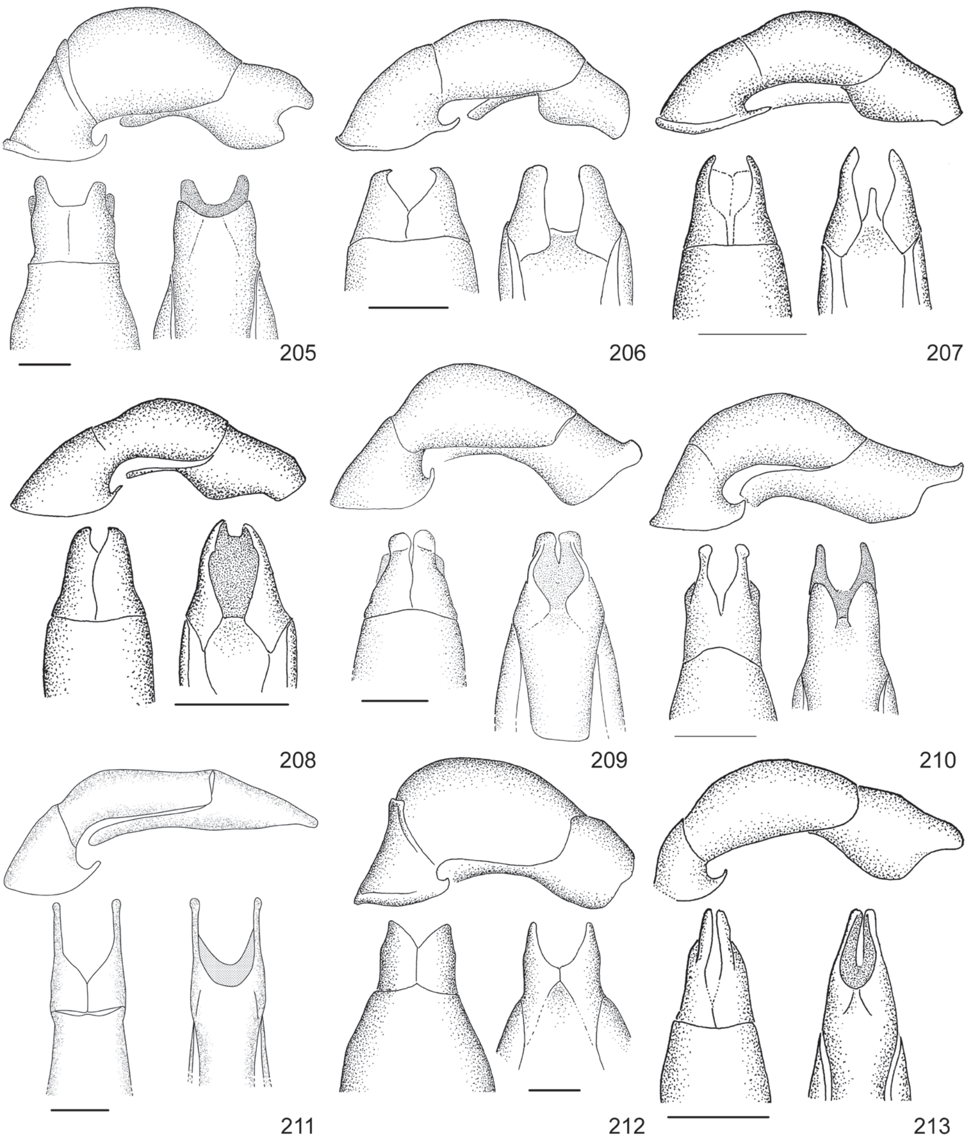

**Figures 178–186.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **178** *Anomala strigodermoides* (Bijagua, Alajuela, MNCR) **179** *A. subaenea* (Estación Maritza, Guanacaste, MNCR) **180** *A. subridens* (Reserva Forestal Río Macho, Cartago, MNCR) **181** *A. subusta* (Estación Cacao, Guanacaste, MNCR) **182** *A. tenoriensis* (Parque Nacional Volcán Tenorio, Alajuela, MNCR) **183** *A. testaceipennis* (Boca Tapada, Alajuela, MNCR) **184** *A. trapezifera* (Parque Nacional Tapantí, Cartago, CEUA) **185** *A. tuberculata* (Isla Bonita, Alajuela, CEUA) **186** *A. undulata* (Estación Cacao, Guanacaste, MNCR). Scale bars: 1 mm. Fig. 183 modified from Filippini et al. (2014); Fig. 178 from Filippini et al. (2015c); Figs 180–182, 184–185 from Filippini et al. (2015d).



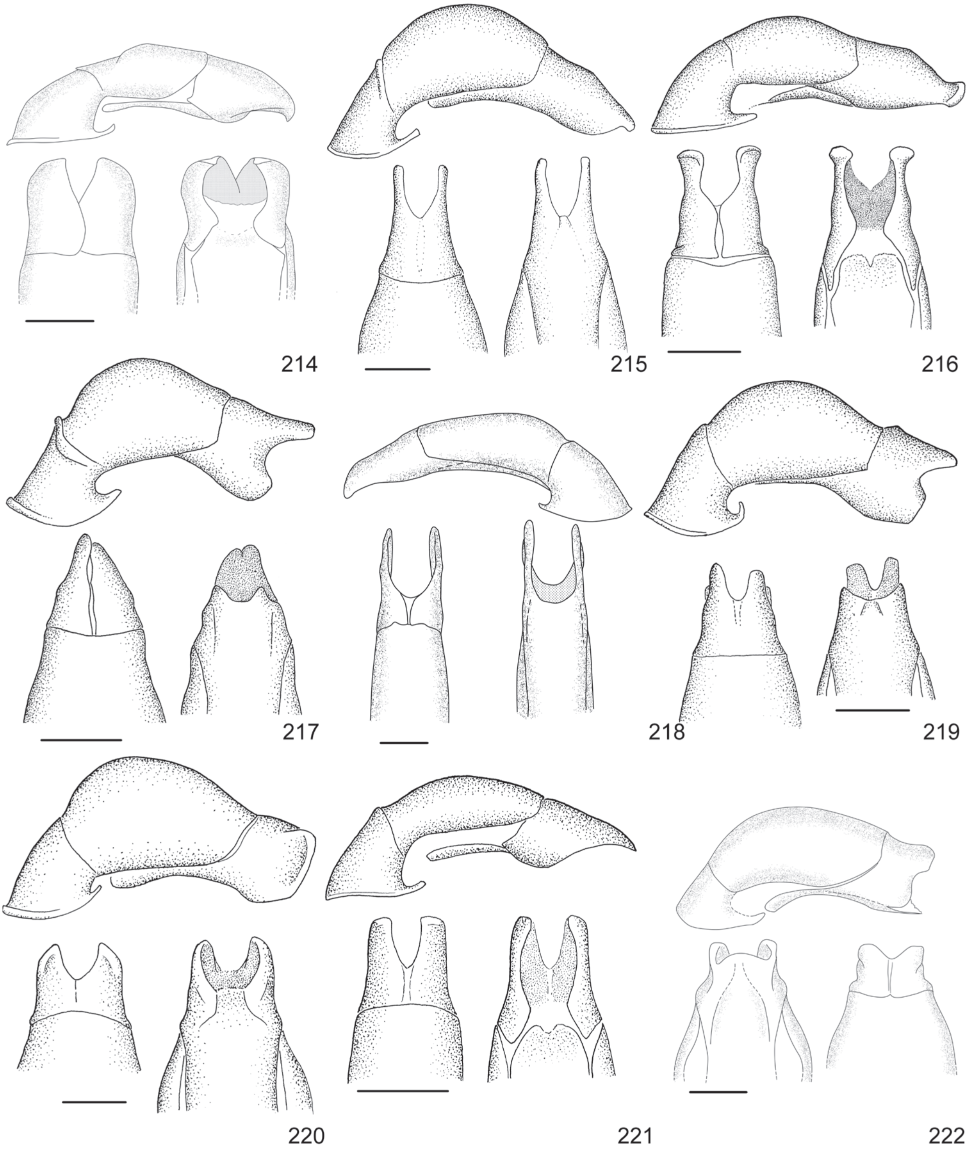

**Figures 187–195.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **187** *Anomala unilineata* (Parque Nacional Santa Rosa, Guanacaste, MNCR) **188** *A. valida* (La Cruz, Guanacaste, MNCR) **189** *A. vallisneria* (Sector Las Pailas, Guanacaste, MNCR) **190** *A. veraecrucis* (Finca Jenny, Guanacaste, MNCR) **191** *A. volsellata* (Las Quebraditas, Puntarenas, MNCR) **192** *A. vulcanicola* (San Gerardo de Dota, San José, MNCR) **193** *A. zumbadoi* (Rancho quemado, Puntarenas, MNCR) **194** *Anomalorhina turrialbana* (Cabanga, Alajuela, CEUA) **195** *Callistethus calonotus* (Alto de Las Moras, Puntarenas, MNCR). Scale bars: 1 mm. Figs 191, 193 from Filippini et al. (2014); Fig. 195 modified from Filippini et al. (2015a); Fig. 187 from Filippini et al. (2015c); Figs 189, 192 from Filippini et al. (2015d).



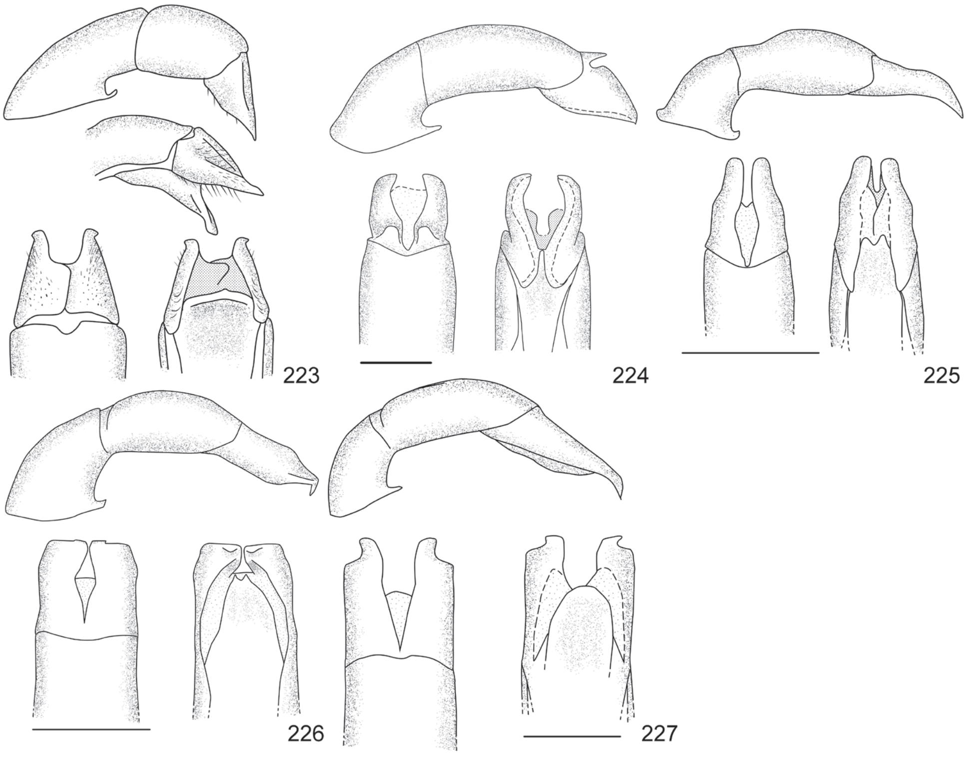

**Figures 196–204.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **196** *Callistethus carbo* (Río San Lorenzo, Guanacaste, MNCR) **197** *C. chlorotoides* (Estación Hitoy Cerere, Limón, MNCR) **198** *C. chontalensis* (El Copal, Cartago, CEUA) **199** *C. chrysanthe* (Chiriqui, MNHUB) **200** *C. chrysomelinus* (San Luis, Puntarenas, MNCR) **201** *C. flavodorsalis* (Finca Cafrosa, Puntarenas, MNCR) **202** *C. fuscorubens* (La Esquadra, Puntarenas, MNCR) **203** *C. granulipygus* (Rancho Quemado, Puntarenas, MNCR) **204** *C. jordani* (Estación Cacao, Guanacaste, MNCR). Scale bars: 1 mm. Figs 196–199, 201–204 modified from Filippini et al. (2015a).



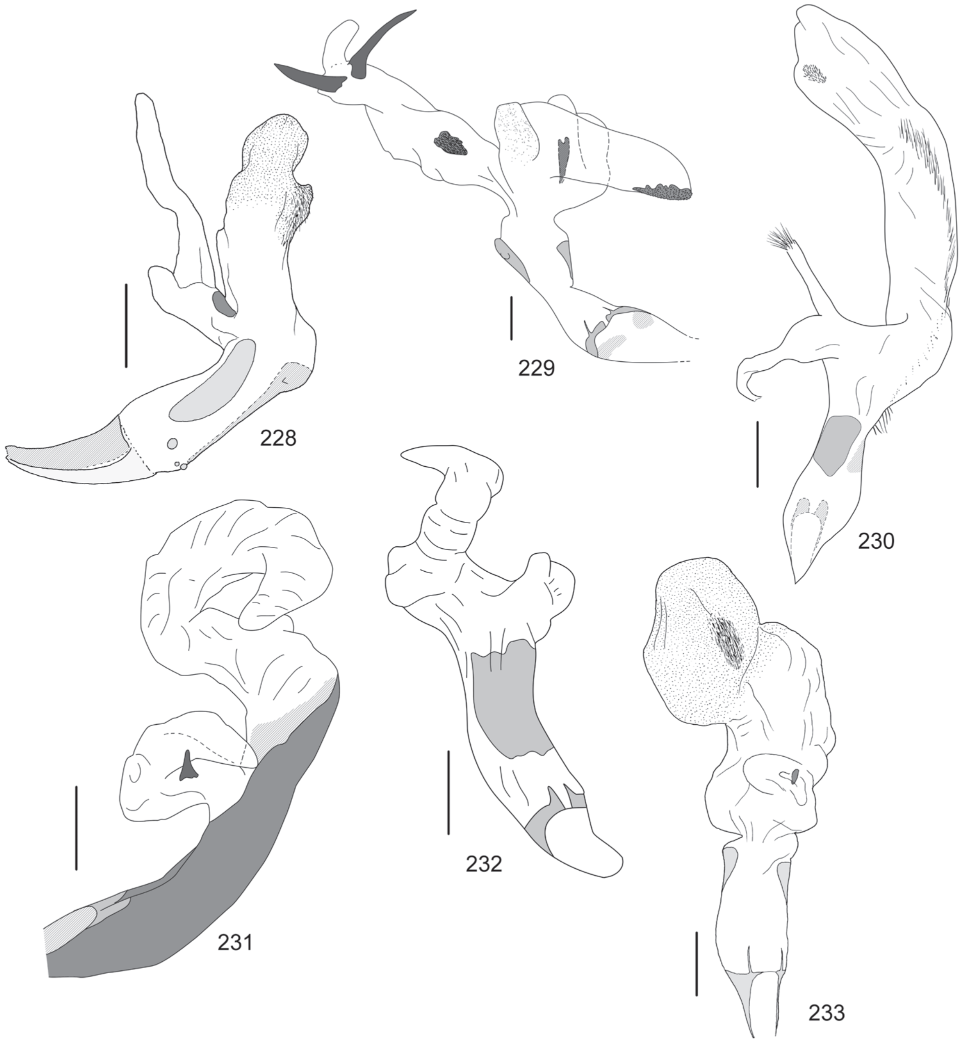

**Figures 205–213.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right) **205** *Callistethus lativittis* (Dos de Tilaran, Guanacaste, MNCR) **206** *C. levigatus* (Estación La Casona, Puntarenas, MNCR) **207** *C. macroxantholeus* (Sector Cerro Cocori, Limón, MNCR) **208** *C. microxantholeus* (Est. Pitilla, Guanacaste, MNCR) **209** *C. mimeloides* (La Montura, San José, CEUA) **210** *C. multiplicatus* (Sector Cerro Cocori, Limón, MNCR) **211** *C. nicoya* (Estación Quebrada Bonita, Puntarenas, MNCR) **212** *C. parapulcher* (Estación Pittier, Puntarenas, MNCR) **213** *C. pseudocollaris* (Estación La Casona, Puntarenas, MNCR). Scale bars: 1 mm. Figs 205–210, 212–213 modified from Filippini et al. (2015a).



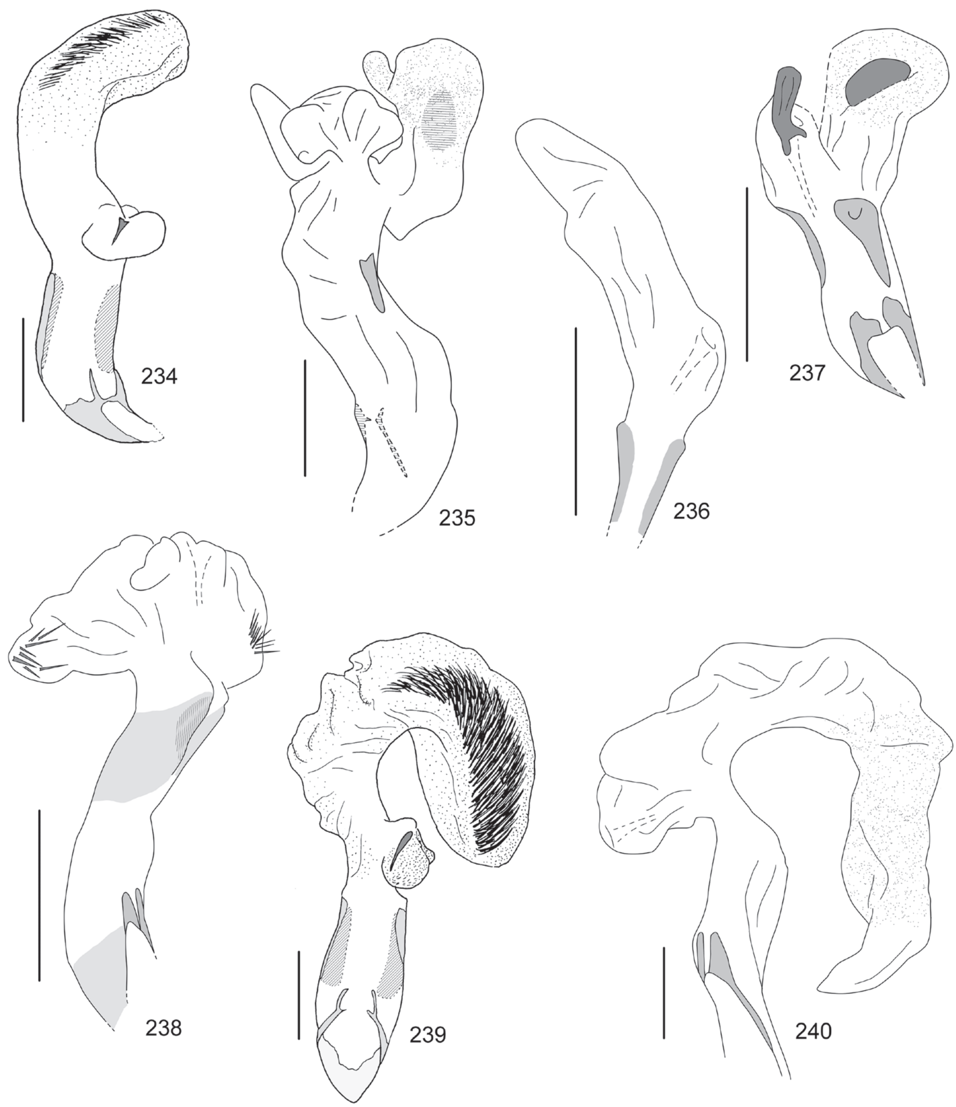

**Figures 214–222.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **214** *Callistethus ruteloides* (holotype) **215** *C. schneideri* (Albergue Heliconias, Alajuela, MNCR) **216** *C. specularis* (Costa Rica, BMNH) **217** *C. stannibractea* (Estación Barva, Heredia, MNCR) **218** *C. sulcans* (Reserva Biológica Hitoy Cerere, Limón, MNCR) **219** *C. valdecostatus* (Alto de las Moras, Puntarenas, MNCR) **220** *C. vanpatteni* (Cinco Esquinas de Carrizal, Alajuela, MNCR) **221** *C. xiphostethus* (Los Ángeles, Heredia, MNCR) **222** *C. yalizo* (Cerro Chompipe, Heredia). Scale bars: 1 mm. Figs 215–217, 219–221 modified from Filippini et al. (2015a); Figs 214, 222 from Filippini et al. (2015b).



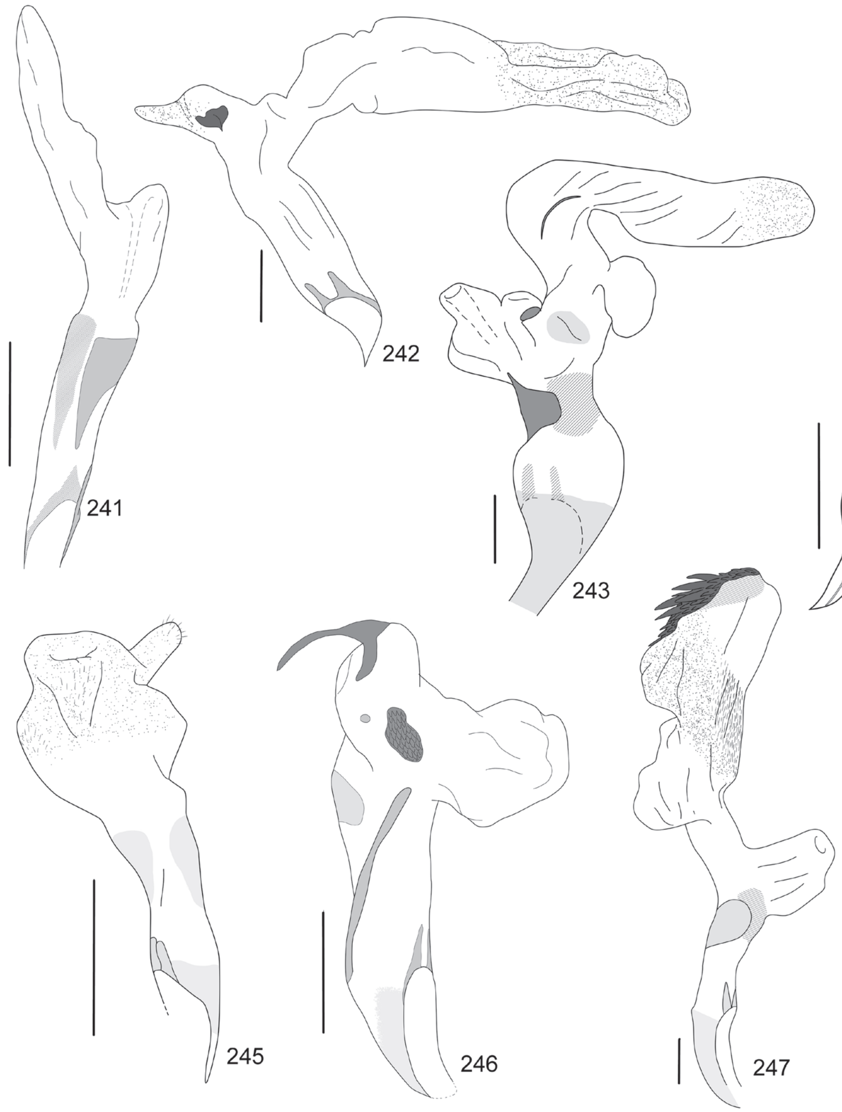

**Figures 223–227.** Shape of aedeagus, lateral view (top), dorsal view (bottom left), ventral view (bottom right). **223** *Moroniella nitidula*, below lateral view: detail of parameres when endophallus is everted (Lateral view: Guatemala, MNHUB; other: Zarcero, Alajuela, MNCR) **224** *Strigoderma auriventris* (Sector San Ramón de dos ríos, Alajuela, MNCR) **225** *Strigoderma biolleyi* (Macizo de la Muerte, Cartago, MNCR) **226** *S. nodulosa* (Estación Quebrada Bonita, Puntarenas, MNCR) **227** *S. sulcipennis* (Finca Jenny, Guanacaste, MNCR). Scale bars: 1 mm.



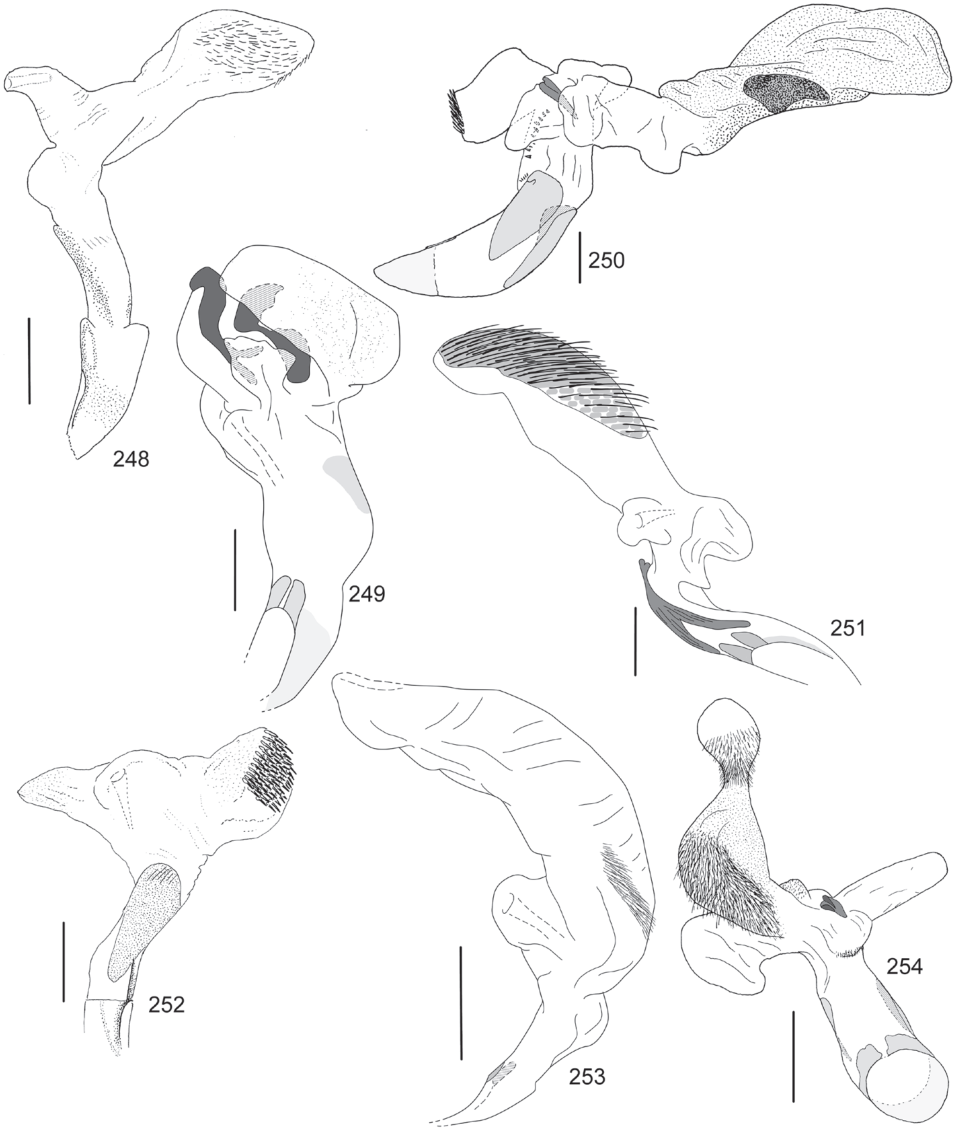

**Figures 228–233.** Endophallus of **228** *Anomala aereiventris* (Parque Nacional Tapantí, Cartago, MNCR) **229** *A. aglaos* (Isla Bonita, Alajuela, CEUA) **230** *A. antica* (Parque Nacional Santa Rosa, Guanacaste, MNCR) **231** *A. arara* (Albergue Heliconias, Alajuela, CEUA) **232** *A. arthuri* (Estación Maritza, Guanacaste, MNCR) **233** *A. aspersa* (Villa Mills, Cartago, MNCR). Scale bars: 1 mm. Fig. 232 from Filippini et al. (2014), Fig. 229 from Filippini et al. (2015b); Figs 228, 233 from Filippini et al. (2015d).



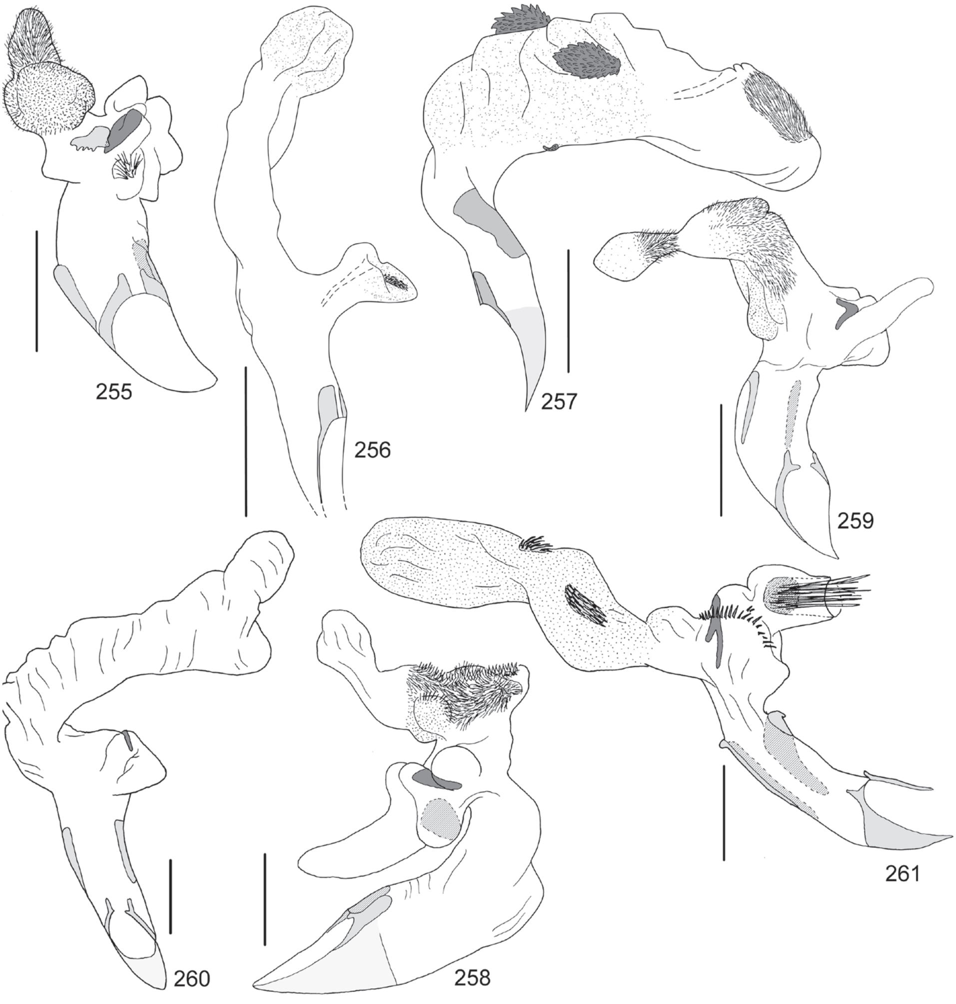

**Figures 234–240.** Endophallus of **234** *Anomala atrivillosa* (Estación Barva, Heredia, MNCR) **235** *A. balzapambae* (Rancho Quemado, Puntarenas, MNCR) **236** *A. calligrapha* (Cabro Muco, Guanacaste, CEUA) **237** *A. chiriquina* (Estación Biológica Las Alturas, Puntarenas, MNCR) **238** *A. cinaedias* (San Luis, Puntarenas, MNCR) **239** *A. clarivillosa* (La Esperanza del Guarco, Cartago, CEUA) **240** *A. clathrata* (Albergue Heliconias, Alajuela, CEUA). Scale bars: 1 mm. Figs 234, 239 from Filippini et al. (2015d).



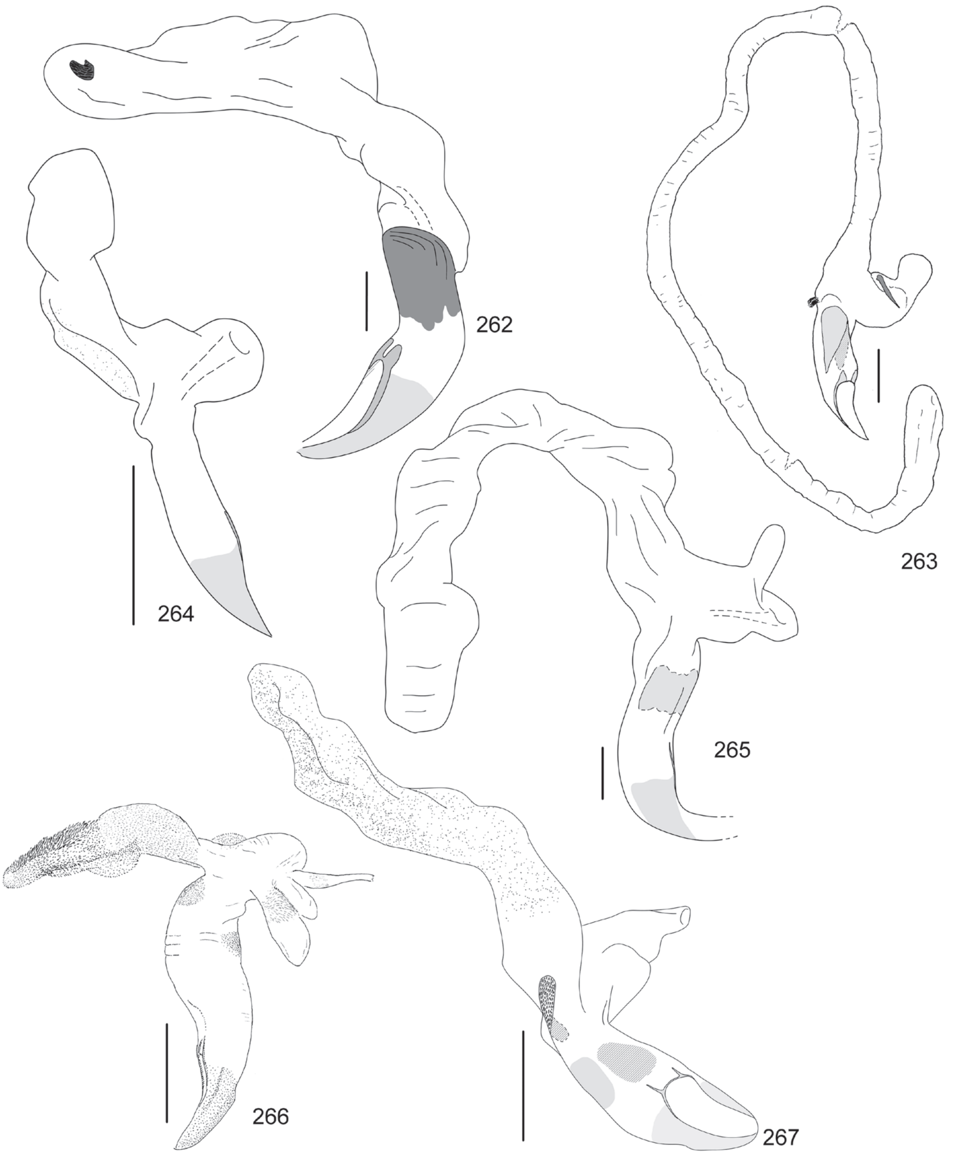

**Figures 241–247.** Endophallus of **241** *Anomala coffea* (Estación Pitilla, Guanacaste, MNCR) **242** *A. cupreovariolosa* (Zona Protectora Las Tablas, Puntarenas, MNCR) **243** *A. cupricollis* (Las Cruces, Puntarenas, MNCR) **244** *A. cyclops* (Finca Jenny, Guanacaste, MNCR) **245** *A. discoidalis* (Estación Cuatro Esquinas, Limón, MNCR) **246** *A. divisa* (Cinco esquinas de Carrizal, Alajuela, MNCR) **247** *A. estrella* (Hacienda Tiquires, San José, MNCR). Scale bars: 1 mm. Fig. 242 from Filippini et al. (2014); Fig. 247 from Filippini et al. (2015b); Figs 241, 244, 246 from Filippini et al. (2015c).



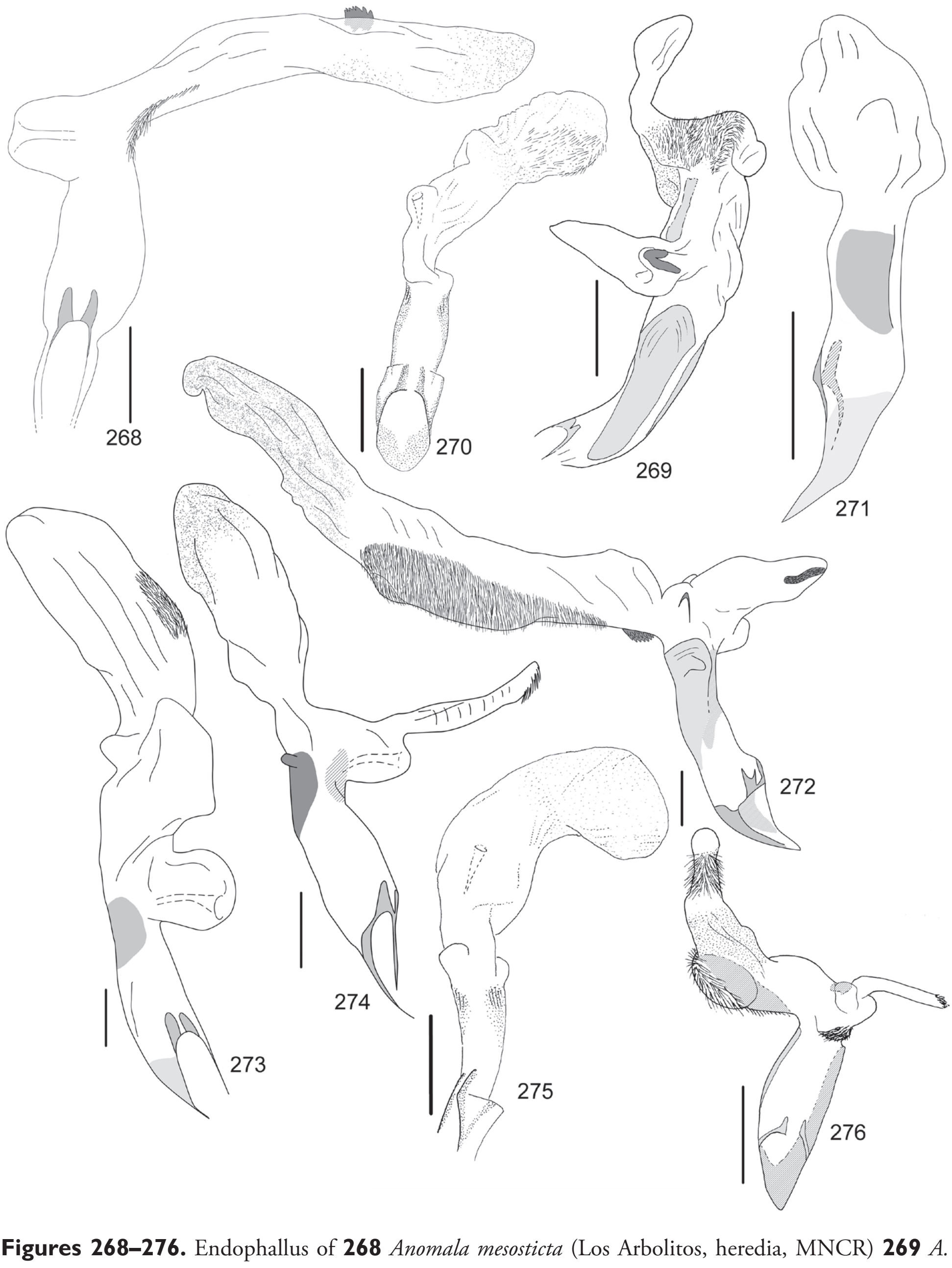

**Figures 248–254.** Endophallus of **248** *Anomala eucoma* (San José, San José, MUCR) **249** *A. eulissa* (Sector Cedrales de la Rita, Limón, MNCR) **250** *A. eusticta* (Estación La Casona, Puntarenas, MNCR) **251** *A. ferrea* (Las Cruces, Puntarenas, MNCR) **252** *A. flavacoma* (Estación Cabro Muco, Guanacaste, CEUA) **253** *A. foraminosa* (Estación Hitoy Cerere, Limón, MNCR) **254** *A. globulata* (reconstructed from two specimens: Macizo de la Muerte and Reserva forestal Río Macho, Cartago, MNCR). Scale bars: 1 mm. Figs 248, 252 from Filippini et al. (2013); Fig. 251 from Filippini et al. (2014); Figs 250, 254 from Filippini et al. (2015d).



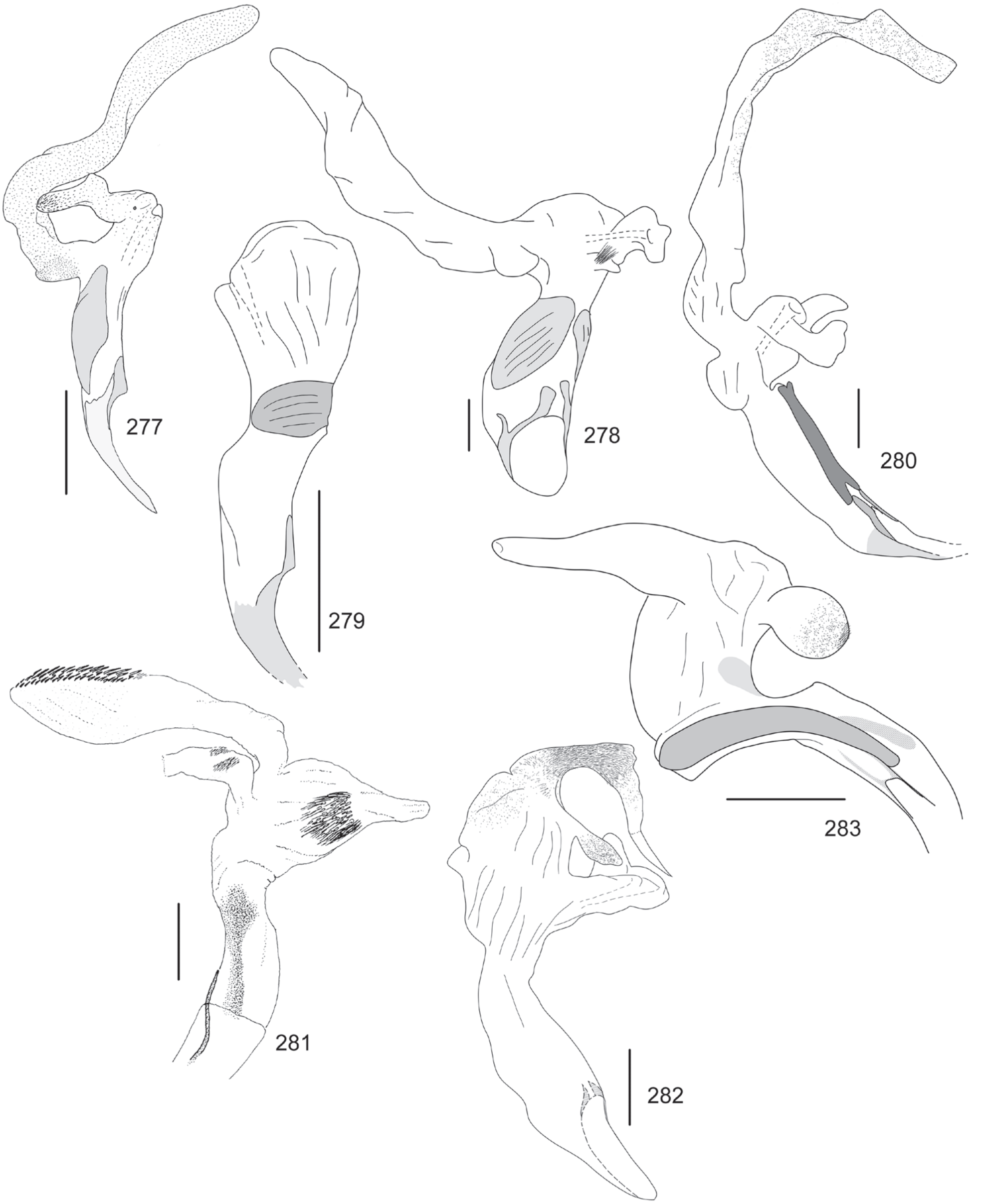

**Figures 255–261.** Endophallus of **255** *Anomala hiata* (Estación Pittier, Puntarenas, MNCR) **256** *A. histrionella* (Estación Murcielago, Guanacaste, MNCR) **257** *A. hoppi*, there is variability in the size and number (1–3) of patches of spines (Las Cruces, Puntarenas, MNCR) **258** *A. inbio* (Volcán Tenorio, Guanacaste, CEUA) **259** *A. latifalculata* (Zona Protectora Cerros de la Carpintera, Cartago, MNCR) **260** *A. leopardina* (Buenos Aires, Puntarenas, MNCR) **261** *A. levicollis* (Estación La Casona, Puntarenas, MNCR). Scale bars: 1 mm. Figs 255, 258–261 from Filippini et al. (2015d).



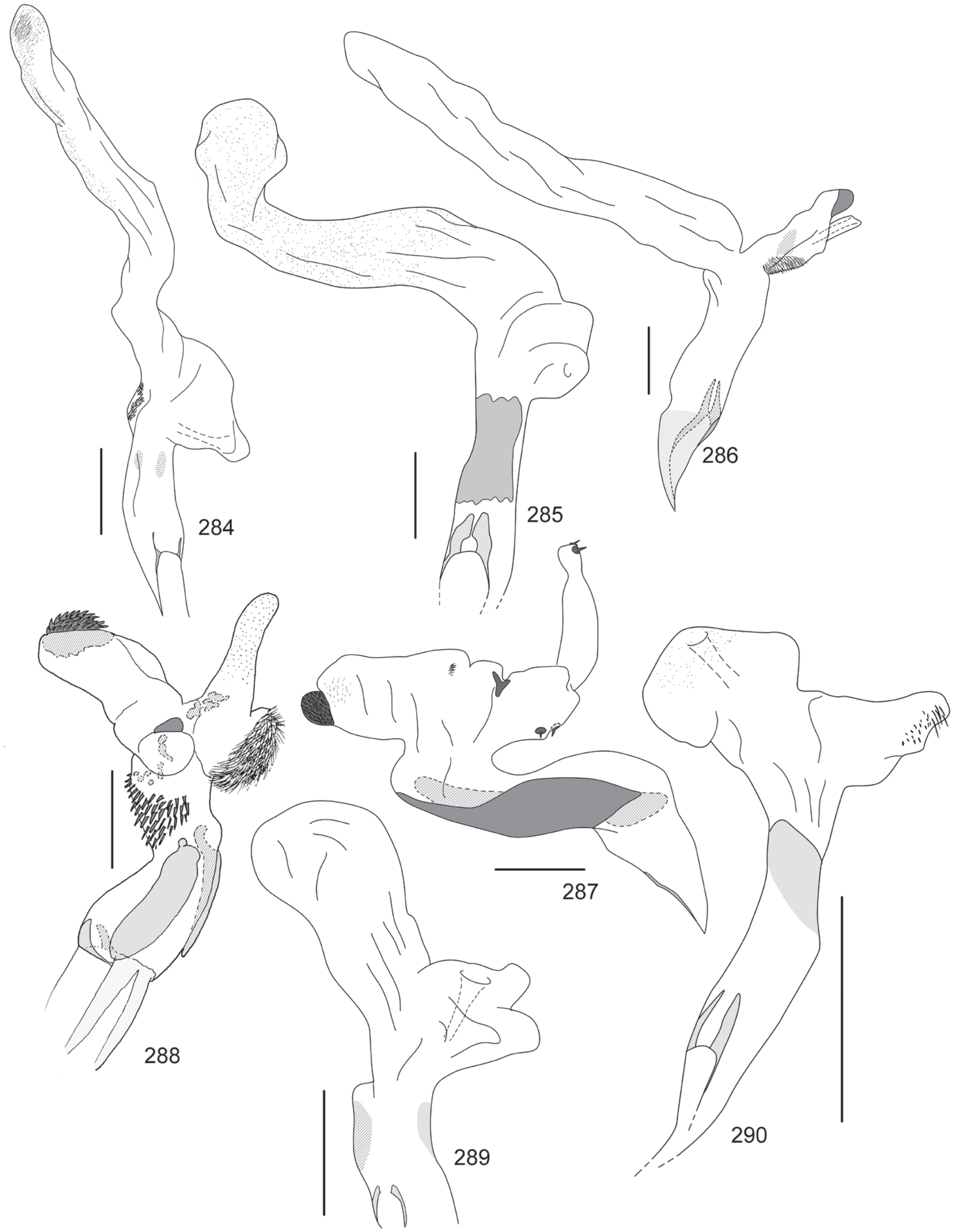

**Figures 262–267.** Endophallus of **262** *Anomala limon* (Estación Hitoy Cerere, Limón, MNCR) **263** *A. longisacculata* (Cabanga, Alajuela, CEUA) **264** *A. ludoviciana* (Parque Nacional Santa Rosa, Guanacaste, MNCR) **265** *A. megalia* (Cerro Tortuguero, Limón, MNCR) **266** *A. megaparamera* (Estación Cuatro Esquinas, Limón, MNCR) **267** *A. mersa* (Sector Palo Verde, Guanacaste, MNCR). Scale bars: 1 mm. Figures 266 from Filippini et al. (2013); Fig. 262 from Filippini et al. (2015b); Fig. 267 from Filippini et al. (2015c); Fig. 263 from Filippini et al. (2015d).



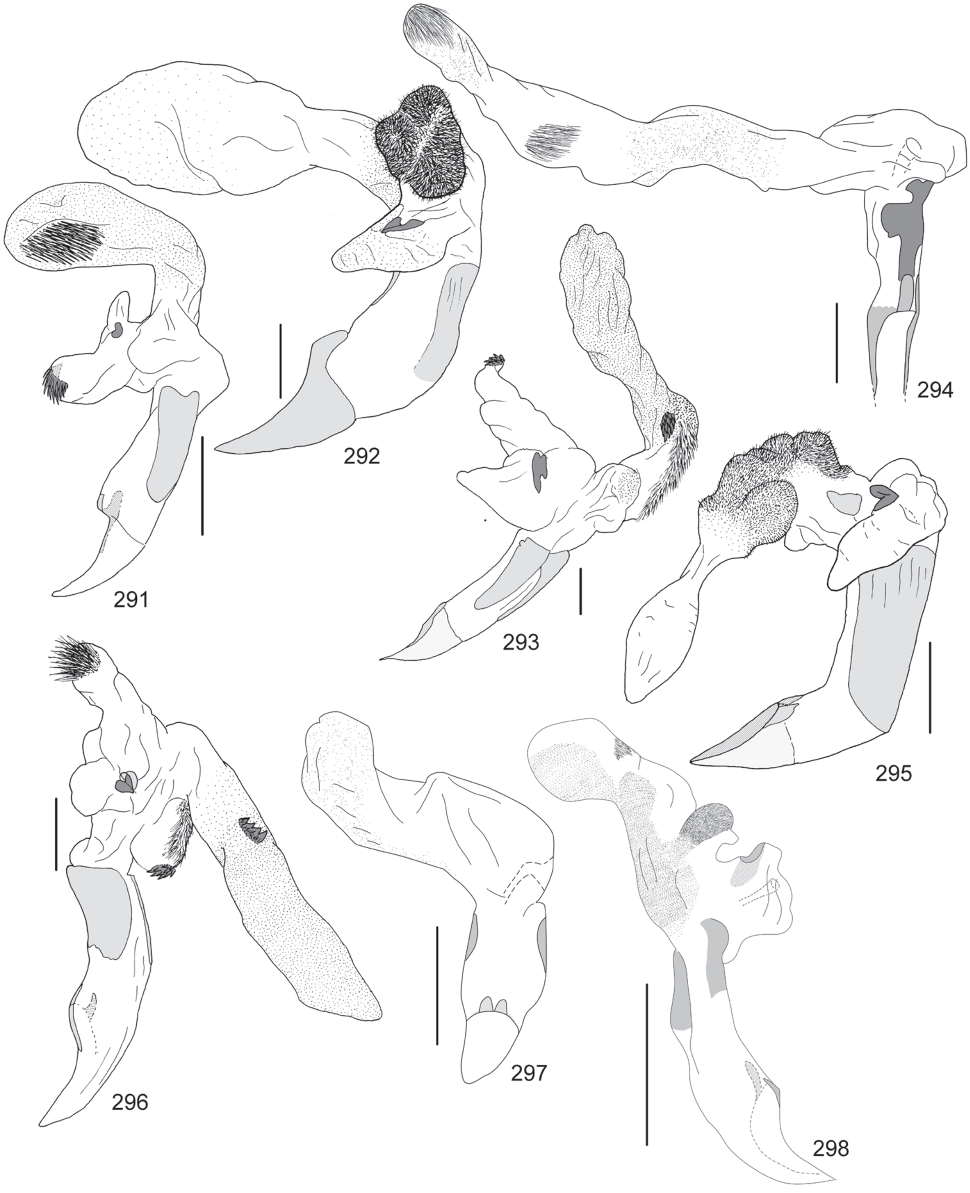

**Figures 268–276.** Endophallus of **268** *Anomala mesosticta* (Los Arbolitos, heredia, MNCR) **269** *A. m-fuscum* (La Esperanza del Guarco, Cartago, MNCR) **270** *A. moroni* (Estación Las Pailas, Guanacaste, MNCR) **271** *A. nigroflava* (Río Rincon, Puntarenas, MNCR) **272** *A. obovata* (Cerro Chompipe, Heredia, MNCR) **273** *A. ochrogastra* (Estación Las Alturas, Puntarenas, MNCR) **274** *A. ochroptera* (La Maritza, Guanacaste, MNCR) **275** *A. parvaeucoma* (Estación Sirena, Puntarenas, MNCR) **276** *A. perspicax* (Buenos Aires, Puntarenas, MNCR). Scale bars: 1 mm. Figures 271 from Filippini et al. (2014); Fig. 272 from Filippini et al. (2015b); Fig. 268 from Filippini et al. (2015c); Figs 269, 276 from Filippini et al. (2015d); Figs 270, 275 from Filippini et al. (2015e).




**Figures 277–283.** Endophallus of **277** *Anomala piccolina* (Estación Biológica Las Alturas, Puntarenas, MNCR) **278** *A. pincelada* (Cuajiniquil, Guanacaste, MNCR) **279** *A. popayana* (Reserva Biológica Hitoy Cerere, Limón, MNCR) **280** *A. praecellens* (Orosilito, Guanacaste, CEUA) **281** *A. pseudoeucoma* (Estación Hitoy Cerere, Limón, MNCR) **282** *A. quiche* (Estación Maritza, Guanacaste, MNCR) **283** *A. robiginosa* (Zarcero, Alajuela, MNCR). Scale bars: 1 mm. Figures 281 from Filippini et al. (2013); Fig. 278 from Filippini et al. (2015b); Fig. 283 from Filippini et al. (2015c); Fig. 277 from Filippini et al. (2015d).

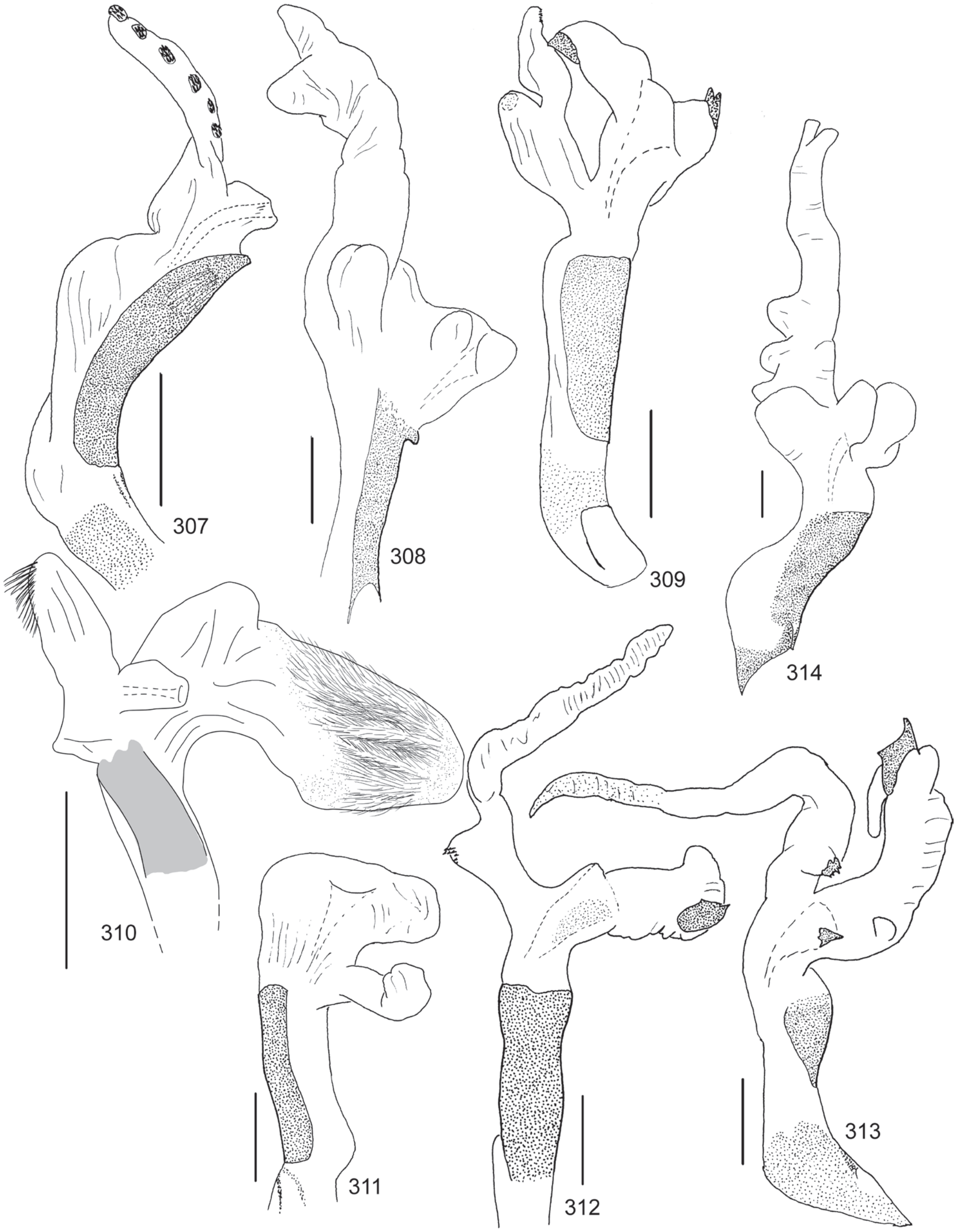



**Figures 284–290.** Endophallus of **284** *Anomala ruatana* (Playa Naranjo, Guanacaste, MNCR) **285** *A. semicincta* (Albergue Heliconias, Alajuela, CEUA) **286** *A. semilla* (Albergue Heliconias, Alajuela, CEUA) **287** *A. solisi* (Estación Pitilla, Guanacaste, MNCR) **288** *A. stillaticia* (Río Grande de Orosí, Cartago, MNCR) **289** *A. strigodermoides* (holotype) **290** *A. subaenea* (Estación Maritza, Guanacaste, MNCR). Scale bars: 1 mm. Figs 286–287 from Filippini et al. (2014); Fig. 289 from Filippini et al. (2015c); Fig. 288 from Filippini et al. (2015d).

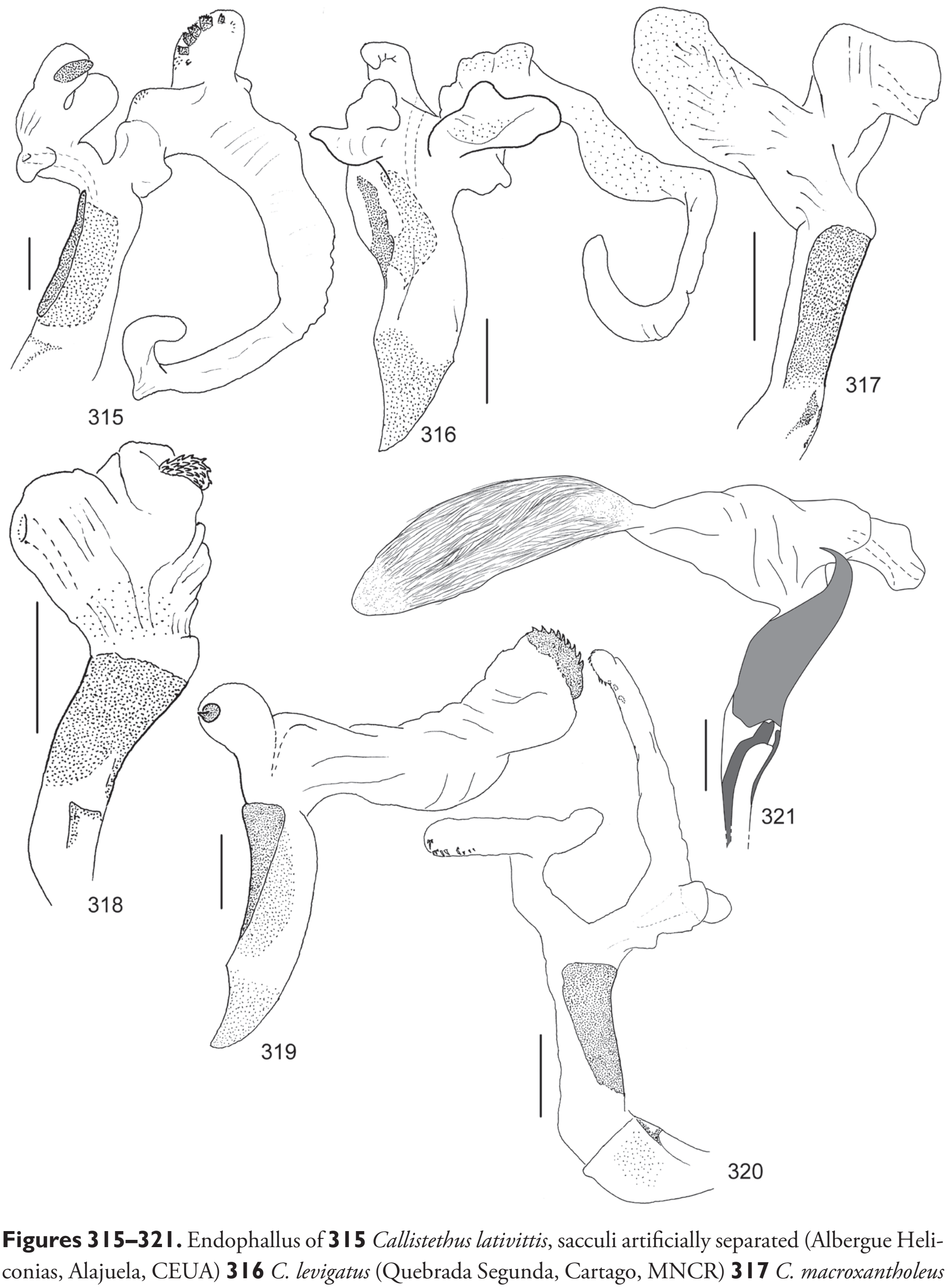



**Figures 291–298.** Endophallus of **291** *Anomala subridens* (Reserva Forestal Río Macho, Cartago, MNCR) **292** *A. subusta* (Estación Cacao, Guanacaste, MNCR) **293** *A. tenoriensis* (Parque Nacional Volcán Tenorio, Alajuela, MNCR) **294** *A. testaceipennis* (Vuelta Cmpana, Heredia, MNCR) **295** *A. trapezifera* (Fila Matama, Limón, MNCR) **296** *A. tuberculata* (Albergue Heliconias, Alajuela, CEUA) **297** *A. undulata* (Zarcero, Alajuela, MNCR) **298** *A. unilineata* (Parque Nacional Santa Rosa, Guanacaste, MNCR). Scale bars: 1 mm. Figs 298 from Filippini et al. (2015c); Figs 291–293, 295–296 from Filippini et al. (2015d).

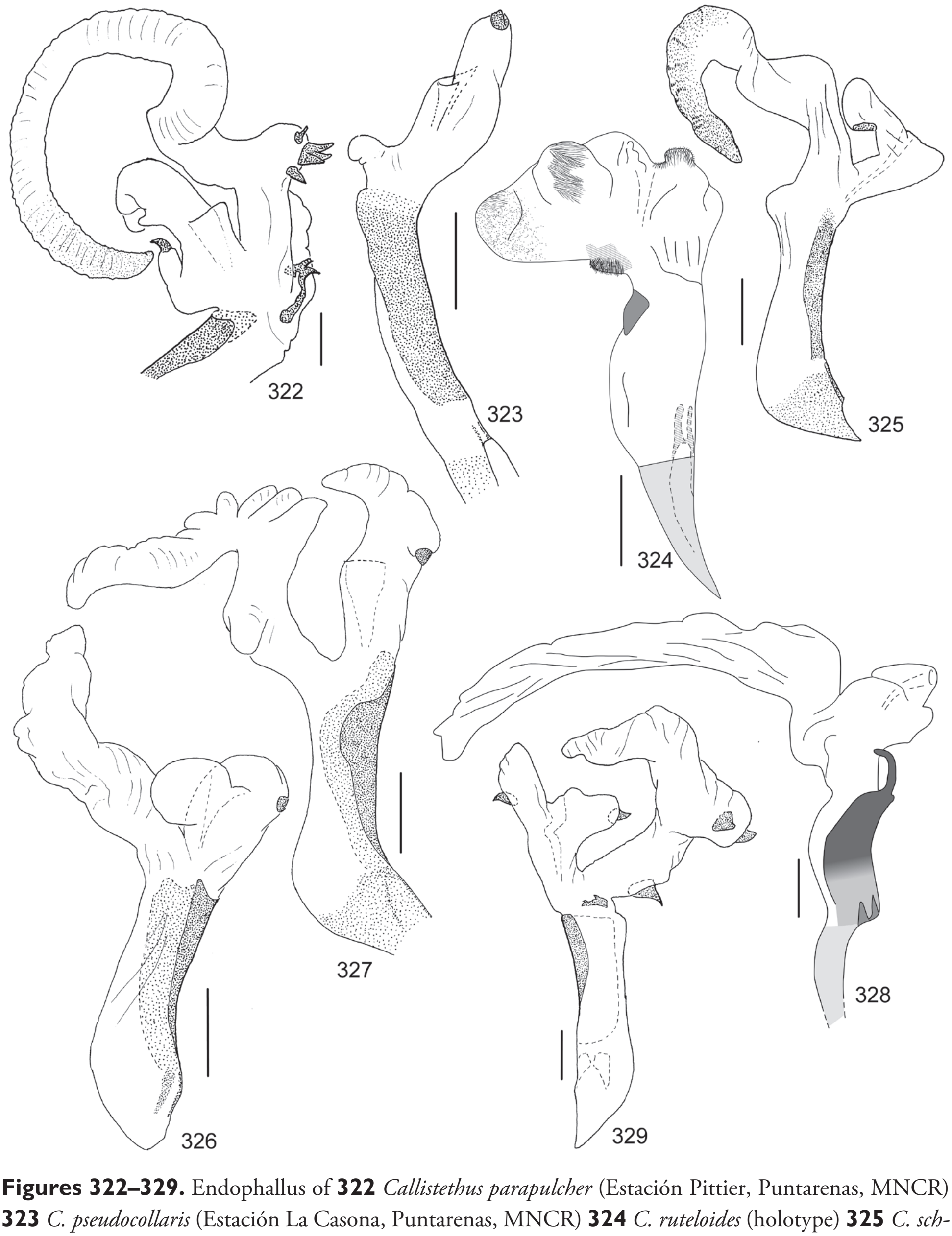

**Figures 299–306.** Endophallus of **299** *Anomala valida* (Estación Biológica La Selva, Heredia, MNCR) **300** *A. vallisneria* (Sector Las Pailas, Guanacaste, MNCR) **301** *A. veraecrucis*, A and B: oppsite lateral views (Finca Jenny, Guanacaste, MNCR) **302** *A. volsellata* (Las Quebraditas, Puntarenas, MNCR) **303** *A. vulcanicola* (San Gerardo de Dota, San José, MNCR) **304** *A. zumbadoi* (Rancho quemado, Puntarenas, MNCR) **305** *Anomalorhina turrialbana* (Cabanga, Alajuela, CEUA) **306** *Callistethus calonotus* (Alto de Las Moras, Puntarenas, MNCR). Scale bars: 1 mm. Figs 302, 304 from Filippini et al. (2014); Fig. 306 modified from Filippini et al. (2015a); Figs 300, 303 from Filippini et al. (2015d).



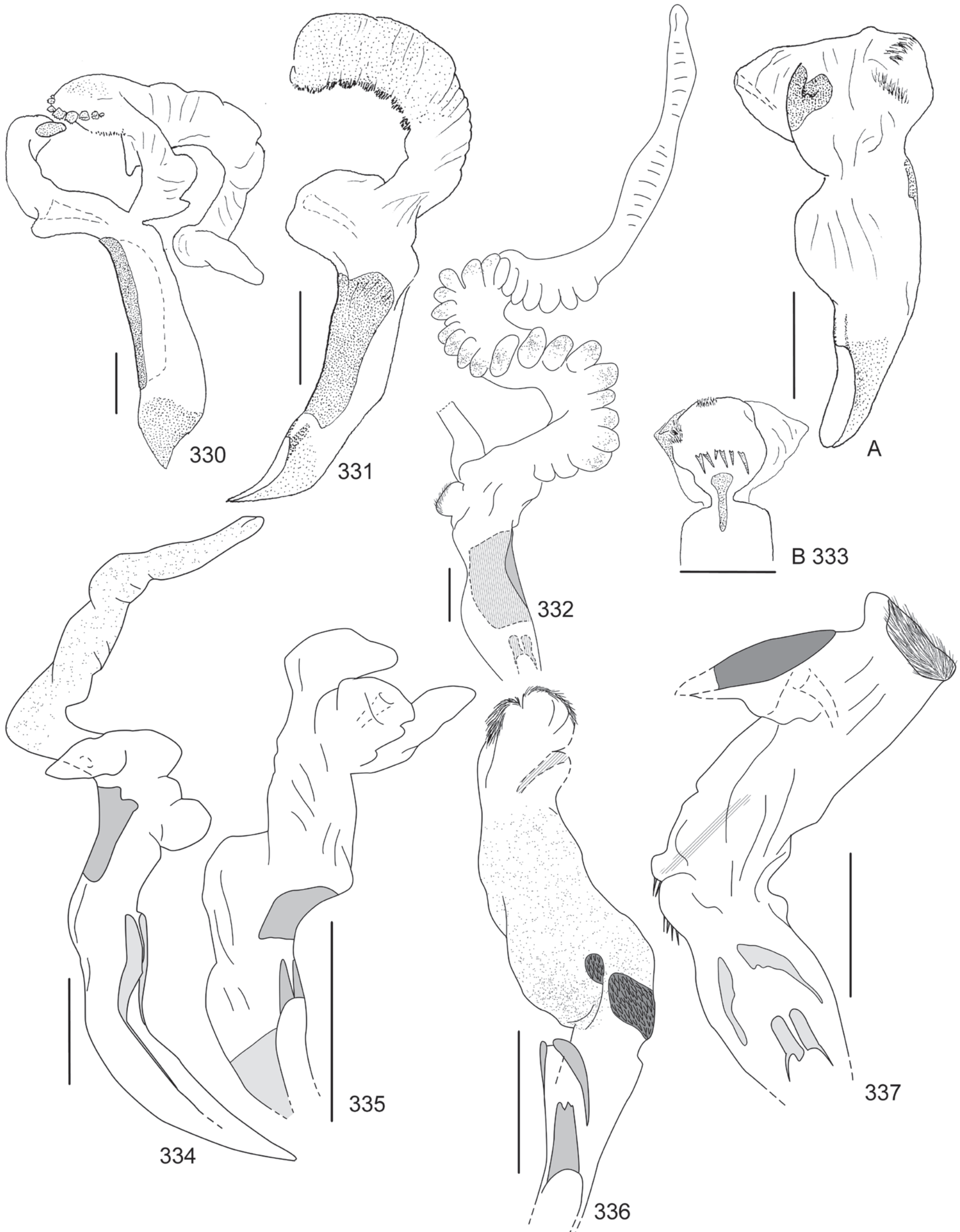

**Figures 307–314.** Endophallus of **307** *Callistethus carbo* (Río San Lorenzo, Guanacaste, MNCR) **308** *C. chlorotoides* (Estación Hitoy Cerere, Limón, MNCR) **309** *C. chontalensis* (El Copal, Cartago, CEUA) **310** *C. chrysomelinus* (Buen Amigos, Puntarenas, MNCR) **311** *C. flavodorsalis* (Finca Cafrosa, Puntarenas, MNCR) **312** *C. fuscorubens* (Estación Altamira, Puntarenas, MNCR) **313** *C. granulipygus* (Estación Quebrada Bonita, Puntarenas, MNCR) **314** *C. jordani* (Estación Cacao, Guanacaste, MNCR). Scale bars: 1 mm. Figs 307–309, 311–314 modified from Filippini et al. (2015a).




**Figures 315–321.** Endophallus of **315** *Callistethus lativittis*, sacculi artificially separated (Albergue Heliconias, Alajuela, CEUA) **316** *C. levigatus* (Quebrada Segunda, Cartago, MNCR) **317** *C. macroxantholeus* (Río San Lorencito, Alajuela, MNCR) **318** *C. microxantholeus* (Est. Pitilla, Guanacaste, MNCR) **319** *C. mimeloides* (Orosilito, Guanacaste, CEUA) **320** *C. multiplicatus* (Sector Cerro Cocori, Limón, MNCR) **321** *C. nicoya* (Estación Quebrada Bonita, Puntarenas, MNCR). Scale bars: 1 mm. Figs 315–320 modified from Filippini et al. (2015a).




**Figures 322–329.** Endophallus of **322** *Callistethus parapulcher* (Estación Pittier, Puntarenas, MNCR) **323** *C. pseudocollaris* (Estación La Casona, Puntarenas, MNCR) **324** *C. ruteloides* (holotype) **325** *C. schneideri* (Albergue Heliconias, Alajuela, MNCR) **326** *C.specularis*, sacculi artificially separated (Quebrada Segunda, Cartago, MNCR) **327** *C. stannibractea* (Estación Barva, Heredia, MNCR) **328** *C. sulcans* (Estación La Maritza, Guanacaste, MNCR) **329** *C. valdecostatus* (Estación Biológica Las Alturas, Puntarenas, MNCR). Scale bars: 1 mm. Figs 322–323, 325–327, 329 modified from Filippini et al. (2015a); Fig. 324 from Filippini et al. (2015b).




**Figures 330–337.** Endophallus of **330** *Callistethus vanpatteni* (Cinco Esquinas de Carrizal, Alajuela, MNCR) **331** *C. xiphostethus* (Los Ángeles, Heredia, MNCR) **332** *C. yalizo* (holotype) **333** *Moroniella nitidula*, A: lateral view, B: dorsal view (Zarcero, Alajuela, MNCR) **334** *Strigoderma auriventris* (Sector San Ramón de dos ríos, Alajuela, MNCR) **335** *Strigoderma biolleyi* (San Luis, Puntarenas, MNCR) **336** *S. nodulosa* (Estación Quebrada Bonita, Puntarenas, MNCR) **337** *S. sulcipennis* (Finca Jenny, Guanacaste, MNCR). Scale bars: 1 mm. Figs 330–331 modified from Filippini et al. (2015a); Fig. 332 from Filippini et al. (2015b).

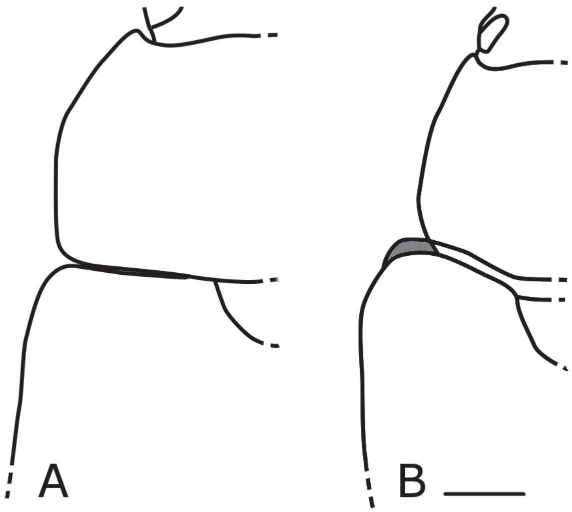



**Figure 338.** Mesepimeron of **A** *Anomalorhina turrialbana* **B** *Strigoderma nodulosa*. Scale bars: 1 mm.

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# *Gondwanamyia*, a new empidoid (Diptera) genus of uncertain placement

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### Abstract
A new minute-size empidoid fly genus, *Gondwanamyia* **gen. n.** and two new species (*G. chilensis* Cumming & Saigusa, **sp. n.**, *G. zealandica* Sinclair & Brooks, **sp. n.**) are described, illustrated, and their distributions mapped. The family and subfamily assignments remain uncertain, but features of the female terminalia potentially suggest Trichopezinae (Brachystomatidae).

### Keywords
Empidoidea, Brachystomatidae, Trichopezinae, Empididae, Chile, New Zealand, new species, new genus

## Introduction

The higher classification of the exceedingly diverse Empidoidea, commonly referred to as dance flies and long-legged flies, consists of five well-defined families, namely Empididae, Hybotidae, Atelestidae, Brachystomatidae and Dolichopodidae s.l., plus three small unassigned genus-groups (Sinclair and Cumming 2006) that are sometimes given separate family status (i.e., Homalocnemidae, Oreogetonidae) (Thompson 2009; Pape et al. 2011; Marshall 2012; Sinclair, in press), or probably soon will be (i.e., *Iteaphila* Zetterstedt group). There are still numerous new empidoid genera awaiting description that can all be placed confidently within these various groups. However, in this paper we report on a remarkable new empidoid genus that we cannot positively assign to either family or subfamily.

The genus contains two minute-size new species, one from southern Chile and the other from the North Island of New Zealand. Here we formally describe this new genus and its two included species. The potential phylogenetic placement of this curious Southern Hemisphere group within the Empidoidea, is also discussed.

## Material and methods

This study is based on material borrowed from or deposited in the following institutions: Canadian National Collection of Insects, Ottawa, Canada (CNC); Biosystematics Laboratory, Kyushu University, Fukuoka, Japan (KUMF); National Museum of Wales, Cardiff, UK (NMWC); New Zealand Arthropod Collection, Landcare, Auckland, New Zealand (NZAC). Label data for primary types are cited from the top downward, with the data from each label in quotation marks. Labels are cited in full, with original spelling, punctuation, and date, and label lines are delimited by a slash (/). The repository of each type is given in parentheses. Secondary type data are abridged and listed alphabetically.

Terms used for adult structures primarily follow Cumming and Wood (2009), except for the antenna and wing venation, where the terms of Stuckenberg (1999) and Saigusa (2006) are used, respectively. Male and female abdomens of certain specimens were macerated in hot 85% lactic acid and immersed in glycerin in order to examine terminalia.

## Taxonomy

***Gondwanamyia* Sinclair, Cumming, Brooks, Plant & Saigusa, gen. n.**
http://zoobank.org/2AC98033-68E1-4C80-8C91-B07BB900C12E

**Type-species.** *G. chilensis* Cumming & Saigusa, sp. n.

**Diagnosis.** Body size minute, 1.1–1.4 mm. Arista-like stylus very long, longer than thorax, lacking basal article; males and females dichoptic, eye facets convex, appearing larger than in other empidoids; clypeus strongly convex; mouthparts with large epipharyngeal carina and paired epipharyngeal blades; wing with weakened fold near base, only two longitudinal veins fully developed ($R_{4+5}$ and $M_4$), $R_{4+5}$ branched; abdomen with abdominal plaques; male terminalia symmetrical and unrotated, epandrium and hypandrium desclerotized and fused together, epandrial lobe and cercus projected anterodorsally, phallus tubular with or without an elongate apical filament, ejaculatory apodeme slender, rod-like; female terminalia sclerotized, sclerites beyond segment 6 mostly bare; tergite and sternite 8 anteroventrally articulated; female cercus sclerotized, projecting horizontally.

**Description. Male.** *Head:* Dichoptic; eye facets convex; some short scattered ommatrichia. Antenna with scape reduced, strap-like with several setulae; pedicel globular, slightly shorter than postpedicel; arista-like stylus longer than thorax, lacking basal article. Ocellar triangle small, not raised, with stout ocellar setae inserted anteriorly, opposite anterior ocellus; several setulae posterior to ocellar triangle; vertical seta lateroclinate; 1 shorter seta between vertical seta and ocellar triangle; several postocular setae present. Mouthparts with swollen or inflated clypeus; epipharyngeal carina elongate and slender, extended well into clypeal region; epipharyngeal blades present at apex of carina, slender and pointed apically; labrum thickly sclerotized laterally; hypopharynx slender, stylet-like; lacinia apparently absent; palpus oval, flattened on inner face, with several long setulae; labellum pointed apically, narrow, without pseudotracheae, apical margin with series of peg-like sensilla.

*Thorax:* Chaetotaxy well developed and in distinct rows; acrostichals present or absent. Prosternum separated between fore coxae. Dorsal mesepimeral pocket present; metasternal furca tapered to narrow apex, lacking apical projections. Laterotergite bare. Fore leg simple, not raptorial; tibia without basal gland. Mid femur with row of stout posteroventral setae. Hind tibia with posteroapical comb.

*Wing:* Length: 1.1–1.5 mm. Cuneate and narrowed at base, slightly infuscate; anal lobe and alula not developed. Costa circumambient with basal costal seta and several subequal setae proximal to $R_1$; slender, erect costal setae widely distributed to beyond $R_4$; costal break distal to Sc, continuing posteriorly as weakened transverse fold across cell bm; costa with second break at $R_1$; $R_1$ very short, terminating in basal 0.25 of wing; $R_{2+3}$ very short, nearly vertical, terminating at apex of $R_1$; two longitudinal veins fully developed ($R_{4+5}$ and $M_4$); $R_{4+5}$ branched, with $R_4$ nearly perpendicular to $R_5$; $M_4$ nearly straight, slightly arched toward wing margin; cell dm absent; cell bm quadrate; cell br longer than cell bm; cell cua weakly open parallel to wing margin. Halter long, subequal in length to scutum; shaft with several basal setulae; knob tapered apically.

*Abdomen:* Abdominal tergites and sternites without modifications, sparsely setose; abdominal plaques present; tergite 8 slender, strap-like; sternite 8 expanded laterally to cradle terminalia, thinly sclerotized medioventrally; posterior marginal setae on sternite 8 distinct and well defined.

*Male terminalia:* Upright, symmetrical and unrotated; epandrium and hypandrium desclerotized and fused together; gonocoxal apodeme slender, rod-shaped; cercus well developed; phallus tubular with or without elongate apical filament, ejaculatory apodeme slender.

*Female terminalia:* Sclerotized, mostly bare; tergite 8 shallowly notched posteromedially with four posteromarginal setae; tergite and sternite 8 anteroventrally articulated; tergite ten subtriangular, not divided medially with one pair of posterolateral and one pair of apical setae, apical setae closely approximated; sternite ten triangular, pigmented laterally with pair of lateral setae; cercus thickly sclerotized, similar to sclerite 10, with apex bearing pair of long, stout setae; spermatheca thread-like, extending full length of abdomen.

**Etymology.** Named after the southern Mesozoic continent of Gondwana, in reference to the probable age and distribution of this genus of flies on the southern continents of South America and Australasia (Figs 10, 11). All five authors are responsible for the new genus name. TS first identified this new genus, and both ARP and JMC + BJS independently studied separate series. SEB recently discovered the New Zealand species.

### *Gondwanamyia chilensis* Cumming & Saigusa, sp. n.

http://zoobank.org/51E405D1-466A-4904-B4FB-914F911BE7B5
Figs 4–6, 8, 9, 11

**Type locality.** Chile: Los Lagos (Region X), Osorno Province, Puyehue National Park, Antillanca [ca. 40°46'S 72°12'W], 1300 m, *Nothofagus*, tree line.

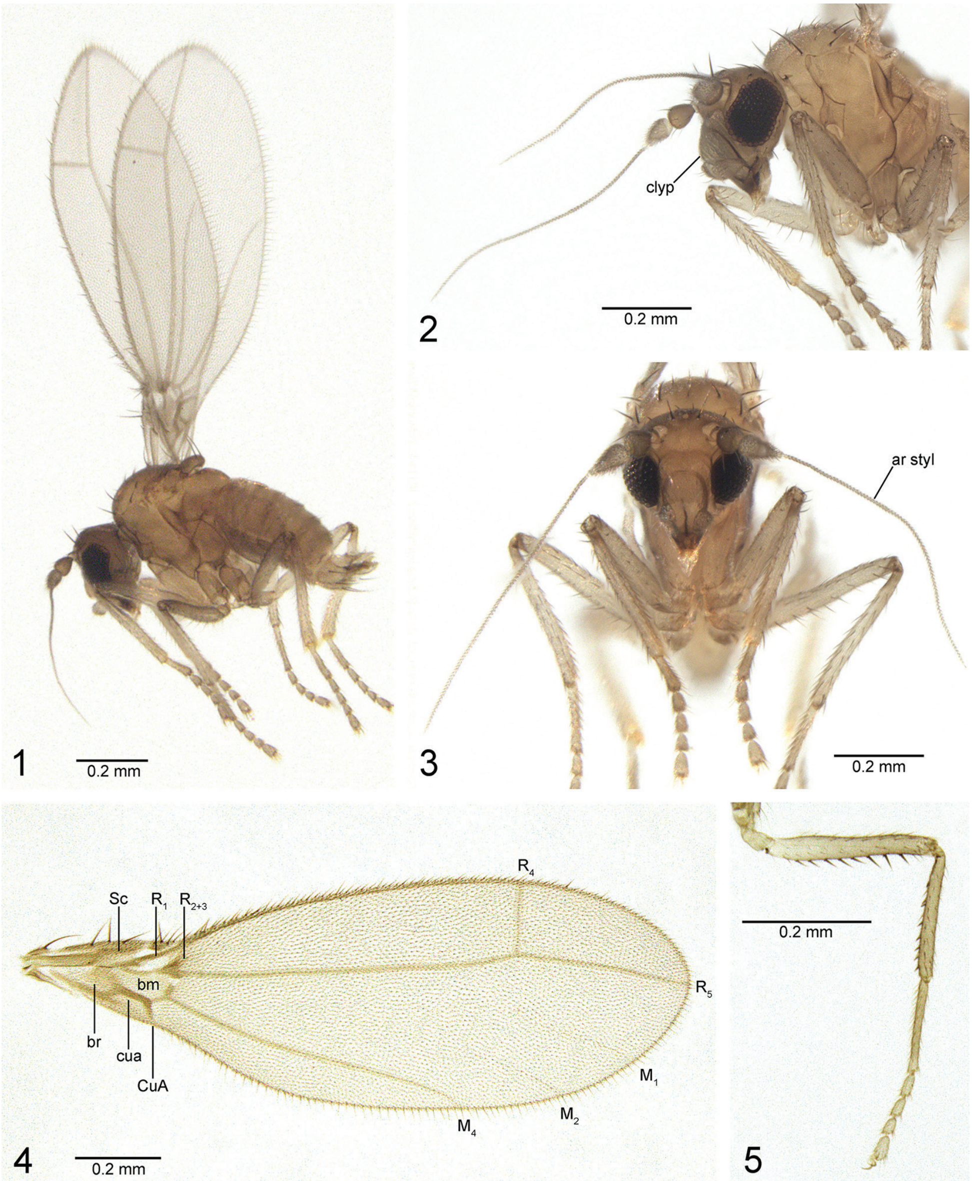
**Type-specimen. Holotype** male, pinned. Original label: "CHILE: Osorno, Puyehue/ N.P. Antillanca 1300m/ Feb. 11, 1988/ Nothofagus, tree line/ L. Masner, Chile Exp"; "HOLOTYPE/ *Gondwanamyia*/ *chilensis*/ Cumming & Saigusa" [red label] (CNC). **Paratypes**: **CHILE. Los Lagos (Region X)**. Chiloé Province: Chiloe Is., Ahoni Alto [ca. 42°46'S 73°34'W], 70 m, iv.1988, L. Masner (1 ♂, CNC). Llanquihue Province: N. Correntoso [ca. 41°26'S 72°35'W], N.E. Peurto Montt, vi-vii.1989 (2 ♂, 1 ♀, CNC). Osorno Province: Puyehue NP, Anticura [ca. 40°39'S 72°16'W], 250 m, *Nothofagus*, 12.ii.1988, L. Masner (15 ♂, 12 ♀, CNC); Puyehue NP, 1300 m, Antillanca [ca. 40°46'S 72°12'W], *Nothofagus*, tree-line, 11.ii.1988, L. Masner (18 ♂, 4 ♀, CNC). **Los Ríos (Region XIV)**. Valdivia Province: 4.1 km W Anticura, 270 m, 19–25.xii.1982, A. Newton & M. Thayer (5 ♂, 5 ♀, KUMF); 30 km W La Union, Las Trancas, *Nothofagus*, 500 m, 7–8, 25.ii.1988, L. Masner (2 ♂, 2 ♀, CNC). **Aysén del General Carlos Ibáñez del Campo (Region XI)**. Rio Gualas Sipi, Pto Gualas [ca. 46°31'S 73°42'W], 16.ii.1986, yellow pan traps in dense rainforest, N.A. Deans (1 ♀ in alc., NMWC).

**Additional material examined. CHILE**. **Los Lagos (Region X)**. Osorno Province: Puyehue NP, Volcan Casablanca [ca. 40°43'S 71°57'W], 1370 m, nr. snowline, A. Newton & M. Thayer (1 ♂, CNC).

**Recognition.** This species is distinguished from *G. zealandica* by the male mid femur and tibia with stout posteroventral setae, mostly membranous epandrium + hypandrium, and long phallic filament.

**Description. Male.** *Head:* Ocellar setae stout, reclinate. Arista-like stylus slightly longer than 0.5 mm.

*Thorax:* Brown, darker than abdomen. Acrostichals absent; six dorsocentral setae; one postpronotal seta, two notopleural setae, upper longer and stouter; one presutural and two postsutural supra-alar setae; one postalar, elongate, subequal in length to apical scutellar seta; two pairs of scutellar setae, lateral pair slender and shorter than apical pair.




**Figures 1–5.** *Gondwanamyia*, habitus, wing and mid leg. **1–3** *G. zealandica* sp. n., holotype ♂ (in ethanol, prior to drying and mounting), habitus **4** *G. chilensis* sp. n., male wing **5** *G. chilensis*, male right mid leg, posterior view. Abbreviations: ar styl: arista-like stylus; bm: basal medial cell; br: basal radial cell; clyp: clypeus; CuA: anterior branch of cubital vein; cua: anterior cubital cell; $M_1$, $M_2$, $M_4$: medial veins; $R_1$, $R_{2+3}$, $R_4$, $R_5$: radial veins; Sc: subcostal vein.

*Legs:* Mid femur with posteroventral row of 10–11 stout setae, longer than width of tibia (Fig. 5). Mid tibia with posteroventral row of apically-directed stout setae. Apex of hind tibia broadly expanded with posteroapical comb.

*Wing* (Fig. 4): Length 1.2–1.5 mm. Erect costal setae less conspicuous than in *G. zealandica*; faint subapical vein streaks present, representing veins $M_1$ and $M_2$.

*Abdomen:* Two pairs of posterior setae on male sternite 8 short and slender. Male terminalia (Fig. 6): Cercus slender, apical half narrow and parallel-sided, bearing short, slender setae. Hypandrium + epandrium mostly membranous; slender epandrial lobe anterior, parallel with cercus, lacking setae, apex of lobes united medially; base of lobe and cercus continuous as dark, slender sclerite arching posteriorly to articulate with base of hypandrium. Hypandrium sheath-like, encircling base of phallus; gonocoxal apodeme slender, arched posteriorly, arising along interior of hypandrial sheath. Phallus with elongate apical filament, 3× longer than length of hypandrial sheath; ejaculatory apodeme rod-shaped, with expanded apex, articulated at base of phallus.

**Female.** Similar to male, except posteroventral row of stout setae on mid femur and tibia absent. See genus description for details of female terminalia (Figs 8, 9).

**Etymology.** The species name refers to the country of the type locality.

**Remarks.** This species is confined to southern Chile (Fig. 11) where it is found in mostly damp temperate *Nothofagus* habitats from lowlands to tree line. All specimens were collected with yellow pan traps, except the Newton & Thayer sample, which was collected with a flight-intercept trap.

### *Gondwanamyia zealandica* Sinclair & Brooks, sp. n.

http://zoobank.org/A08B2505-A2DD-49B8-8DEE-D2EFE269C26C
Figs 1–3, 7, 10

**Type locality.** New Zealand: Auckland: Waitakere Range, Matuku Reserve, 25 m, 36.867°S, 174.476°E.

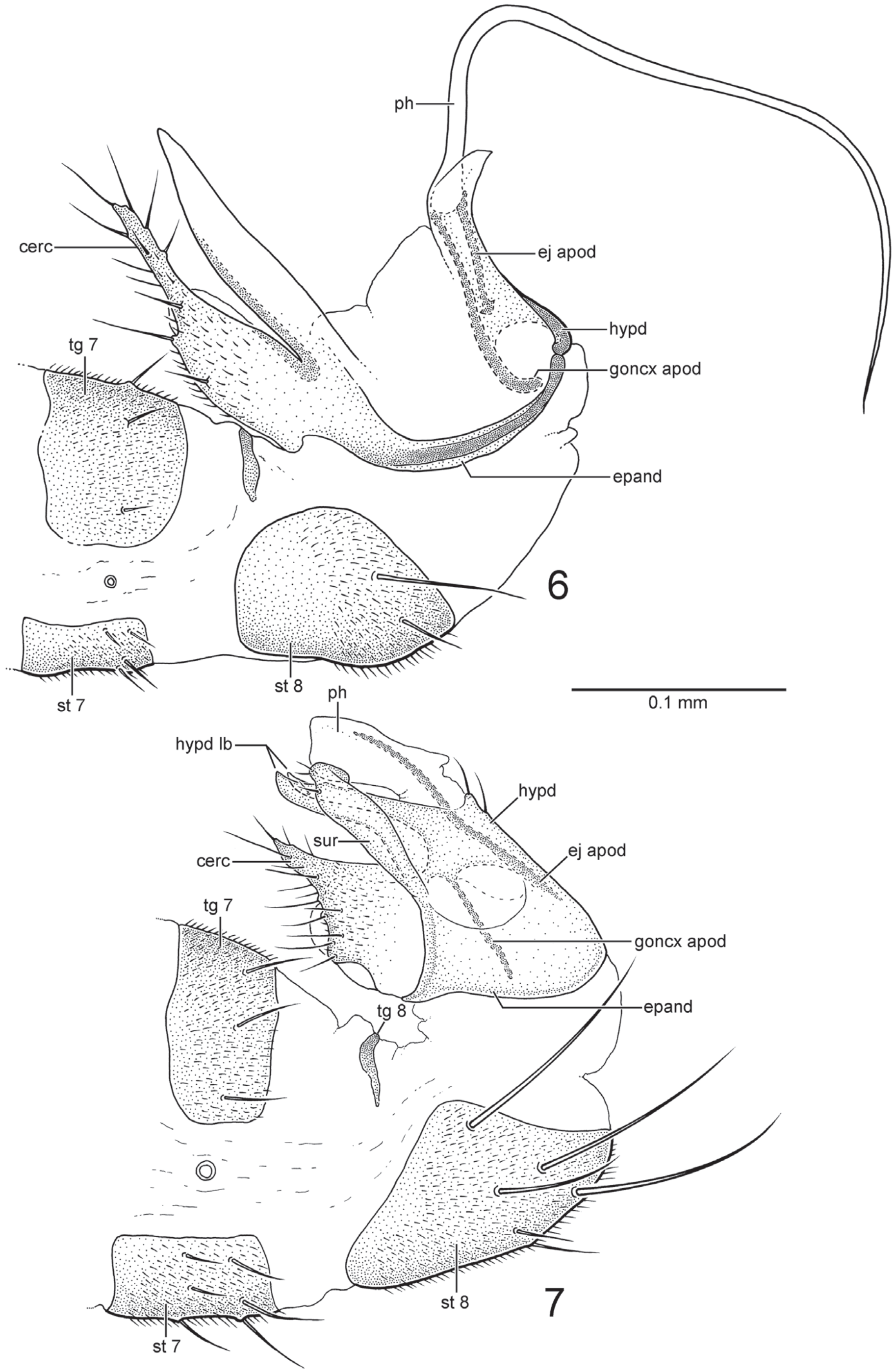
**Type-specimen. Holotype** male, pinned. Original label: "NEW ZEALAND: AK:/ Waitakere Range/ Matuku Reserve, 25 m/ 36.867°S, 174.476°E/ 2–5.iv.2010; L. Masner/ YPT [yellow pan trap] #23"; "HOLOTYPE/ Gondwanamyia/ zealandica/ Sinclair & Brooks" (NZAC).

**Recognition.** This species is distinguished from *G. chilensis* by the less stout posteroventral row of setae on the mid femur and tibia, presence of acrostichal setae, arista-like stylus slightly shorter, posterior setae on male sternite 8 longer and stouter, and phallus without an apical filament.

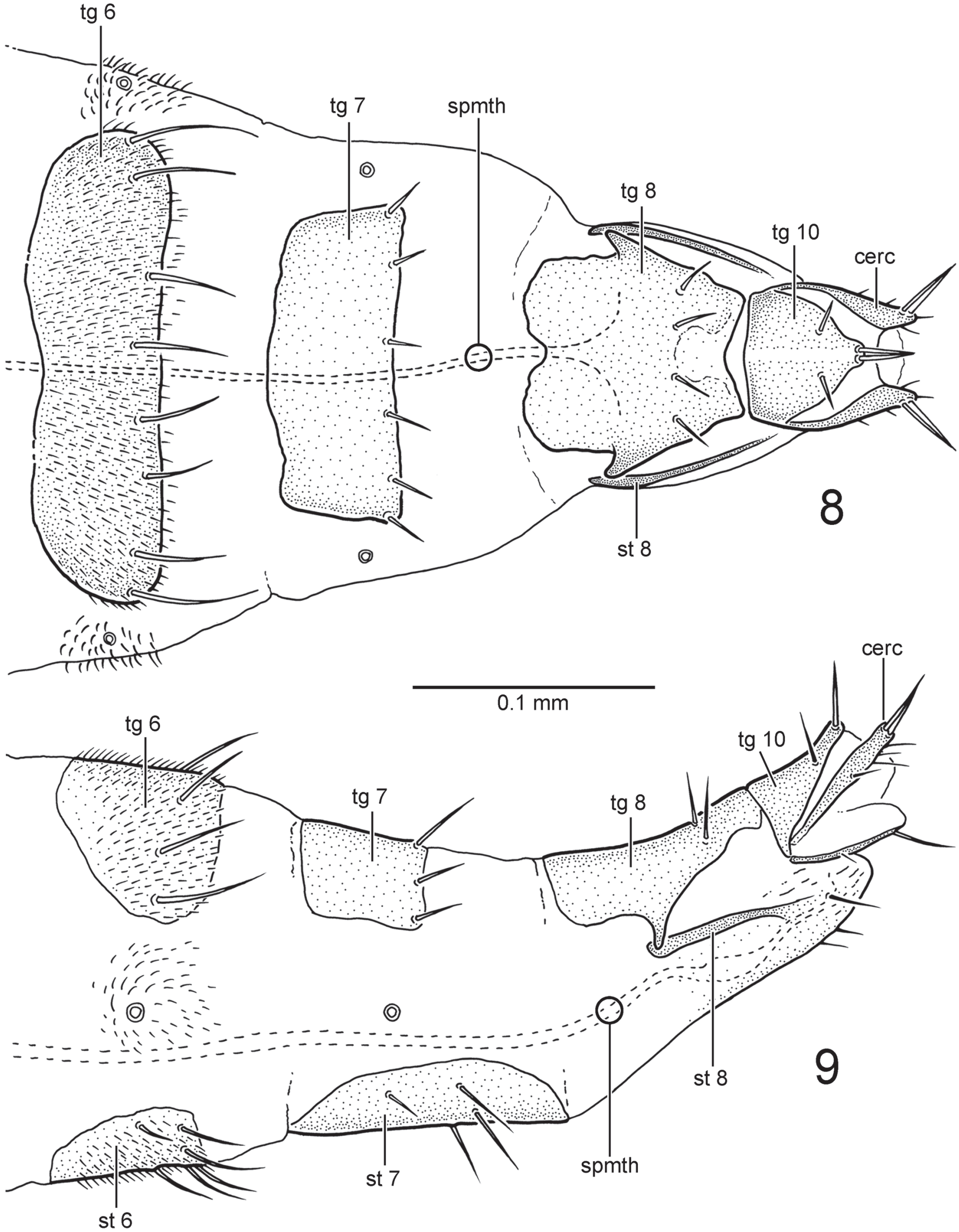
**Description. Male.** *Head:* Ocellar setae stout, reclinate. Arista-like stylus approximately 0.5 mm.

*Thorax:* Light brown, concolourous with abdomen. Acrostichal setulae present, at least three, uniserial; five dorsocentral setae, anterior seta stouter and laterally offset; one postpronotal seta, two strong, subequal notopleural setae; one presutural and three postsutural supra-alar setae; one postalar; two pairs of scutellar setae, lateral pair slender and shorter than apical pair.

*Legs:* Mid femur with posteroventral row of pale setae, longer than width of tibia. Mid tibia without posteroventral row of stout setae. Apex of hind tibia slightly expanded with posteroapical comb.



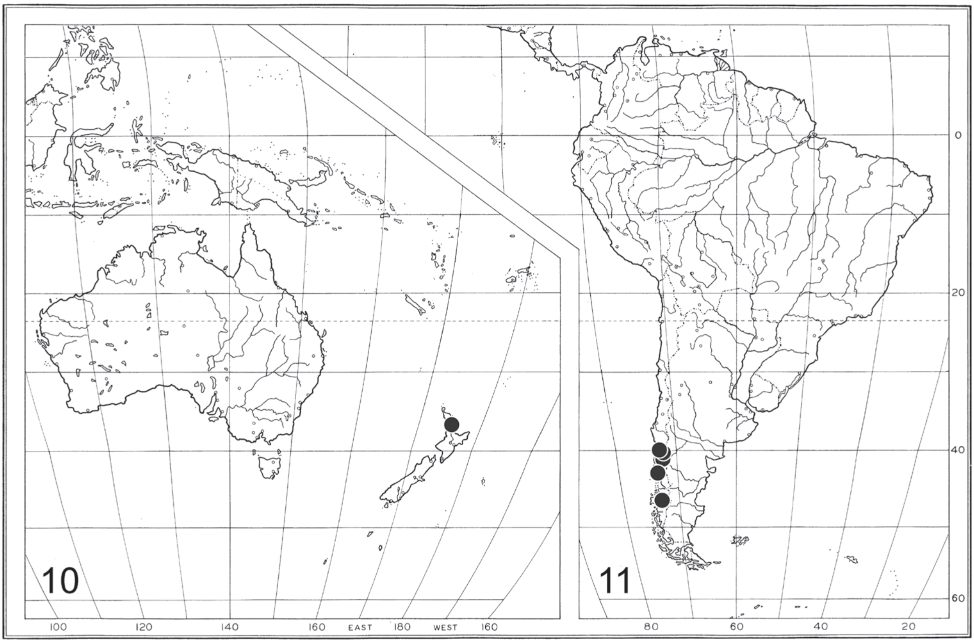

**Figures 6–7.** *Gondwanamyia*, male terminalia in lateral view. **6** *G. chilensis* sp. n. **7** *G. zealandica* sp. n. Abbreviations: cerc: cercus; ej apod: ejaculatory apodeme; epand: epandrium; goncx apod: gonocoxal apodeme; hypd: hypandrium; hypd lb: hypandrial lobe; ph: phallus; st: sternite; sur: surstylus; tg: tergite.




**Figures 8–9.** *Gondwanamyia chilensis* sp. n., female terminalia. **8** dorsal view **9** lateral view. Abbreviations: cerc: cercus; spmth: spermatheca; st: sternite; tg: tergite.

*Wing:* Length 1.1 mm. Erect costal setae more conspicuous than in *G. chilensis*; subapical vein streaks present, representing veins $M_1$ and $M_2$.

*Abdomen:* Four pairs of posterior setae on male sternite 8 long and stout. Male terminalia: Cercus broadly expanded at base, tapered to narrow apex; bearing fine setae.




**Figures 10–11.** Distribution of *Gondwanamyia*. **10** Known distribution of *G. zealandica* sp. n. **11** Known distribution of *G. chilensis* sp. n.

Hypandrium + epandrium with broad ventral connection; slender surstylus with pair of preapical setae; apex arched medially. Hypandrium sheath-like, with two pairs of tapered and apically pointed anterior hypandrial lobes; gonocoxal apodeme very slender, straight, arising on interior of hypandrial sheath. Phallus with hood-like apex, without apical filament; ejaculatory apodeme rod-shaped, very long and slender, running along posterior margin of hypandrium.

**Female.** Unknown.

**Etymology.** The species name refers to the country of the type locality.

**Remarks.** This species is known only from the type-locality, on the North Island of New Zealand (Fig. 10). The New Zealand habitat is apparently very different than that for *G. chilensis*, but collection of additional specimens and observations on the precise micro-habitat of this species in the Matuku Reserve are required.

## Discussion

Members of *Gondwanamyia* are among the smallest empidoid flies known. Based on the structure of their mouthparts, with free epipharyngeal blades, it is probable that they are predators on tiny arthropods, but nothing is currently known of their habits. Collection dates from both Chile (Dec., Feb., April, June, July) and New Zealand (April) indicate that this is primarily a late flying autumnal genus, apart from the December record. The weather in Chile and New Zealand during these months can be cool to cold. Most specimens were collected using yellow pan traps on the ground, indicating that members of this genus possibly fly low in the forest understory.

The small size of *Gondwanamyia* has presumably led to reductions in certain features such as wing venation. This has undoubtedly resulted in a loss of informative synapomorphies resulting in some confusion with homologies, creating uncertainty with the family and subfamily assignment of the genus. For example, the homologies of the male terminalia of both species are not completely resolved. The epandrium and hypandrium of *G. zealandica* appear fused together (Fig. 7), as presumably they are in *G. chilensis*, although with more desclerotization (Fig 6). In addition, the hypandrial lobe in *G. zealandica* has a lateral and medial component that could include the postgonite, whereas the similarly positioned large undivided lobe in *G. chilensis* may also incorporate the surstylus.

*Gondwanamyia* obviously does not belong to the Hybotidae or Dolichopodidae s.l., based on presence of a branched $R_{4+5}$ wing vein, unrotated male terminalia, and absence of a palpifer and fore tibial gland. It cannot be placed in the Atelestidae based on a branched $R_{4+5}$ wing vein, setose scape, elongate hypandrium, and presence of female tergite 10. The genus is also clearly not assignable to either the *Homalocnemis* Philippi, *Oreogeton* Schiner, or *Iteaphila* genus (or family) groups.

*Gondwanamyia* might represent a new lineage of Empididae, although no convincing synapomorphies appear to align it with any included member of that family. The male terminalia of the new genus show some similarities to most Nearctic species of *Chelipoda* Macquart (Empididae: Hemerodromiinae) (MacDonald 1993, fig. 12), particularly in the fusion of the epandrium and hypandrium. However, no other features of the terminalia are shared between these two groups and not all species of *Chelipoda* exhibit the epandrial-hypandrial fusion (Plant 2007). Although wing venation reduction is also common among certain genera of Hemerodromiinae (Plant 1993, 2005), the pattern of reduction in both the Hemerodromiinae and in *Gondwanamyia* does not appear to be homologous. Males of the monotypic New Zealand hemerodromiine genus *Monodromia* Collin, also have a wing with a similar weakened fold near the base. The function of this weakening (present in both sexes in *Gondwanamyia*) is unknown in both genera.

The form of the female terminalia of *Gondwanamyia* (only known for *G. chilensis*) suggests inclusion in the Brachystomatidae based on the anterior articulation of tergite and sternite 8, the more thickly sclerotized terminal segments with absence of micro-setae, and well developed setae at the apex of the cerci and tergite 10 (Sinclair and Cumming 2006). If the genus does belong in this family, it is not assignable to the Ceratomerinae due to the absence of a conus on the antennal pedicel, or to the Brachystomatinae due to its shortened cell cua, absence of a lacinia and straight spermatheca (Sinclair and Cumming 2006). This implies that *Gondwanamyia* by default, probably belongs in the Trichopezinae. This subfamily is a very heterogenous group and many genera (including *Gondwanamyia*) lack the internal median apodeme that projects anteriorly from female tergite 8, which originally formed the basis for recognizing this lineage (Sinclair 1995). Further study and analysis of the Trichopezinae is required to determine more conclusively whether *Gondwanamyia* should be assigned to this lineage.

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