

Species of the genus *Chrysotimus* Loew from China (Diptera, Dolichopodidae)

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Abstract

The following three species are described as new to science: *C. dalongensis* **sp. n.**, *C. huairouensis* **sp. n.**, and *C. hubeiensis* **sp. n.**, *Chrysotimus apicicurvatus* Yang, is recorded from Palearctic China for the first time. A key to the Chinese species of the genus is presented.

Keywords

Diptera, Dolichopodidae, *Chrysotimus*, new species, China, Taxonomy

Introduction

The genus *Chrysotimus* Loew, 1857 belongs to the subfamily Peloropeodinae. The genus is distributed worldwide except the Afrotropical region with 67 known species, 14 species are known from the Palearctic, 25 species from the Oriental (Yang et al. 2006). Thirty-three species are known from China including those newly described

herein. *Guzeriplia* Negrobov, 1968, embodies the characters of *Chrysotimus* Loew in the head and thorax with the yellow hairs and bristles and biseriate acr. Thus, it was synonymized with *Chrysotimus* by Yang et al. (2006).

Materials and methods

Specimens were studied and illustrated with a ZEISS Stemi 2000–c stereo microscope. Genitalic preparations were made by macerating the apical portion of the abdomen in warm 10% NaOH for 17–20 min, after examination it was transferred to 75% alcohol and stored in a microvial pinned below the specimen. All specimens are deposited in the Entomological Museum of China Agricultural University (CAU), Beijing, China.

Abbreviations are as follows:

acr	acrostichal bristles
ad	anterodorsal bristles
av	anteroventral bristles
dc	dorsocentral bristles
LI	fore leg
LII	mid leg
LIII	hind leg
oc	ocellar bristles
pd	posterodorsal bristles
pv	posteroventral bristles
v	ventral bristles
CuAx ratio	length of m-cu / length of distal portion of CuA.

Systematics

Genus *Chrysotimus* Loew, 1857

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

Chrysotimus Loew, 1857: 48. Type-species: *Chrysotimus pusio* Loew, 1861, des. Coquillett (1910: 524).

Guzeriplia Negrobov, 1968 : 470. Type species: *Guzeriplia chlorina* Negrobov, 1968. (original designation).

Diagnosis. Body with yellow or brownish hairs and bristles, small first flagellomere, most males with hind tarsomere 1 bearing several short black ventral bristles at base, and males with mid tarsomere 1 at least as long as the total of corresponding tarsomeres 2–4, male genitalia with 1–2 subepandrial processes, lateral epandrial lobe distinct.

Key to species (males) from China

- 1 Hind tarsomere 1 at most with sparse black bristles at base.....2
- Hind tarsomere 1 with bundle(s) of black ventral bristles at base10
- 2 Hind tarsomere 1 without black ventral bristles at base (unknown in *grandis*)3
- Hind tarsomere 1 with black ventral bristles at base.....6
- 3 Acr present4
- Acr absent.....5
- 4 Mid tarsomere 1 shorter than tarsomeres 2–5; surstylus with single lobe
..... *C. beijingensis* (Yang & Saigusa)
- Mid tarsomere 1 longer than tarsomeres 2–5; surstylus divided into 2 lobes.
..... *C. grandis* Wang & Yang
- 5 Mid tibia with 2 pd, hind tibia with 1 ad and 2 pd; wide epandrium process
nearly quadrate *C. guangxiensis* Yang & Saigusa
- Mid tibia with 1 pd, hind tibia with 2 ad and 1 pd; wide epandrium process
with apical concavity..... *C. sinensis* Parent
- 6 Antenna with 1st and 2nd antennal segments yellow *C. basiflavus* Yang
- Antenna wholly black7
- 7 Five dc; acr absent..... *C. apicicurvatus* Yang
- Six dc; acr present.....8
- 8 Nine to ten irregularly paired acr; hind tarsomere 1 with 2 black ventral bristles
at base..... *C. ningxianus* Wang, Yang & Grootaert
- Less than six irregularly paired acr; hind tarsomere 1 with 6–8 sparse black
ventral bristles on basal 1/4.....9
- 9 Hind tibia with 2 ad; epandrium with long wide and trifurcated lateral process
(Figs 2–3)..... *C. dalongensis* sp. n.
- Hind tibia with 1 ad; epandrium with short and bifurcated lateral process....
..... *C. acutatus* Wang, Yang & Grootaert
- 10 Four or five dc; acr absent11
- Six dc; acr present17
- 11 Arista dorsal; hypandrium with broad lateral process12
- Arista subapical; hypandrium with thin finger-like lateral process13
- 12 Hind tibia with row of v; surstylus wide..... *C. dorsalis* Yang
- Hind tibia without row of v; surstylus slender (Figs 5–6)
..... *C. huairouensis* sp. n.
- 13 Hind tarsomere 1 with 3–4 short black spine-like ventral bristles at base
..... *C. songshanus* Wang, Yang & Grootaert
- Hind tarsomere 1 with about 10 or more black ventral bristles at base.....14
- 14 Hairs and bristles on thorax yellow15
- Hairs and bristles on thorax brownish or brown.....16
- 15 Fore tarsomere 1 with row of about 10 v; hind tarsomere 1 with 22 short
black ventral bristles on basal 1/4; surstylus basally without inner process.....
..... *chikuni* Wang, Yang & Grootaert

- Fore tarsomere 1 without row of v; hind tarsomere 1 with less than 20 black ventral bristles on basal 1/4; surstylus basally with inner process *C. shennongjianus* Yang & Saigusa
- 16 Hind tarsomere 1 with about 12 short black ventral bristles; surstylus not furcated apically *C. bispinus* Yang & Saigusa
- Hind tarsomere 1 with 15–16 short black ventral bristles; surstylus furcated apically *C. xuae* Wang, Yang & Grootaert
- 17 Acr 2–4 pairs 18
- Acr 5 or more pairs 25
- 18 Hind tarsomere 1 with group of 8–12 black ventral bristles at base (which are somewhat sparse), but without distinct pv 19
- Hind tarsomere 1 with 1 (or 2) bundles of black basal ventral bristles, and row of 7–8 pv 21
- 19 CuAx ratio about 0.2; lateral process on epandrium not concave near middle 20
- CuAx ratio 0.35; lateral process on epandrium concave near middle *C. yunlonganus* Yang & Saigusa
- 20 First flagellomere as long as wide; hind tibia without distinct v *C. lii* Wang & Yang
- First flagellomere about 1.5 times wider than long; hind tibia with 2 pv *C. linzhiensis* Wang & Yang
- 21 R₄₊₅ and M parallel apically; hind tarsomere 1 with bundle of 4–5 black ventral bristles at base 22
- R₄₊₅ and M slightly convergent apically; hind tarsomere 1 with 2 bundles of 3–4 black ventral bristles at base *C. bifascia* Yang & Saigusa
- 22 Hairs and bristles on thorax yellow or pale; surstylus on epandrium not furcated apically 23
- Hairs and bristles on thorax brown; surstylus on epandrium furcated apically *C. sanjiangyuanus* Wang, Yang & Grootaert
- 23 Fore tarsomere 1 without row of v; hind tarsomere 1 with 4–5 black ventral bristles at base 24
- Fore tarsomere 1 with row of 5–6 v; hind tarsomere 1 with 8 black ventral bristles at base *C. guangdongensis* Wang, Yang & Grootaert
- 24 Hind femur with row of ad and pd; cercus long and narrow *C. xiaolongmensis* Zhang, Yang & Grootaert
- Hind femur without distinct d; cercus round. *C. unifascia* Yang & Saigusa
- 25 Hind tarsomere 1 with row of about 10 pv 26
- Hind tarsomere 1 without distinct v 29
- 26 Hind tarsomere 1 with 10–12 black ventral bristles at base; mid tibia without distinct av or pv 27
- Hind tarsomere 1 with about 20 black ventral bristles at base; mid tibia with 1 pv 28

- 27 First flagellomere somewhat round, 2.0 times wider than long; cercus not furcated; dorsal lobe of surstylus thick and straight *C. qinlingensis* Yang & Saigusa
- First flagellomere subtriangular, about as long as wide; cercus bifurcated; dorsal lobe of surstylus thin and curved.....*C. bifurcatus* Wang & Yang
- 28 Fore and mid tarsomere 1 without distinct v; epandrium basally with short process *C. setosus* Yang & Saigusa
- Fore and mid tarsomere 1 each with row of 5–6 v; epandrium basally with long and broad process *C. xiaohuangshanus* Wang, Yang & Grootaert
- 29 Hind tarsomere 1 with single bundle of short black ventral bristles; surstylus rather wide and thick; hypandrium with small apical incision.....**30**
- Hind tarsomere 1 with 2–3 bundles of 14–15 black ventral bristles on basal 1/6 (which contains 1–2 small tight bundles and 1 large loose bundle); surstylus narrow finger-like; hypandrium without apical incision *C. digitatus* Yang & Saigusa
- 30 Hairs and bristles on thorax pale or yellow; hind tarsomere 1 with 12 or less short black ventral bristles.....**31**
- Hairs and bristles on thorax dark brown; hind tarsomere 1 with 15–16 black ventral bristles..... *C. pingbianus* Yang & Saigusa
- 31 Hind tarsomere 1 with 7 or less short black ventral bristles; 6 irregularly paired acr; palpus yellow**32**
- Hind tarsomere 1 with 12 short black ventral bristles; 8 irregularly paired acr; palpus dark brown *C. incisus* Yang & Saigusa
- 32 Hind tibia with 2 pd; hind tarsomere 1 with 4–5 short black ventral bristles; surstylus slender (Fig. 8) *C. hubeiensis* sp. n.
- Hind tibia with 1 pd; hind tarsomere 1 with 7–8 short black ventral bristles; surstylus very wide *C. lijanganus* Yang & Saigusa

***Chrysotimus dalongensis* Wang, Chen & Yang, sp. n.**

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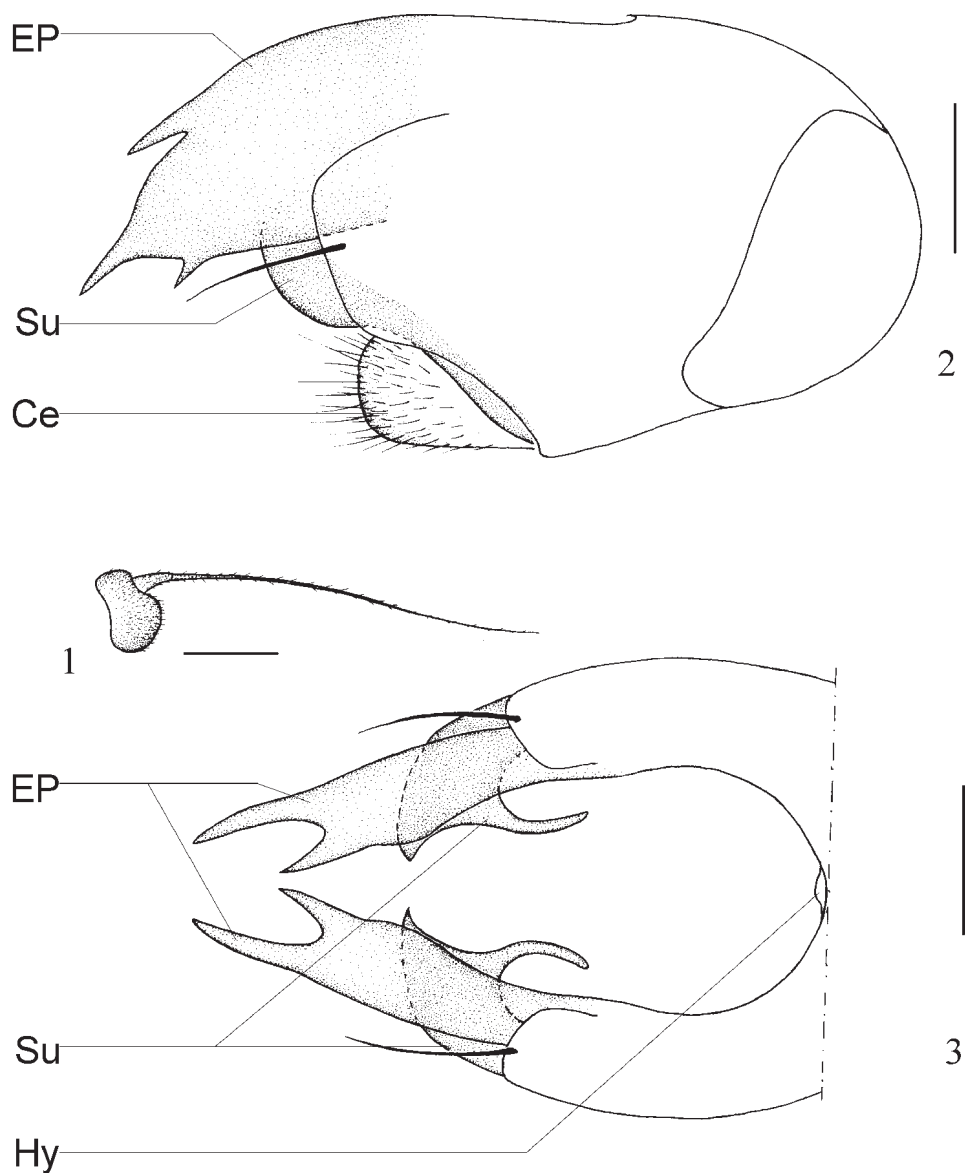
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Figs 1–3

Diagnosis. Acr 5–6 irregularly paired. Mid and hind tibiae each with 2 ad and 2 pd. Fore, mid and hind tarsomere 1 each with row of 5–7 v. Epandrium apically with long and wide lateral process, trifurcated apically; surstylus long and curved inward apically, with hook curved backwards.

Description. Male. Body length 2.25–2.45 mm, wing length 2.30–2.45 mm.

Head metallic green with gray pollen; frons and face brilliant. Hairs and bristles on head yellow. Ocellar tubercle weak, with 2 very long oc and 2 very short posterior hairs. Lower postocular bristles (including ventral hairs) pale. Antenna (Fig. 1) black-



Figures 1–3. *Chrysotimus dalongensis* sp. n., male. **1** first flagellomere, lateral view **2** male genitalia, lateral view **3** tip of male genitalia, ventral view. Abbreviations: **Ce** Cerus **EP** epandrium process **Hy** hypandrium **Su** surstylus.

ish; first flagellomere blackish, rather short, about 0.5 times as long as wide; arista dorsal, with basal segment very short. Proboscis brown, with brown hairs; palpus pale yellow, with pale hairs and 2 pale yellow apical bristles.

Thorax metallic green with pale gray pollen, mesonotum and scutellum brilliant. Hairs and bristles on thorax yellow; 6 dc, 5–6 irregularly paired acr short and hair-like;

scutellum with 2 pairs of bristles. Propleuron with 1 pale bristle on lower portion. Legs including coxae yellow with 5th tarsomere brown. Hairs and bristles on legs yellow; coxae with yellowish hairs and bristles; fore coxa with 3–4 anterior and apical bristles, mid coxa with 2–3 anterior and apical bristles, hind coxa with 1 brown outer bristle near middle. Mid femur with 1 av apically; hind femur with 1 short av and 1 short pv apically. Mid tibia with 2 ad and 2 pd, apically with 4 bristles; hind tibia with 2 ad and 2 pd, apically with 3 bristles. Fore and mid tarsomere 1 each with row of 6–7 v. Hind tarsomere 1 with 6–8 short and thick black ventral bristles at base, and row of 5–6 pv. Relative lengths of tibia and 5 tarsomeres of legs. LI 2.4 : 1.4 : 0.6 : 0.5 : 0.3 : 0.3; LII 3.3 : 2.1 : 0.8 : 0.6 : 0.4 : 0.3; LIII 3.5 : 1.4 : 0.9 : 0.6 : 0.4 : 0.3.

Wing hyaline; veins brownish, R_{4+5} and M parallel apically; CuAx ratio 0.3. Squama yellow with pale yellow hairs. Halter pale yellow.

Abdomen metallic green with pale gray pollen, dorsum brilliant, sterna 1–2 yellow. Hairs and bristles on abdomen brown.

Male genitalia (Figs 2–3) dark brown: Epandrium distinctly longer than wide, apically with long and wide lateral process, trifurcated apically; surstylus long and curved inward apically, with curved backwards hook; cercus round, with moderately long hairs; hypandrium indistinct.

Female. Unknown.

Type material. Holotype ♂, Hubei: Shennongjia, Dalongtan pound (31°75'N, 110°67'E), 30.VI.2009, Qifei Liu. Paratypes, 12♂♂, same data as holotype; 5♂♂, Hubei: Shennongjia, Dapingqian (31°75'N, 110°67'E), 7. VII. 2009, Qifei Liu. Type specimens are stored in 75% ethanol.

Distribution. Known only from the type locality in Hubei.

Remarks. This new species is similar to *Chrysotimus acutatus* Wang, Yang & Grootaert, but may be separated from the latter by 2 ad on hind tibia, and and by the long, wide, trifurcated lateral process on epandrium. In *C. acutatus*, the hind tibia has 1 ad, and the lateral epandrial process is short and bifurcated (Wang et al. 2005).

Etymology. The specific epithet is derived from the type locality Dalong (Hubei).

***Chrysotimus huairouensis* Wang, Chen & Yang, sp. n.**

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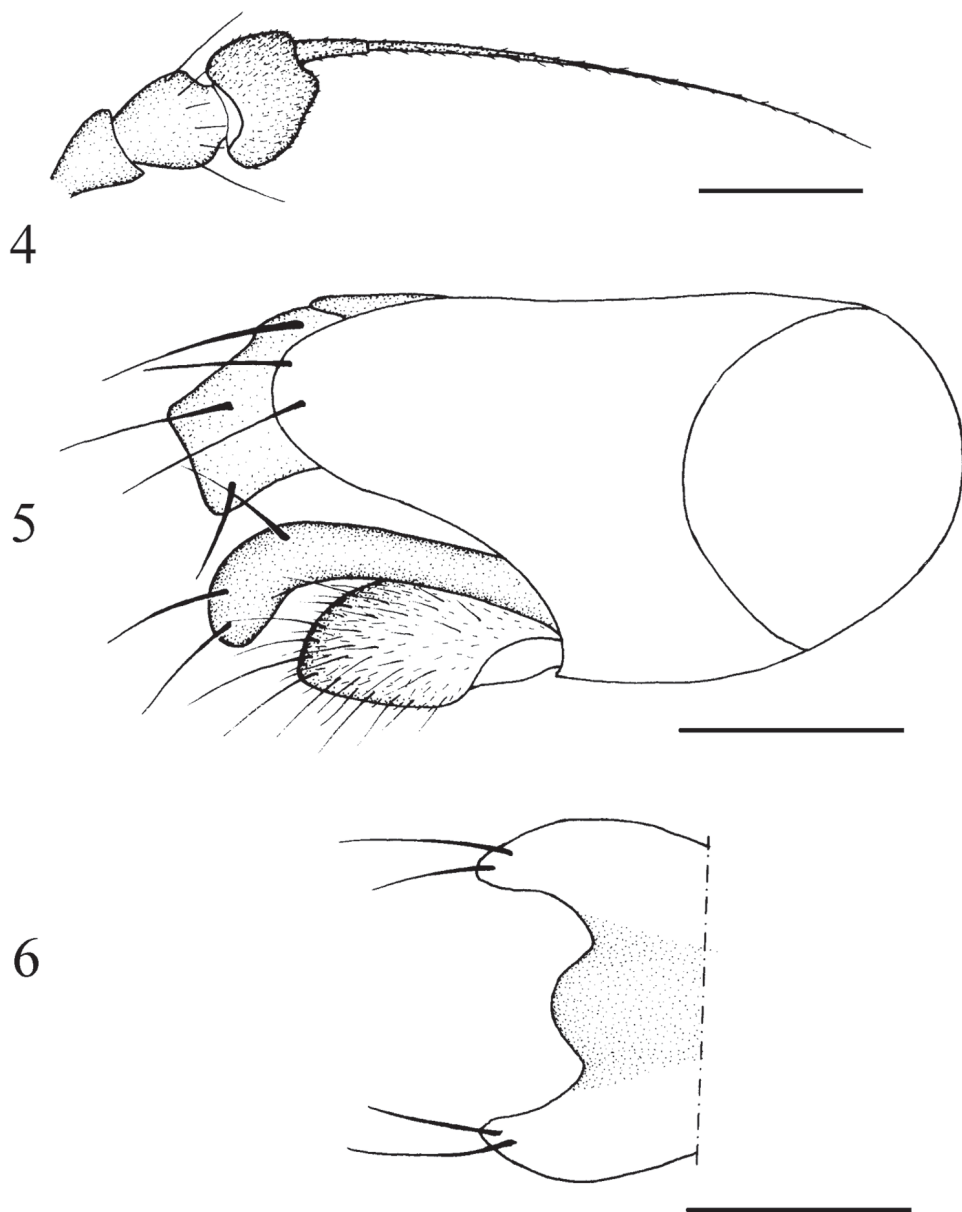
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Figs 4–6

Diagnosis. First flagellomere somewhat trapeziform, about 0.8 times as long as wide. Acr absent. Hind tibia with 1 ad, 3 pd and row of v. Hind tarsomere 1 with 18–20 short and thick black ventral bristles at base. Epandrium apically with wide lateral process, process truncate apically; surstylus curved and somewhat swollen apically.

Description. Male. Body length 2.1–2.3 mm, wing length 2.0–2.3 mm.

Head metallic green with gray pollen; frons and face brilliant. Hairs and bristles on head yellow. Ocellar tubercle weak, with 2 very long oc and 2 very short posterior



Figures 4–6. *Chrysotimus huairouensis* sp. n. **4** antenna, lateral view **5** male genitalia, lateral view **6** tip of hypandrium, ventral view.

hairs. Lower postocular bristles (including ventral hairs) pale. Antenna (Fig. 4) blackish; first flagellomere blackish, somewhat trapeziform, rather short, about 0.8 times as long as wide; arista dorsal, with basal segment very short. Proboscis dark brown, with blackish hairs; palpus pale yellow, with pale hairs and 2 pale yellow apical bristles.

Thorax metallic green with pale gray pollen, mesonotum and scutellum brilliant. Hairs and bristles on thorax yellow; 6 dc, no acr; scutellum with 2 pairs of bristles. Propleuron with 1 pale bristle on lower portion. Legs including coxae yellow with 5th tarsomere brown. Hairs and bristles on legs brown; coxae with yellowish hairs and bristles; mid and hind coxae each with 1 brown outer bristle. Mid and hind femura each with 1 av apically. Mid tibia with 2 ad and 2 pd, apically with 4 bristles; hind tibia with 1 ad, 3 pd and one row of v, apically with 3 bristles. Hind tarsomere 1 with 18–20 short and thick black ventral bristles at base. Relative lengths of tibia and 5 tarsomeres of legs. LI 3.2 : 2.2 : 0.9 : 0.7 : 0.6 : 0.6; LII 4.2 : 2.6 : 0.9 : 0.6 : 0.4 : 0.3; LIII 5.6 : 2.4 : 1.3 : 1.0 : 0.7 : 0.6.

Wing hyaline; veins brownish, R_{4+5} and M parallel apically; CuAx ratio 0.23. Squama pale yellow with yellow hairs. Halter pale yellow.

Abdomen metallic green with pale gray pollen, dorsum brilliant, sterna 1–4 yellow. Hairs and bristles on abdomen yellow.

Male genitalia (Figs 5–6) dark brown: Epandrium distinctly longer than wide, apically with wide lateral process, process truncate apically; surstylus long and finger-like, curved and somewhat swollen apically; cercus round, with moderately long hairs; hypandrium shorter than epandrium.

Female. Unknown.

Type material. Holotype ♂, Beijing: Huairou, Labagou (40°32'N, 116°63'E), 29.VII.2009, Yan Li. Paratype 1 ♂, same data as holotype. Type specimens are stored in 75% ethanol.

Distribution. Known only from the type locality in Beijing.

Remarks. This new species is similar to *Chrysotimus dorsalis* Yang, but may be separated from the latter by the single row of v on the hind tibia, and slender surstylus. In *C. dorsalis*, the hind tibia lacks row of v, and the surstylus is wide (Yang 2001).

Etymology. The specific epithet derives from the type locality Huairou (Beijing).

***Chrysotimus hubeiensis* Wang, Chen & Yang, sp. n.**

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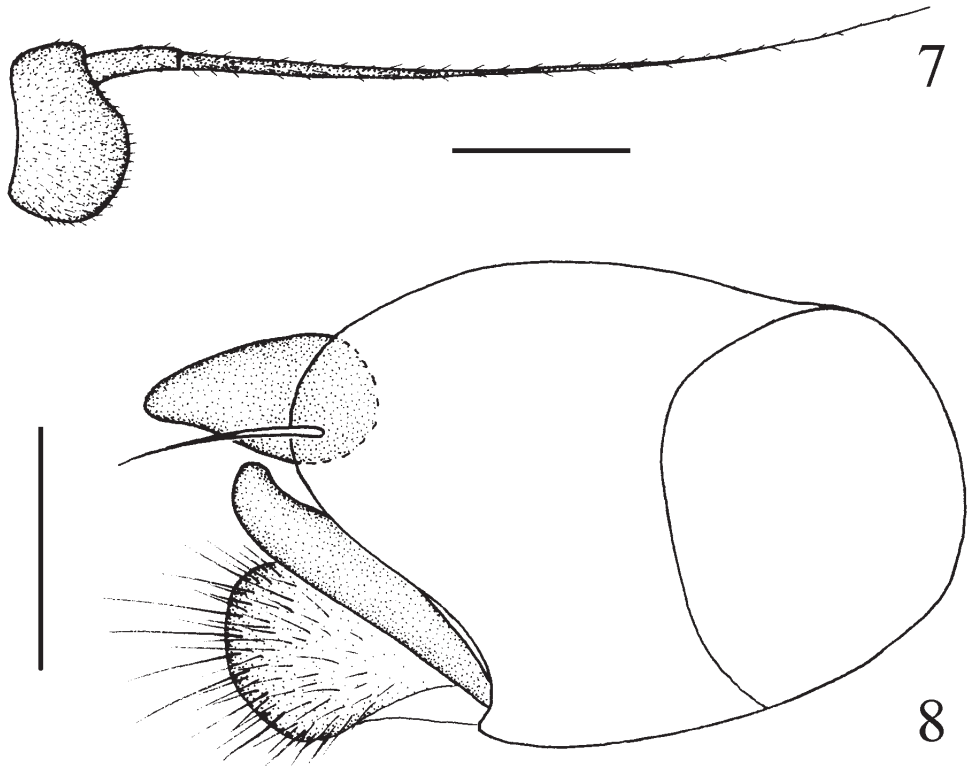
http://species-id.net/wiki/Chrysotimus_hubeiensis

Figs 7–8

Diagnosis. Acr 4–5 irregularly paired. Hind tarsomere 1 with 4–5 short and thick black ventral bristles at base. Epandrium apically with short and wide lateral process, acute apically.

Description. Male. Body length 2.5–2.7 mm, wing length 2.4–2.6 mm.

Head metallic green with gray pollen; frons and face brilliant. Hairs and bristles on head yellow. Ocellar tubercle weak, with 2 very long oc and 2 very short posterior hairs. Lower postocular bristles (including ventral hairs) pale. Antenna blackish; first flagellomere (Fig. 7) blackish, rather short, about 0.6 times as long as wide; arista dorsal, with basal segment very short. Proboscis brown, with brown hairs; palpus pale yellow, with pale hairs and 2 pale yellow apical bristles.



Figures 7–8. *Chrysotimus hubeiensis* sp. n. **7** first flagellomere, lateral view **8** male genitalia, lateral view.

Thorax metallic green with pale gray pollen, mesonotum and scutellum brilliant. Hairs and bristles on thorax yellow; 6 dc, 4–5 irregularly paired acr short and hair-like; scutellum with 2 pairs of bristles. Propleuron with 1 brown bristle on lower portion. Legs including coxae yellow with 5th tarsomeres brown. Hairs and bristles on legs dark yellow; coxae with yellowish hairs and bristles; fore coxa with 6–7 anterior and apical bristles, mid coxa with 2–3 anterior and apical bristles, hind coxa with 1 brown outer bristle near middle. Mid femur with 1 av apically; hind femur with 1 short av and 1 short pv apically. Mid tibia with 2 ad and 2 pd, apically with 3 bristles; hind tibia with 2 ad and 1 pd, apically with 3 bristles. Hind tarsomere 1 with 4–5 short and thick black ventral bristles at base. Relative lengths of tibia and 5 tarsomeres of legs. LI 4.5 : 2.3 : 1.2 : 0.9 : 0.6 : 0.7; LII 6.2 : 3.4 : 1.4 : 1.0 : 0.5 : 0.5; LIII 6.8 : 2.8 : 1.8 : 1.2 : 1.0 : 0.6.

Wing hyaline; veins brownish, R_{4+5} and M parallel apically; CuAx ratio 0.3. Squama dark yellow with brown hairs. Halter pale yellow.

Abdomen metallic green with pale gray pollen, dorsum brilliant, sterna 1–2 yellow. Hairs and bristles on abdomen brown.

Male genitalia (Fig. 8) dark brown: Epandrium distinctly longer than wide, apically with short and wide lateral process, process acute apically; surstylus slender and finger-like; cercus short and thick, with round apex.

Female. Unknown.

Type material. Holotype ♂, Hubei: Shennongjia, Dalongtan pound (31°75'N, 110°67'E), 1.VII.2009, Qifei Liu. Paratypes, 5♂♂, same data as holotype. Type specimens are stored in 75% ethanol.

Distribution. Known only from the type locality in Hubei.

Remarks. This new species is similar to *Chrysotimus lijianus* Yang & Saigusa, but may be separated from the latter by 2 pd on hind tibia, 4-5 black ventral bristles on hind tarsomere 1, and slender, finger-like surstylus. In *C. lijianus*, the hind tibia has 1 pd, hind tarsomere 1 has 7-8 black ventral bristles at base, and the surstylus is very wide (Yang and Saigusa 2001b).

Etymology. The specific epithet derives from the type locality Hubei.

Chrysotimus apicicurvatus Yang, 2001

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

Chrysotimus apicicurvatus Yang, 2001: 434. Type locality: China: Zhejiang, Tianmushan (Holotypes deposited in Entomological Museum of China Agricultural University, Beijing).

Specimens examined. 3♂♂6♀♀, Liaoning: Kuandian, Quanshan Linchang (40°73'N, 124°78'E, 650m), 9. VII. 2009, Yan Li.

Distribution. Liaoning (Kuandian), Zhejiang (Tianmushan).

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A new marine gobiid species of the genus *Clariger* Jordan & Snyder (Gobiidae, Teleostei) from Taiwan

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Abstract

A new species of *Clariger* Jordan & Snyder, 1901 was collected from northern Taiwan. The genus was previously known only from Japanese waters. This discovery is the first formal and southernmost record of these marine gobies from the waters of subtropical Taiwan. The new species, *Clariger taiwanensis* **sp. n.**, is distinguished from its congeners by a unique combination of features: (1) fin rays: dorsal-fin rays III, I/8; anal-fin rays modally I/8; and pectoral-fin rays modally 19 (2+16+1); (2) longitudinal dermal ridge on head with 6 barbels; and (3) specific coloration pattern: head and trunk dark brown with scattered pale spots and blotches; cheek, ventral portion of head sometimes pale with deep brown spots; pectoral-fin base with a dark brown band; and caudal fin mostly dark brown proximally and with alternating and irregular dark brown and pale bands distally. A diagnostic key to all nominal species from Japan and Taiwan is provided.

Keywords

Fish fauna, fish taxonomy, marine fish, new goby, Taiwan

Introduction

The generally small body-sized gobiid fishes of the family Gobiidae constitute the most diverse group of marine teleost fishes (Miller 1988; Chen and Kottelat 2005). Within the family, the *Luciogobius* generic complex includes three related genera: *Luciogobius*

Gill (1859), *Astrabe* Jordan and Snyder (1901) and *Clariger* Jordan and Snyder (1901), which share the following features (Akihito et al. 2000; 2002): slender to elongate body with 30 or more vertebrae in most species, a longitudinal infraorbital papillae pattern, and first dorsal fin with fewer than 4 spinous rays or first dorsal fin absent. These gobies mainly inhabit coastal waters of Japan (Akihito et al. 2000; 2002), but their ranges also extend toward Korea, eastern China, and Taiwan (Chen and Fang 1999; Akihito et al. 2000; 2002; Wu et al. 2009). Yamada et al. (2009) investigated the molecular phylogenetics of the *Luciogobius* generic complex based on the Japanese species and revealed the very close relationship of these three gobiid genera.

One member of the *Luciogobius* complex, the coastal gobiid genus *Clariger*, has been recognized as an endemic genus of Japan that includes at least 5 nominal species: *C. cosmurus* Jordan and Snyder (1901), *C. exilis* Snyder (1911), *C. papillosus* Ebina (1935), *C. sirahamaensis* Sakamoto (1932), *C. chionomaculatus* Shiogaki (1988) (Shiogaki 1988, Eschmeyer and Fricke 2011) and one undescribed species, *C. sp.*, that was recognised in Akihito et al. (2000, 2002).

Clariger is characterized by its cylindrical body and 3-spined first dorsal fin, which separates it from *Luciogobius*, which lacks a first dorsal fin (Akihito et al. 1984, 2000, 2002). The major differences between *Clariger* and *Astrabe* are the following features: only 1-2 free filamentous rays on the upper part of the pectoral fin in *Clariger* vs. 5-6 rays in *Astrabe*; pectoral-fin rays 18-20 vs. 24-27; and a slender body profile, rather similar to that of *Luciogobius*, vs. robust body profile in *Astrabe* (Jordan and Snyder 1901, Akihito et al. 1984, 2000, 2002; Shiogaki 1988).

Recently, collections of marine gobiid fishes have been made by the National Taiwan Ocean University (NTOU) team in the coastal region of northern Taiwan. An unusual dark goby species taken in one of these surveys appears to be an undescribed species and the first appearance of the Japanese endemic genus *Clariger* in Taiwan. The aim of this paper is to document the first record of *Clariger* from Taiwan and to describe this endemic species as new to science. A diagnostic key to all 6 nominal species of *Clariger* including the undescribed Japanese congener from Japan and Taiwan is also provided.

Materials and methods

All type specimens of the new species were collected by hand-net. All counts and measurements were made from specimens stored in 70% ethanol after 10% formalin preservation. Morphometric methods are from Miller (1988), and meristic methods follow Akihito et al. (1984). Terminology of cephalic sensory canals and free neuromast organ (sensory papillae) is from Wongrat and Miller (1991), based on Sanzo (1911). Type specimens are deposited in the collections of National Taiwan Ocean University (NTOUP), Keelung; and National Museum of Marine Science and Technology (NMMST), Keelung.

Abbreviations: A, anal fin; C, caudal fin; D1 and D2, first and second dorsal fins, respectively; P, pectoral fin; V, pelvic fin; and VC, vertebral count. All fish lengths are standard length (SL).

Systematics

Clariger taiwanensis sp. n.

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

Figs 1–2

Type material. Holotype: 28.3 mm SL, Taiwan, Keelung City, Chau-Jin Park, 25°8.48'N, 121°48.140'E, tidal pool, 31 May 2011, Y. H. Gong (NTOUP-2011-11-062).

Paratypes: 1 specimen, 29.0 mm SL, same locality as holotype, 5 June 2006, I-S. Chen (NTOUP-2006-06-156). 5, 26.4–35.5 mm SL, Taiwan, New Taipei City, Yeliu, 25°12.08'N, 121°41.62'E, tidal pool, 7 November 2000, S. C. Wang et al. (NMMSTP 01302). 1, 30.0 mm SL, same locality as holotype, 1 November 2011, Y. H. Gong (NTOUP-2011-11-057). 1, 30.9 mm SL, Taiwan, New Taipei City, Aodi, 25°3.25'N, 121°55.81'E, tidal pool, 1 July 2011, tidal pool, Y. H. Gong et al. (NTOUP-2011-11-059).

Diagnosis. *Clariger taiwanensis* can be distinguished from other congeners by the following unique combination of features: (1) fin rays: dorsal-fin rays III, I/8; anal-fin rays modally I/8; and pectoral-fin rays modally 19 (2 free +16+1 free); (2) head with longitudinal dermal ridge including 6 barbels; and (3) specific coloration pattern when alive: head and trunk dark brown with scattered pale spots and blotches; cheek, ventral portion of head sometimes pale with deep brown spots; pectoral-fin base with a dark brown band; and caudal fin mostly dark brown proximally and with alternating and irregular dark brown and pale bands distally.

Description. Body rather slender, cylindrical anteriorly and laterally compressed posteriorly (all morphometric data are shown in Table 1). Head flat and depressed. Eye small. Interorbital region wide, bony interorbital width more than twice diameter of eye. Horizontal, infraorbital dermal ridge on upper part of cheek with 6 barbels (Fig. 1).

Snout flat and rather short. A pair of distinct longitudinal dermal folds beside nasal tubes on snout. Anterior nasal opening in forward-facing short tube, and posterior nasal opening round, flat. Mouth rather large, maxilla extending to vertical through rear margin of orbit. Teeth minute, jaws with 3–5 rows of conical teeth, teeth in outer rows largest in both jaws. Tongue margin bilobed anteriorly. Gill opening somewhat restricted, extending only slightly below lower margin of pectoral-fin base. Anus located anterior to vertical through origin of second dorsal fin. VC 14 + 18 = 32 (9 specimens). Trunk and head entirely naked.

Fins: D1 III (9 specimens); D2 I/8 (9); A I/8 (8) or I/9 (1); P 19 (2 + 16 + 1) (8) or 20 (2 + 17 + 1) (1). D1 very short in height and length. D2 and A of similar size and shape. A origin just in front of D2 origin. D2 origin on vertical between 1st and 2nd branched rays of A. P small and rounded, its length about equal to postorbital length, with 2 thin free, filamentous rays dorsally and 1 free, filamentous ray ventrally. C rounded. V with round sucking disc with complete frenum.

Head lateral-line system: Head canals: head lacking sensory canals and head pores (as for genus). Sensory papillae: all infraorbital sensory papillae arranged in longitu-

Table 1. Morphometry of *Clariger taiwanensis* sp. n. from Taiwan

Type status	Holotype	All type specimens			
Sample No.	1	9			
		min	max	mean	standard deviation
Total length	34.4	30.3	41.0		
Standard length	29.3	26.4	35.5		
In SL (%)					
Head length	24.4	22.8	26.7	25.3	1.2
Snout to 1st dorsal fin origin	50.0	43.6	50.0	45.8	2.1
Snout to 2nd dorsal fin origin	63.4	61.7	65.6	63.4	1.3
Snout to anus	63.5	56.6	63.5	59.8	2.3
Snout to anal fin origin	64.5	60.3	65.5	63.1	1.7
Caudal peduncle length	21.8	20.4	24.2	21.9	1.4
Caudal peduncle depth	9.9	9.9	12.5	11.1	0.8
1st dorsal fin base	4.0	4.0	7.1	5.3	1.0
2nd dorsal fin base length	16.6	15.1	19.0	16.7	1.3
Anal fin base length	16.6	15.4	19.4	16.9	1.5
Caudal fin length	19.6	14.7	19.7	17.1	1.9
Pectoral fin length	13.6	13.1	16.8	14.6	1.3
Pelvic fin length	9.7	9.7	12.5	11.2	1.0
Body depth at pelvic fin origin	11.0	10.4	11.0	10.7	0.2
Body depth at anal origin	11.5	11.4	13.5	12.6	0.8
Body width at anal origin	8.5	8.5	12.2	10.3	1.1
Pelvic fin origin to anus	35.2	30.9	38.0	33.9	2.2
Gap between bases of two dorsal fins origin	16.5	16.5	20.3	18.4	1.3
In HL (%)					
Snout length	23.8	21.3	25.4	23.5	1.3
Eye diameter	14.1	11.3	14.3	13.3	1.2
Postorbital length	67.4	63.6	69.9	67.4	2.3
Interorbital width	16.5	14.4	19.6	16.3	1.5
Head width	54.1	54.1	66.0	58.3	4.0
Lower jaw length	35.8	31.3	38.5	35.0	2.5

dinal pattern. Row *a* long and extending forward to below nostrils. Row *b* extending from anterior region of dermal ridge to posterior region of cheek. Row *c* long, running below the dermal ridge. Single *cp* located near row *c*. Row *d* located just above upper lip, row *d1* well separated from row *d*. Rows *ot* and *oi* well separated. Row *p* surrounding orbit in interorbital region.

Colouration in fresh and preserved specimens: Head and trunk mostly dark brown with scattered pale spots and blotches when alive. Some individuals with larger pale spots in ventral half of trunk. Cheek, ventral portion of head, and underside of anterior portion of trunk sometimes pale with deep brown spots. First dorsal fin translucent

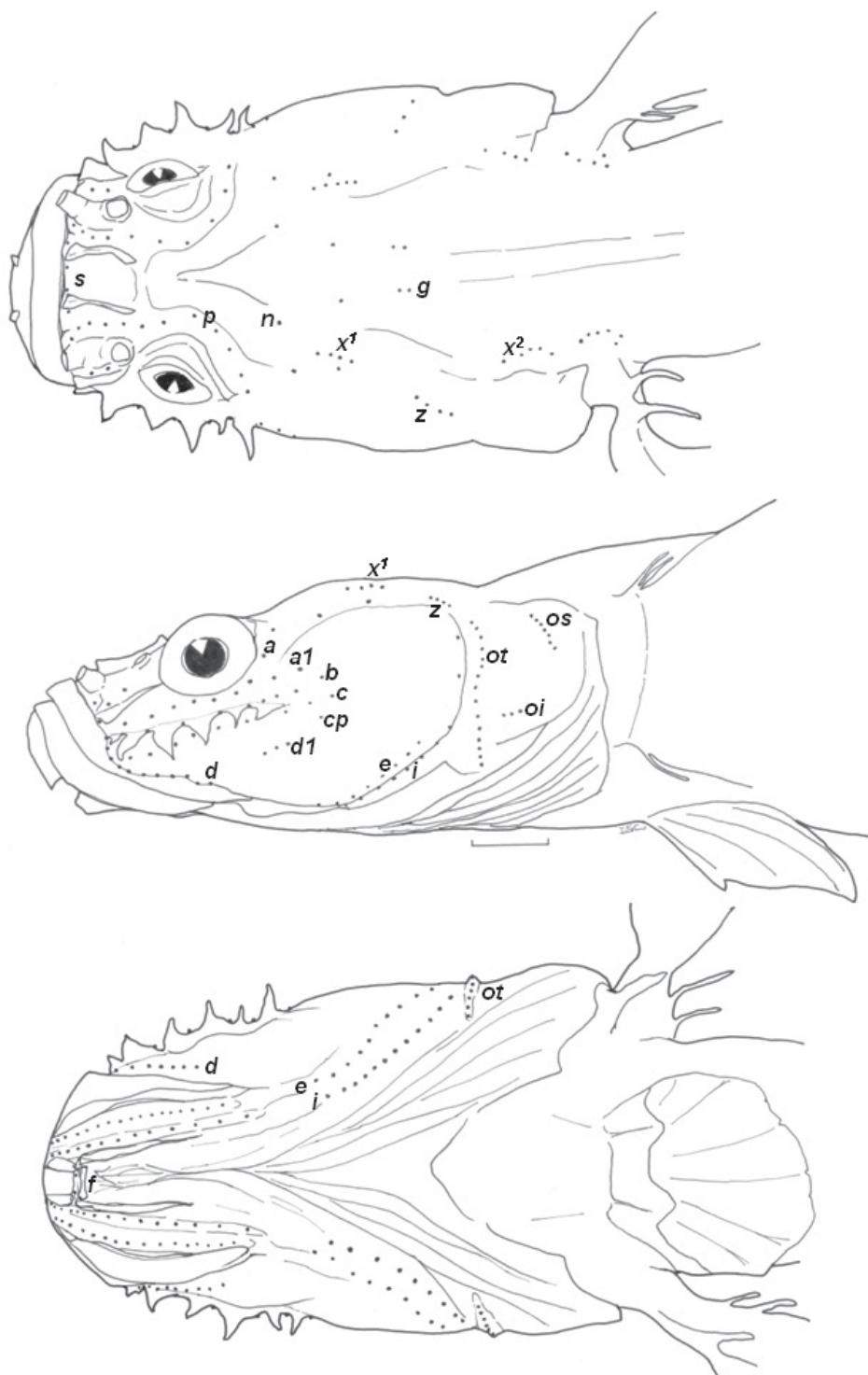


Figure 1. Head lateral-line system of *Clariger taiwanensis*, NTOUP-2011-11-062, holotype, 28.3 mm SL



Figure 2. **a** A living specimen of *Clariger taiwanensis* sp. n., NTOUP-2011-11-057, paratype, 30.0 mm SL, Keelung City, Taiwan; **b** Formalin-fixed holotype, NTOUP-2011-062, 28.3 mm SL, Keelung City, Taiwan (Photograph by Kuan-Te Chen).

with brown dotted spinous rays. Pectoral and second dorsal fins translucent with small deep brown spots. Pectoral-fin base with a dark brown band. Anal fin translucent with a few dark brown spots mostly on the branched rays. Caudal fin mostly dark brown proximally and with alternating and irregular dark brown and pale bands distally.

Long preserved specimens with similar overall dark pattern as described above except disappearance of body pale spots.

Distribution. The new species has only been found from the coastal regions of Taipei County as well as Keelung City, Taiwan. It is highly likely that it represents an endemic marine gobiid species of Taiwan (Fig. 3).

Habitats. *Clariger taiwanensis* was found in tidal pools with gravel on the rocky substratum of northern coast of Taiwan. The habitat also supports other marine gobies, including several *Bathygobius* spp. (dominant), *Eviota* spp, *Gobiopsis* spp. and *Prionolepis semidoliata*, as well as the *Luciogobius* spp.

Etymology. The specific name, *taiwanensis*, is in reference to the type locality from the coastal rocky shores of northern Taiwan.

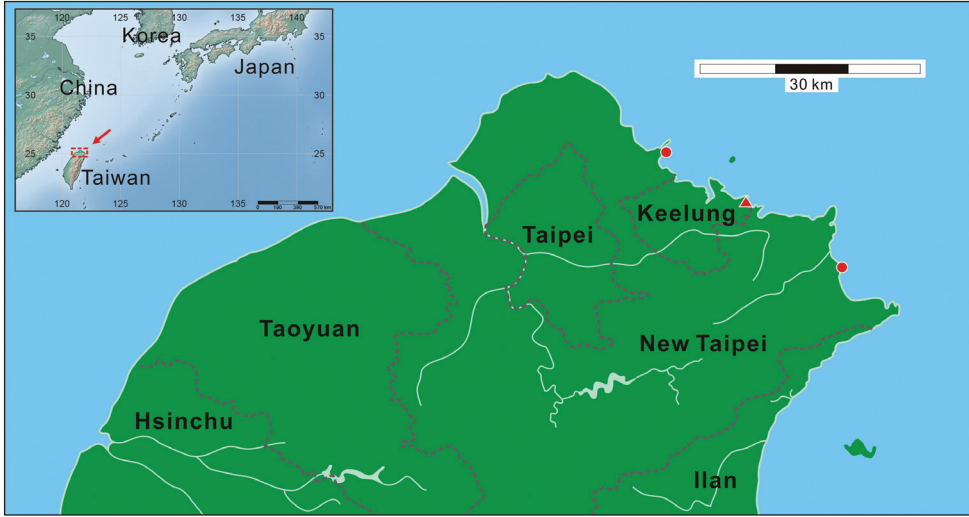


Figure 3. Map showing the collection localities (red symbols) for the *Clariger taiwanensis* sp. n. examined in this study in the coastal area of northern Taiwan. The red triangle shows the collection site of holotype.

Remarks. *Clariger taiwanensis* shares a morphological similarity (infraorbital dermal ridge with several distinct cheek barbels) with the following four species: *C. cosmurus*, *C. exilis*, *C. papillosus*, and *C. chionomaculatus*. Cheek barbels are lacking in *C. sirahamaensis*. In addition to differences in cheek barbels, the new species can be separated from *C. sirahamaensis* by the pattern of pigmentation on the caudal-fin: fin dark brown proximally with dark brown and pale bands distally in *C. taiwanensis* vs. fin uniform grayish black with a pair of white spots on basal regions of both upper and lower lobes in *C. sirahamaensis*. *Clariger taiwanensis* can be separated from *C. chionomaculatus* by the number of free pectoral-fin rays (2 free rays dorsally vs. 1); and coloration (no large white marks on trunk vs. several large, round white marks on upper half of trunk). *Clariger taiwanensis* can be distinguished from the remaining three nominal species, *C. cosmurus*, *C. exilis*, and *C. papillosus* by the following features: (1) fin-rays counts: second dorsal-fin rays 8 vs. 10–13 in others; anal-fin rays 8 vs. 9–11; and (2) squamation: body entirely naked vs. body scaled at least on caudal peduncle.

So far as is known, *C. taiwanensis* is the only species of *Clariger* found outside Japan, now known from the subtropical island of Taiwan. It is very essential to survey more comprehensively the coastal waters of Taiwan as well as southern China to obtain a better understanding of the species diversity, distribution, and evolutionary history of *Clariger* and other members of the *Luciogobius* complex.

A diagnostic key to all nominal species of *Clariger* from Japan and Taiwan (adapted from Shiogaki 1988 and Akihito et al. 2000, 2002):

- 1a Well-developed barbels on fleshy ridge below eye 2
- 1b No barbels below eye *C. sirahamaensis* Sakamoto

- 2a Only one free, filamentous ray on upper region of pectoral fin; anal-fin rays modally 13.....***C. chionomaculatus* Shiogaki**
- 2b Two free, filamentous rays on upper region of pectoral fin; anal-fin rays always less than 13.....**3**
- 3a Body entirely naked, second dorsal-fin rays 8.....
.....***C. taiwanensis* Jang-Liaw, Gong & Chen sp. n.**
- 3b Body with small scales at least on caudal peduncle, second dorsal-fin rays more than 9**4**
- 4a Gap between bases of two dorsal fins somewhat longer than body depth at anal-fin origin, head lacking distinct markings.....***C. exilis* Snyder**
- 4b Gap between bases of two dorsal fins less than body depth at anal-fin origin, head with a horizontal dark stripe**5**
- 5a Dorsal-fin rays 10; anal-fin rays 9-10**6**
- 5b Dorsal-fin rays 13; anal-fin rays 11***C. papillosus* Ebina**
- 6a Dark mark extending below the dermal barbels on ridge below eye
.....***C. cosmurus* Jordan & Snyder**
- 6b No dark mark below the dermal barbels on ridge below eye***C. sp.***

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Taxonomy and species-groups of the subgenus *Crematogaster* (*Orthocrema*) in the Malagasy region (Hymenoptera, Formicidae)

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Abstract

The species-level taxonomy of the subgenus *Crematogaster* (*Orthocrema*) in the Malagasy region is evaluated with both morphological data from worker and queen ants, and genetic data from three nuclear markers (long wavelength rhodopsin, arginine kinase and carbamoylphosphate synthase). These two types of data support the existence of six *Orthocrema* species: *Crematogaster madecassa* Emery, *C. rasoherinae* Forel, *C. telolafy* **sp. n.**, *C. razana* **sp. n.**, *C. volamena* **sp. n.** and *C. mpanjono* **sp. n.**. Two new synonyms of *C. rasoherinae* Forel are recognized, *C. rasoherinae brunneola* Emery, **syn. n.** and *C. voeltzkowi* Forel, **syn. n.**, as these were not supported as distinct taxa by the data. A neotype is designated for *C. rasoherinae*; lectotypes are designated for *C. madecassa*, *C. rasoherinae brunneola* and *C. voeltzkowi*. Species descriptions, images, distribution maps and identification keys based on worker and queen ants are given for all six species. A diagnosis of the subgenus *Orthocrema* in the Malagasy region is presented for both workers and queens. Within the Malagasy *Orthocrema*, three distinct phylogenetic lineages are suggested by molecular and morphological data. Newly defined monophyletic species-groups are thus the *C. madecassa*-group (*C. madecassa*, *C. telolafy* and *C. razana*) and the *C. volamena*-group (*C. volamena* and *C. mpanjono*); *C. rasoherinae* represents an isolated lineage in the Malagasy region and its closest relatives remain unclear. Other interesting biological findings are the presence of an intermediate caste between workers and queens in *C. rasoherinae* and *C. madecassa*, and unusually large workers in *C. volamena* resembling a major caste.

Keywords

Crematogaster, *Orthocrema*, Madagascar, Indian Ocean islands, taxonomy, intermediate workers

Introduction

The large and species-rich ant genus *Crematogaster* Lund (> 450 described species; Bolton 2011) has a global distribution throughout most forest and savannah habitats in warm-temperate to subtropical and tropical climates. *Crematogaster* species diversity is highest in the tropics and subtropics however, where these ants often form a dominant part of the local ant community. The majority of *Crematogaster* species nest arboreally, for example in twigs or under bark, but ground nesting seems to be equally common in temperate and cooler climates and also more prevalent in some species-groups in the tropics. The species-level taxonomy of *Crematogaster* ants is notoriously difficult and encumbered by synonyms and ambiguous subspecies names (Longino 2003; Ward 2010). Blaimer (2010) provided a comprehensive review on the natural history and taxonomic state of *Crematogaster*.

In the Malagasy region, here defined as Madagascar and the surrounding Indian Ocean islands, the taxonomy of *Crematogaster* is currently being revised in a series of publications, subdivided into the several distinct species-groups present in the region (see Blaimer 2010, 2012). The total species diversity of *Crematogaster* in the Malagasy region is estimated to be approximately 33 species (Blaimer, unpublished data). This estimate represents a mixture of previously described species, species new to science, and reductions due to synonymy. Most of these species occur only in Madagascar, but five species also are found on the Comoros Islands, Mayotte and the Seychelles. Recent intensive inventories of arthropods and especially the ant fauna in the Malagasy region (see e.g. Fisher and Penny 2008) have immensely increased the extent of available specimens for revisionary work, generating much more complete distribution records for already described species and discovering numerous undescribed new species.

The present study is part of this larger revisionary work and treats all species associated with the subgenus *Orthocrema* Santschi (1918) in the Malagasy region. Recent molecular work (Blaimer, in prep.) has found Malagasy species placed in the subgenus *Mesocrema* Santschi (1928) to be closely related to the former, and these are therefore included with *Orthocrema* in the present revision. This altered classification follows anticipated changes in the subgeneric classification of *Crematogaster* in the near future, based upon a molecular phylogenetic framework (Blaimer in prep.).

Up to now, one species has been described from the Malagasy region for *Orthocrema*, *C. madecassa* Emery, whereas three species and subspecies have been described for *Mesocrema*: *C. rasoherinae* Forel, *C. rasoherinae brunneola* Emery and *C. voeltzkowi* Forel. The latter has been recorded exclusively from the Comoros Islands, whereas the other species were first described from Madagascar. My observations suggest that the Malagasy *Orthocrema* present an exception to the predominantly arboreal life habit of *Crematogaster* ants in this region. Most species in this group appear to be generalists, as they have been collected nesting both on the ground in rotten logs or branches, or arboreally in dead twigs or bark and canopy moss mats. A very interesting aspect of the biology of some of the Malagasy species in this group is the presence of intermediate workers in the colony. These possess morphological

features that are intermediate between workers and queens, but their function and behavior in the colony remains unclear. Intermediates have also been reported in the North American *Crematogaster* (*Orthocrema*) species *C. smithi*, where they were denoted as 'large workers' (Heinze et al. 1999). In the case of the latter, it was shown that these had the ability to lay unfertilized trophic eggs, but were not capable of sexual reproduction (Heinze et al. 1999, 2000). The presence of this separate caste may be a more widespread phenomenon in *Orthocrema* species.

In the following, I focus on a reevaluation of the presently described Malagasy *Orthocrema* species with both morphological and molecular methods, and further describe new species that are supported by these two types of data. A second aim of this study is the delimitation of two morphologically and genetically distinct species-groups within Malagasy *Orthocrema*.

Materials

Morphological study

All morphological observations were made with a Leica MZ12.5 stereomicroscope. Standard measurements (in mm) were taken at 50× with a Wild M5A stereomicroscope and a dual-axis Nikon micrometer wired to a digital readout. Measurements are given to the second decimal place, and indices are presented as decimal fractions (also to the second decimal). Ranges are always expressed as minimum – maximum values. Measured specimens were chosen to represent the entire distribution range of a given species. The abbreviations used for measurements and indices below follow Blaimer (2010) and Longino (2003); for illustrations of these see Blaimer (2010).

Measurements and indices

HW	Maximum head width including eyes, in full face view.
HL	Head length; perpendicular distance from line tangent to rearmost points of vertex margin to line tangent to anterior most projections of clypeus, in full face view.
EL	Eye length; measured along the maximum diameter.
SL	Scape length; length of scape shaft from apex to basal flange, not including basal condyle and neck. If scape is strongly arched, this measurement is taken as the chord length from the basal flange to the apex.
PTL	Petiole length; measured in lateral profile as the distance from dorsoposterior margin of segment to anterior inflection point where petiole curves up to condyle.
PTH	Petiole height; measured in lateral profile as vertical distance from ventral margin to highest point of dorsoposterior margin.

PTW	Petiole width; maximum width of petiole in dorsal view.
PPL	Postpetiole length; measured in dorsal view at an angle that maximizes length.
PPW	Postpetiole width; measured in same view as and perpendicular to postpetiole length.
WL	Weber's length; measured in lateral profile of mesosoma, distance from approximate inflection point, where downward sloping pronotum curves into anteriorly projecting neck, to ventroposterior propodeal lobes.
SPL	Propodeal spine length; measured from tip of propodeal spine to closest point on outer rim of propodeal spiracle, maximizing spine length in lateral view.
LHT	Length of metatibia, excluding the proximomedial condyle.
CI	Cephalic index: HW/HL.
OI	Ocular index: EL/HL.
SI	Scape index: SL/HW.
PTHI	Petiole height index: PTH/PTL.
PTWI	Petiole width index: PTW/PTL.
PPI	Postpetiole width index: PPW/PPL.
SPI	Propodeal spine index: SPL/WL.
LBI	Leg-body index: WL/LHT.

Queen-specific measurements:

MSNW	Mesonotal width; maximum width of mesonotum, measured in dorsal view.
MSNL	Mesonotal length; maximum length of mesonotum, measured in dorsal view.
MSNI	Mesonotal index: MSNW/MSNL.

Color images were created with a JVC KY-F75U digital camera, a Leica MZ16A stereomicroscope and ZERENE STACKER (v1.02) software. The scanning electron microscope images were taken at the California Academy of Sciences using a Zeiss/LEO 1450VP SEM. All ant images presented here are also publicly available on AntWeb (www.antweb.org). Line drawings were produced by tracing color images in Adobe Illustrator CS5. Species distributions were plotted with ARCMAP (v9.3) within the software ARCGIS, based on coordinates (latitude and longitude) as given on the specimen labels of all material (see also supplementary table 1 for a species list with GPS coordinates). For material lacking this information, i.e. syntype specimens, the following sources were used to georeference collection sites: the GEOnet Names Server (National Geospatial-Intelligence Agency 2010) and the Gazetteer to Malagasy Botanical Collecting Localities (Schatz and Lescot 2003). Classification of major geographic regions in Madagascar throughout species descriptions follows Gautier and Goodman (2003). Common abbreviations within locality data are: P.N. = Parc National, R.S. = Réserve Spéciale, F = Forêt, P.C. = Parc Naturel Communautaire, R.N.I. = Réserve Naturelle Intégrale.

The International Commission on Zoological Nomenclature (1999) requires lectotypes designated after 1999 to “contain an express statement of deliberate designation” (amended Article 74.7.3). I use the statement ‘lectotype by present designation’ to fulfill this requirement. Lectotypes have been designated where a name lacks a holotype or lectotype and unambiguous syntypes have been identified. The purpose is to provide stability of nomenclature, and designation is done in a revisionary context in agreement with the amended Recommendation 74G of Article 74.7.3. Neotype designations have further been made for names with no extant name-bearing types that are in need of a name-bearing type “to objectively define the nominal taxon” (Article 75.1, ICZN, 1999), and are in agreement with the qualifying conditions stated in Article 75.3 (ICZN, 1999).

Specimens were examined and/or deposited in the following collections:

CASC	California Academy of Sciences, San Francisco, CA, USA
BBBC	B.B. Blaimer Collection, University of California at Davis, CA, USA
MCZC	Museum of Comparative Zoology, Harvard, USA
MHNG	Muséum d'Histoire Naturelle, Genève, Switzerland
MSNG	Museo Civico di Storia Naturale, Genova, Italy
NHMB	Naturhistorisches Museum, Basel, Switzerland
PSWC	P.S. Ward Collection, University of California at Davis, CA, USA
SAMC	South African Museum, Cape Town, South Africa
ZMBH	Museum für Naturkunde der Humboldt Universität, Berlin, Germany

Molecular data collection and phylogenetic analyses

After sorting all available specimens to morphospecies, one to four individual worker ants for each of six putative Malagasy *Crematogaster* (*Orthocrema*) species were selected for genetic analysis. Four non-Malagasy *Orthocrema* species were chosen as outgroups, given their approximate relationships to the Malagasy taxa as known from a previous, larger phylogenetic analysis (Blaimer, in prep.). Two of these (*C. sordidula* Nylander and *C. longipilosa* Forel) represent distant relatives to all Malagasy *Orthocrema*, whereas the remaining two taxa (*C. arcuata* Forel and *C. cf. dolens* Forel) are closer relatives to the Malagasy taxa. For the distribution of the sampled taxa refer to Table 1.

From these 17 specimens, DNA was extracted from either entire worker adults or pupae using a DNeasy Tissue Kit (Qiagen Inc., Valencia, California, U.S.A.), following the manufacturer's protocol but eluting the extract in sterilized water rather than the supplied buffer and at half the suggested volume. I used either a non-destructive method (cuticle of ant pierced prior to extraction, mostly used for adults), enabling me to retain and re-mount voucher specimens after extractions, or a destructive technique (entire ant pulverized, mostly used for pupae) in cases where multiple individuals from the same colony series were available. Three nuclear protein-coding genes were amplified: long wavelength rhodopsin (LW Rh, 856bp exon /255bp intron), arginine kinase (ArgK,

Table 1. Specimen data and GenBank accessions. Information on vouchers, GenBank accession numbers and locality data on all specimens included in the molecular analyses.

Taxon	Voucher	GenBank accession			Collection locality	LatDD	LongDD
		LW Rh	ArgK	CAD			
<i>Crematogaster</i>							
<i>madecassa_amdi</i>	CASENT0068164	JQ326949	JQ326913	JQ326932	Madagascar: Toamasina: Res. Ambodiriana, 4.8 km 306°Manompana, 125m	-16.672	49.701
<i>madecassa_mjy</i>	CASENT0525407	JQ326950	JQ326914	JQ326933	Madagascar: Antsiranana: P.N. Marojejy, Manantenina River, 27.6 km 35° NE Andapa, 775m	-14.435	49.760
<i>mpanjono_man</i>	CASENT0193212	JQ326943	JQ326909	JQ326937	Madagascar: Antsiranana: R.S. Manongarivo, 10.8 km 229° SW Antanambao, 400m	-13.962	48.433
<i>mpanjono_nb</i>	CASENT0056947	JQ326947	JQ326910	JQ326929	Madagascar: Antsiranana: Nosy-Be: Antsirambazaha, Hell-Ville, 143m	-13.413	48.311
<i>razana_kal</i>	CASENT0193589	JQ326952	JQ326915	JQ326938	Madagascar: Toliara: RS Kalambatritra, 1365m	-23.419	46.458
<i>razana_tsi</i>	CASENT0193591	JQ326954	JQ326916	JQ326939	Madagascar: Toliara: P.N. Andohahela, F d'Ambobibory, 1.7 km 61° ENE Tsimelaha, 300m	-24.930	46.646
<i>telolify_isa</i>	CASENT0492527	JQ326951	JQ326917	JQ326935	Madagascar: Fianarantsoa: Parc National d'Isalo, 29.2 km 351° N Ranohira, 500m	-22.313	45.292
<i>volamena_aza</i>	CASENT0193590	JQ326945	JQ326911	JQ326930	Madagascar: Antsiranana: 6.9 km NE Ambanizana, Ambohitsitondroina, 825m	-15.567	50.000
<i>volamena_vaky</i>	CASENT0162194	JQ326946	JQ326912	JQ326931	Madagascar: Toamasina: RS Ambatovaky, Sandrangato river, 400m	-16.817	49.293
<i>rasoherinae_maha</i>	CASENT0070841	JQ326941	JQ326922	JQ326941	Madagascar: Fianarantsoa: R.F. Agnalazaha, Mahabo, 42.9 km 215° Farafangana, 20m	-23.194	47.723
<i>rasoherinae_ahe</i>	CASENT0193412	JN129958	JN129923	JN129882	Madagascar: Toliara: P.N. Andohahela/parcel 3; near Forest station; 3.9km Ranopiso, 170m	-25.018	46.652
<i>rasoherinae_koe</i>	CASENT0487673	JQ326942	JQ326921	JQ326942	Madagascar: Antsiranana: Forêt d' Andavakoetra, 21.4km 75° ENE Ambilobe, 425m	-13.118	49.230
<i>rasoherinae_com</i>	CASENT0147455	JQ326953	JQ326920	JQ326925	Comoros: Anjouan: Hajofo, 10m	-12.122	44.488
<i>sordidula</i>	CASENT0193797	JQ326944	JQ326919	JQ326944	Croatia: N Dalmatia: Pakoštane, 40m	43.917	15.500
<i>longipilosa</i>	CASENT0193780	JQ326948	JQ326918	JQ326934	Malaysia: Selangor: Ulu Gombak, 330m	3.300	101.783
<i>cf_dolens</i>	CASENT0193756	JQ326956	JQ326923	JQ326940	Kenya: Western Prov.: Arabuko Sokoke Forest, 10m	-3.325	39.948
<i>arcuata</i>	CASENT0193084	JQ326955	JQ326924	JQ326936	Venezuela: Aragua: Estacion Rancho-Grande, PN Henri Pittier, 1100m	10.582	-68.474

388bp exon/177bp intron) and carbamoylphosphate synthase (CAD, 529bp exon/252bp intron). The sequence lengths given here refer to the aligned sequence data included in phylogenetic inference and add up to a total of 2457bp. The three amplified genes are widely used for phylogenetic inference in ants and primers are available (Ward and Downie 2005; Brady et al. 2006; Moreau et al. 2006; Ward et al. 2010; Blaimer in prep.), and their usefulness in phylogenetic inference between closely related species has been demonstrated (Lucky 2011; Blaimer 2012). Amplifications were performed using standard PCR methods outlined in Ward and Downie (2005) and sequencing reactions were analyzed on an ABI 3730 Capillary Electrophoresis Genetic Analyzer with ABI BigDye Terminator v3.1 Cycle Sequencing chemistry (Applied Biosystems Inc., Foster City, CA). All sequences have been deposited in GenBank, with accession numbers listed in Table 1; the data matrix and tree used to create Fig. 1 have further been deposited in TreeBase (ID 12240; available at: <http://purl.org/phylo/treebase/phyloids/study/TB2:S12240>).

Sequence data were assembled and edited in the program SEQUENCHER 4.6 (Gene Codes Corporation, 2006, Ann Arbor, MI), aligned in CLUSTALX 2.0.12 (Thompson et al. 1997; Larkin et al. 2007), and corrected by eye in MACCLADE 4.08 (Maddison and Maddison 2000). Phylogenetic analyses within a Bayesian framework (BI hereafter) were performed using MRBAYES v3.1 (Ronquist and Huelsenbeck 2003), accessed through the CIPRES science gateway (Miller et al. 2010); analyses within a maximum likelihood framework (ML hereafter) used GARLI v2.0 (Zwickl 2006) and were performed on an iMac desktop computer. BI- and ML-analyses were based on a concatenated data matrix of the three loci. The data matrix was divided into nine data subsets by gene, translational pattern (exon, intron) and codon position (1st + 2nd vs 3rd). Best-fitting models of nucleotide sequence evolution were selected for each partition using the Akaike information criterion (AIC) in the program MRMODELTEST v2.3 (Posada and Crandall 1998; Nylander et al. 2004) for application in BI-analyses, and in MODELTEST v3.7 (Posada and Crandall, 1998) for specification in ML-analyses, both executed through PAUP* 4.0b10 (Swofford 2000). Selected models for each data subset can be found in Table 2.

BI-analyses each employed two runs of Metropolis-coupled Markov Chain Monte Carlo (MCMCMC) consisting of four chains (temp=0.05) and sampling every 1000 generations. The model parameters transition-transversion ratio, gamma shape, proportion of invariable sites, rate matrix and state frequencies were unlinked across partitions, and a variable rateprior was employed to allow for rate variation among partitions. Convergence of chains and other diagnostic values were assessed in several ways. In MRBAYES I confirmed that the ASDSF had reached values well below 0.01 and PSRF values had approached 1.0 for all parameters. In TRACER v1.5 (Rambaut and Drummond 2007), convergence was confirmed visually and mixing of chains was evaluated with effective sample size (ESS) values. To assess whether tree topologies were sampled in proportion to their true posterior distribution, I further used the compare, slide and cumulative plotting functions on the AWTY-online server (Wilgenbusch et al. 2004). All the above indicators returned good values after MCMCMC-sampling for 20 million generations; consensus trees were summarized in MRBAYES after discarding 25% of samples as burnin. I further performed a ML-search for the best scoring tree (results

Table 2. Data partitions and selected substitution models. Information on data subsets, including number of bases, number of variable characters (VC), number of parsimony-informative characters (PIC) and substitution models selected for the respective partition using the Akaike information criterion in MRMODELTEST v2.3 (Posada and Crandall 1998; Nylander 2004) or MODELTEST v3.7 (Posada and Crandall 1998) for application in BI- or ML-analyses respectively.

Data partition	No. bases	No. VC	No. PIC	Substitution model - BI	Substitution model - ML
LW Rh exons position 1 + 2	570	10	17	HKY+I	HKY+I
LW Rh exons position 3	286	34	17	HKY	K81uf
LW Rh introns	255	25	21	HKY	TrN
ArgK exons position 1 + 2	258	3	8	K80	K80
ArgK exons position 3	130	15	18	HKY	TrN
ArgK introns	177	11	15	HKY	K81uf
CAD exons positions 1 + 2	352	13	13	HKY	HKY
CAD exons positions 3	177	23	18	SYM+G	TVMef+G
CAD introns	252	34	11	HKY	TrN
entire dataset	2457				

not shown), as well as a bootstrap search with 100 replicates in GARLI. Program configuration settings were left at defaults. Trees resulting from the bootstrap search were summarized as majority-rule consensus tree in PAUP* 4.0b10 (Swofford 2000).

Ancillary genetic data supporting the results outlined below has been generated through the joint barcoding initiative of Malagasy ants by the California Academy of Sciences and the Biodiversity Institute of Ontario, Guelph, Canada (www.barcodinglife.org). The barcoding region of cytochrome oxidase I (COI) for ~130 specimens of five of the six below recognized species (with variable taxon sampling of 2–101 individuals per species) was thus available to guide taxonomic decisions. Analyses of these data are to be published elsewhere.

Results

Molecular results

All molecular phylogenetic analyses (BI and ML) of the data strongly suggest that there are six species of Malagasy *Orthocrema*, namely the previously described *C. rasoherinae* and *C. madecassa* and four new species: *C. telolafy* sp. n., *C. razana* sp. n., *C. volamena* sp. n. and *C. mpanjono* sp. n. (Figure 1). The previously described *C. voeltzkowi* from the Comoros Islands shows little genetic differentiation from *C. rasoherinae*, warranting synonymy with the latter (as indicated in Figure 1A). The same applies to *C. rasoherinae brunneola* (as indicated in Figure 1A). Further supported is the presence of two distinct species-groups, the *C. madecassa*-group and the *C. volamena*-group, with members as listed below. *Crematogaster rasoherinae* is shown as quite distantly related to the *C. madecassa* and *C. volamena* species-groups, which in turn also clearly

1

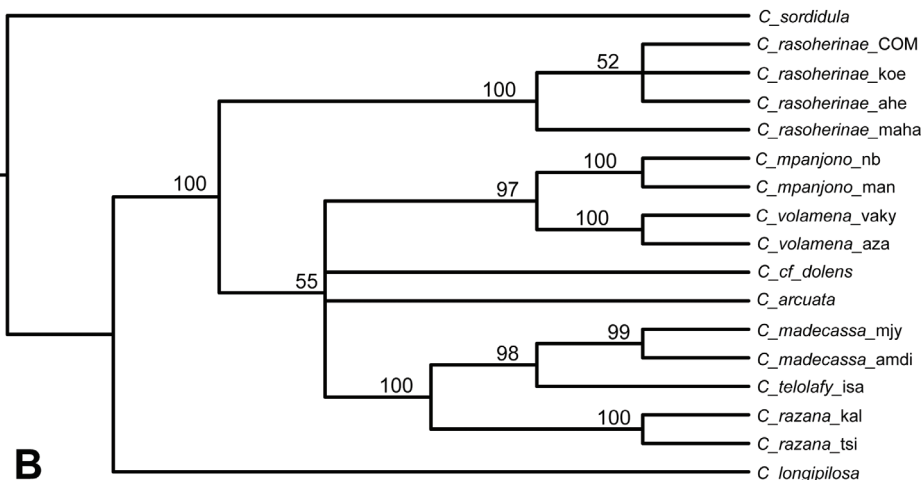
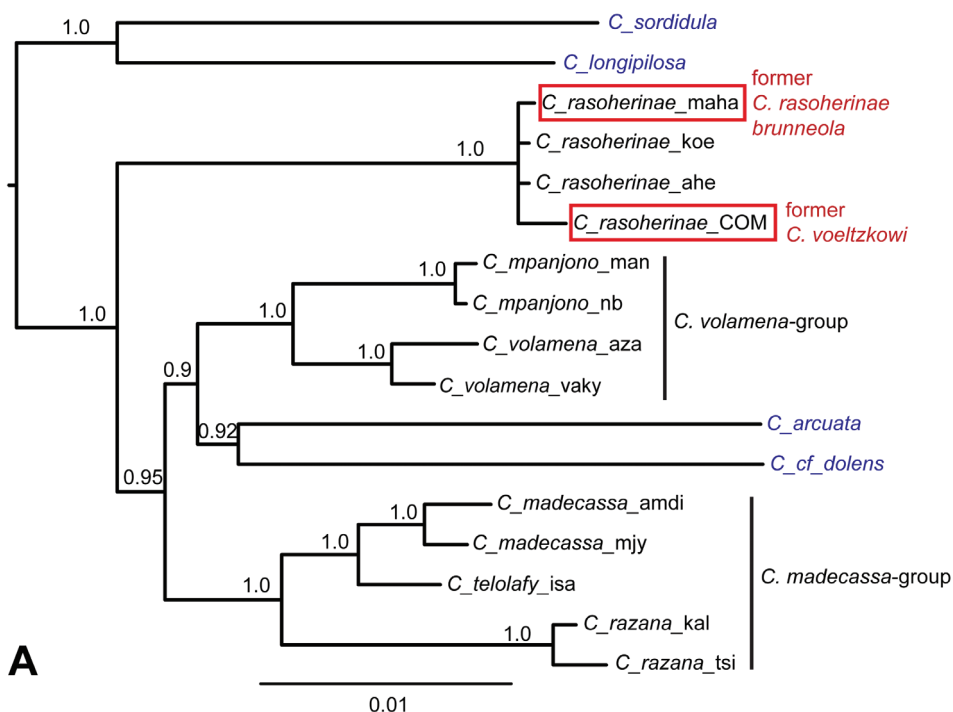


Figure 1. Species phylogeny of Malagasy *Crematogaster* (*Orthocrema*). **A** Results of Bayesian inference summarized as consensus tree in MrBayes. Support values on branches represent posterior probabilities; scalebar shows nucleotide changes per base pair. Newly defined species-groups, and the specimen representing former *C. voeltzkowi* are indicated. Outgroup species are marked by blue font **B** ML-consensus tree with bootstrap support values obtained from analysis with 100 bootstrap replicates in GARLI 2.0.

do not form a monophyletic grouping. This suggests these two species groups and *C. rasoherinae* have originated from separate ancestors and three colonizations of the Malagasy region took place within the *Orthocrema* lineage. The exact relationships of these two species-groups and of *C. rasoherinae* to each other, and to the non-Malagasy taxa *C. arcuata* and *C. cf. dolens* remain unclear as they receive only moderate support in the BI analysis (Figure 1A), and are unresolved in the ML analysis (Figure 1B).

Species list and species-groups of the subgenus *Orthocrema* in the Malagasy region

Crematogaster rasoherinae Forel, 1891

= *C. rasoherinae* var. *brunneola* Emery, 1922 (replacement name for *C. rasoherinae* var. *brunnea* Forel, 1907), **syn. n.**

= *C. voeltzkowi* Forel, 1907, **syn. n.**

Crematogaster madecassa-group:

C. madecassa Emery, 1895

C. telolafy **sp. n.**

C. razana **sp. n.**

Crematogaster volamena-group:

C. volamena **sp. n.**

C. mpanjono **sp. n.**

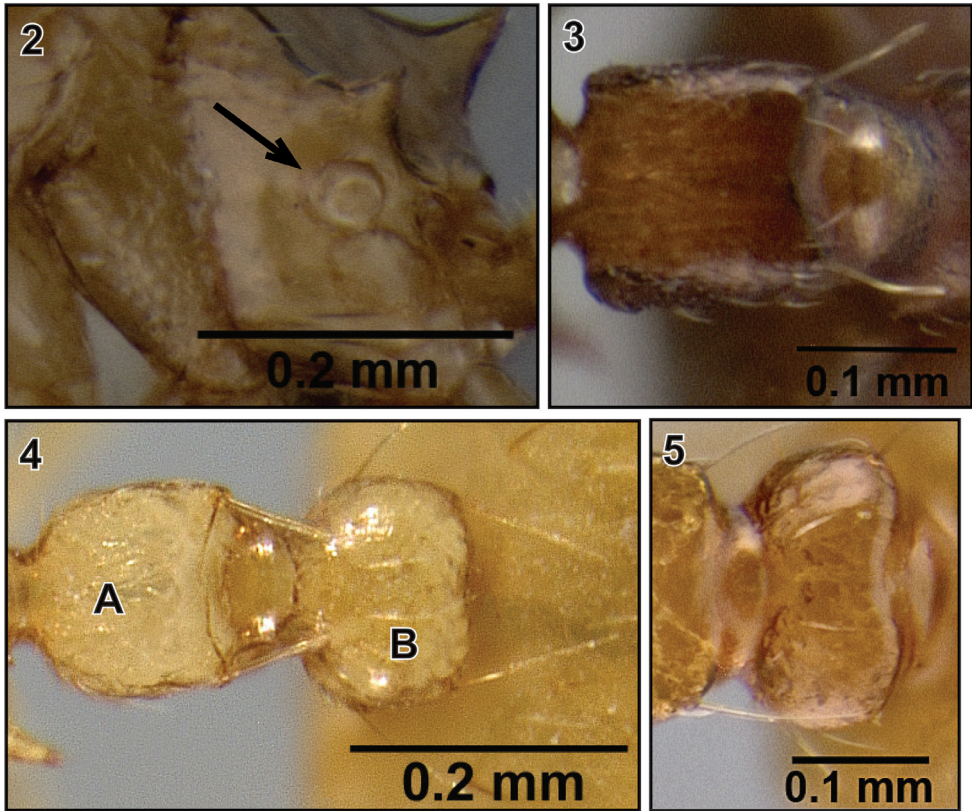
Diagnosis of the subgenus *Orthocrema* in the Malagasy region

Workers

1. Very small to medium-sized (HW 0.43–0.98, WL 0.44–0.95).
2. Antennae 11-segmented, antennal club 2-segmented.
3. Promesonotal suture absent.
4. Lateral margins of promesonotum with at least 4 long, erect setae.
5. Propodeal spiracle circular or subcircular (Figure 2).
6. Petiole in dorsal view rectangular (Figure 3) or ovo-rectangular (Figure 4A).
7. Petiole with dorsoposterior lateral denticles or tubercles that each bear an erect seta (Figures 3 and 4A).
8. Postpetiole either more or less globular (Figure 4B), without median longitudinal impression, or weakly bilobed with a broad impression (Figure 5).
9. Postpetiole with at least one pair of long, dorsoposterior setae (Figure 4B).
10. Subpetiolar process present (form variable).
11. Sculpture overall reduced, mostly aciculate, small regions areolate or reticulate.

Minimal diagnosis

A combination of characters 6, 7, 8 and 9 will unequivocally separate workers of *Orthocrema* species from the remaining *Crematogaster* species in the Malagasy region.



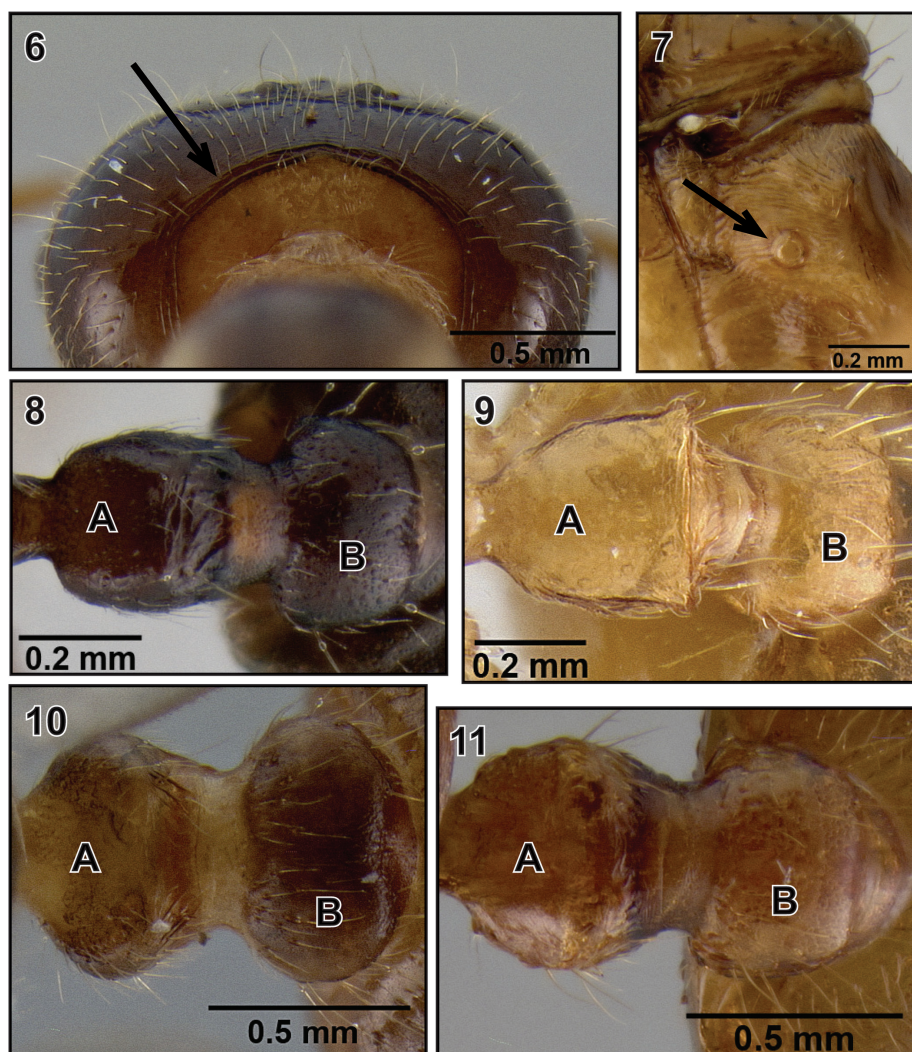
Figures 2–5. Worker diagnoses of Malagasy *Crematogaster* (*Orthocrema*). **2** propodeal spiracle circular (*C. razana*, CASENT0149655) **3** petiole in dorsal view rectangular (*C. rasoharinae*, CASENT0070841) **4** **A** petiole in dorsal view ovo-rectangular **4 B** postpetiole globular (*C. telolafi*, CASENT0419808) **5** postpetiole with broad impression (*C. volamena*, CASENT0077219).

Queens

1. Very small to large (HW 0.73–1.72, WL 0.83–2.70).
2. Antennae 11-segmented, antennal club weakly 2-segmented.
3. Occipital carinae mostly present (Figure 6).
4. propodeal spiracle circular (Figure 7) or subcircular.
5. Petiole in dorsal view rectangular (Figure 8A), ovo-rectangular (Figure 9A), oval (Figure 10A) or subquadrate (Figure 11A).
6. Postpetiole more or less globular, without distinct median longitudinal impression (Figures 8–11B).

Minimal diagnosis

A combination of characters 3, 5 and 6 will unequivocally separate queens of *Orthocrema* species from the remaining *Crematogaster* species in the Malagasy region.



Figures 6–11. Queen diagnoses of Malagasy *Crematogaster* (*Orthocrema*). **6** occipital carinae distinct (*C. volamena*, CASENT0161415) **7** propodeal spiracle circular (*C. razana*, CASENT0148782) **8 A** petiole rectangular **B** postpetiole globular (*C. rasoherinae*, CASENT0193403) **9 A** petiole ovo-rectangular **B** postpetiole globular (*C. madecassa*, CASENT0436253); **10 A** petiole oval **B** postpetiole globular (*C. volamena*, CASENT0161415) **11 A** petiole subquadrate **B** postpetiole globular (*C. mpanjono*, CASENT0067033).

Key to the workers of *C. (Orthocrema)* species in the Malagasy region

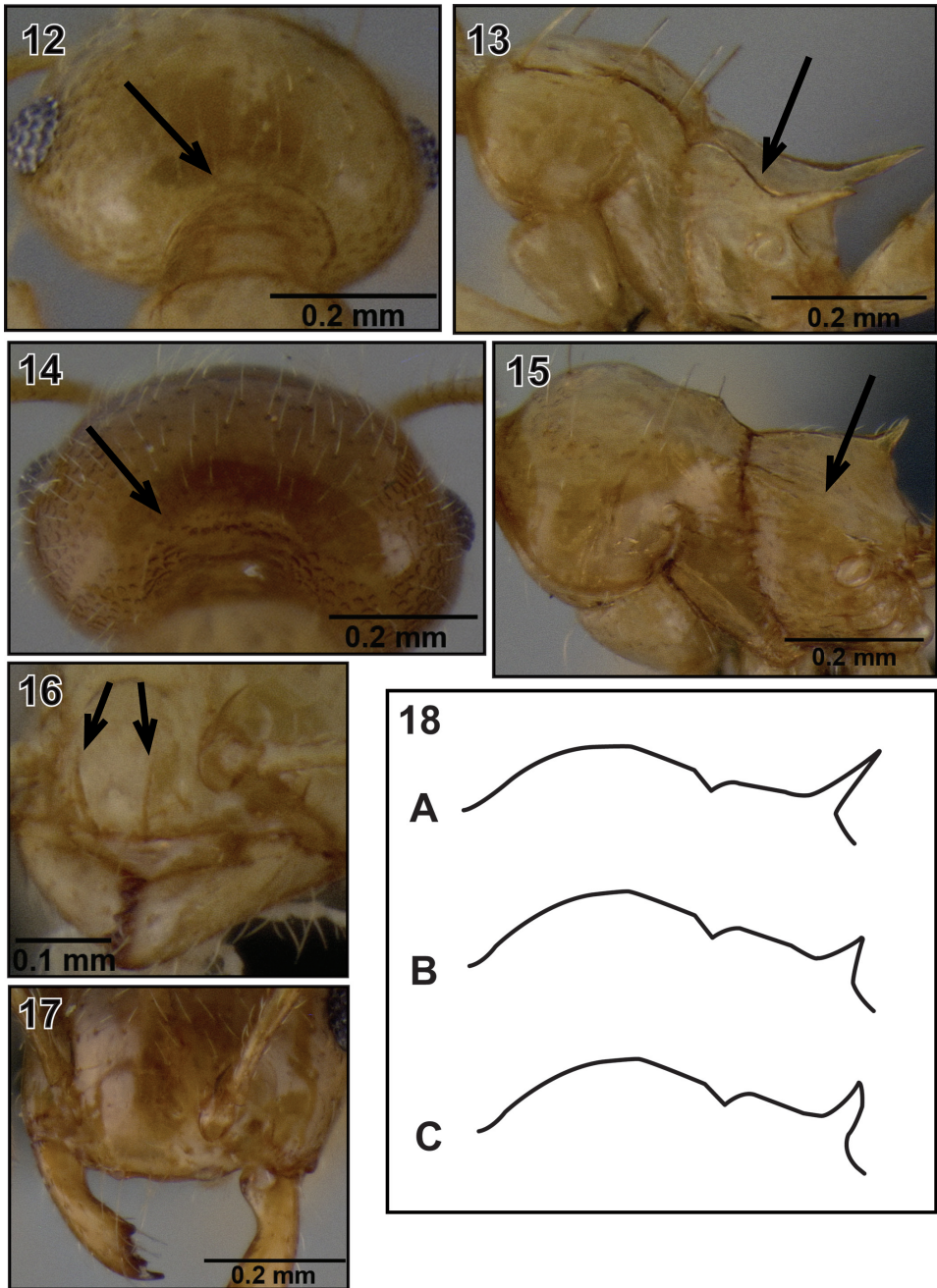
- 1 Petiole in dorsal view rectangular (Figure 3), with both antero- and postero-lateral denticles; abdominal tergite 4 with sparse erect pilosity, often only a single row of setae towards posterior end.....*C. rasoherinae*
- Petiole in dorsal view ovo-rectangular (Figure 4A), with only posterolateral denticles present; abdominal tergite 4 with abundant erect pilosity throughout.....2

- 2(1) Occipital carinae distinct and sharp (Figure 12); eyes larger (OI 0.22–0.28) and distinctly protruding (as in Figure 27A and 29A); propodeum with raised, sharp lateral carinae, confluent with propodeal spines (Figure 13)... **3**
- Occipital carinae indistinct (Figure 14); eyes smaller (OI 0.18–0.22) and less protruding (as in Figure 31A and 33A); propodeum lacking raised, sharp lateral carinae (Figure 15)..... **5**
- 3(2) One pair of long, flexuous setae present on posterior end of lateral mesonotal carinae; clypeus with two distinct median vertical carinae (Figure 16); antennal scapes reaching, or well surpassing posterior margin of head (SI 0.78–1.01); subpostpetiolar process usually present **4**
- Long, flexuous setae absent from posterior end of lateral mesonotal carinae; clypeus lacking median vertical carinae (Figure 17); antennal scapes shorter, barely reaching head margin (SI 0.74–0.77); subpostpetiolar process absent ***C. razana***
- 4(3) Antennal scapes well surpassing posterior margin of head (SI 0.85–1.01); propodeal spines medium-sized (SPI 0.17–0.26), usually thin and acute (Figure 18A), in lateral view directed upwards but straight..... ***C. madecassa***
- Antennal scapes just reaching posterior margin of head (SI 0.78–0.87); propodeal spines shorter (SPI 0.10–0.19), usually in form of acute triangular points (Figure 18B), if more elongate and spiniform, then distinctly curved upwards (Figure 18C) ***C. telolafy***
- 5(2) Propodeal spines shorter (SPI 0.06–0.09); propodeum often with longer erect pilosity; *rare, Madagascar: Nosy Bé, R.S. Manongarivo, Ile St. Marie*.....
- Propodeal spines often longer (SPI 0.06–0.12); propodeum lacking longer erect pilosity; *more common, eastern rainforests of Madagascar*.... ***C. mpanjono***
- Propodeal spines often longer (SPI 0.06–0.12); propodeum lacking longer erect pilosity; *more common, eastern rainforests of Madagascar*.... ***C. volamena***

Note: *Crematogaster volamena* and *C. mpanjono* can only be reliably identified based on queen characters and genetic data.

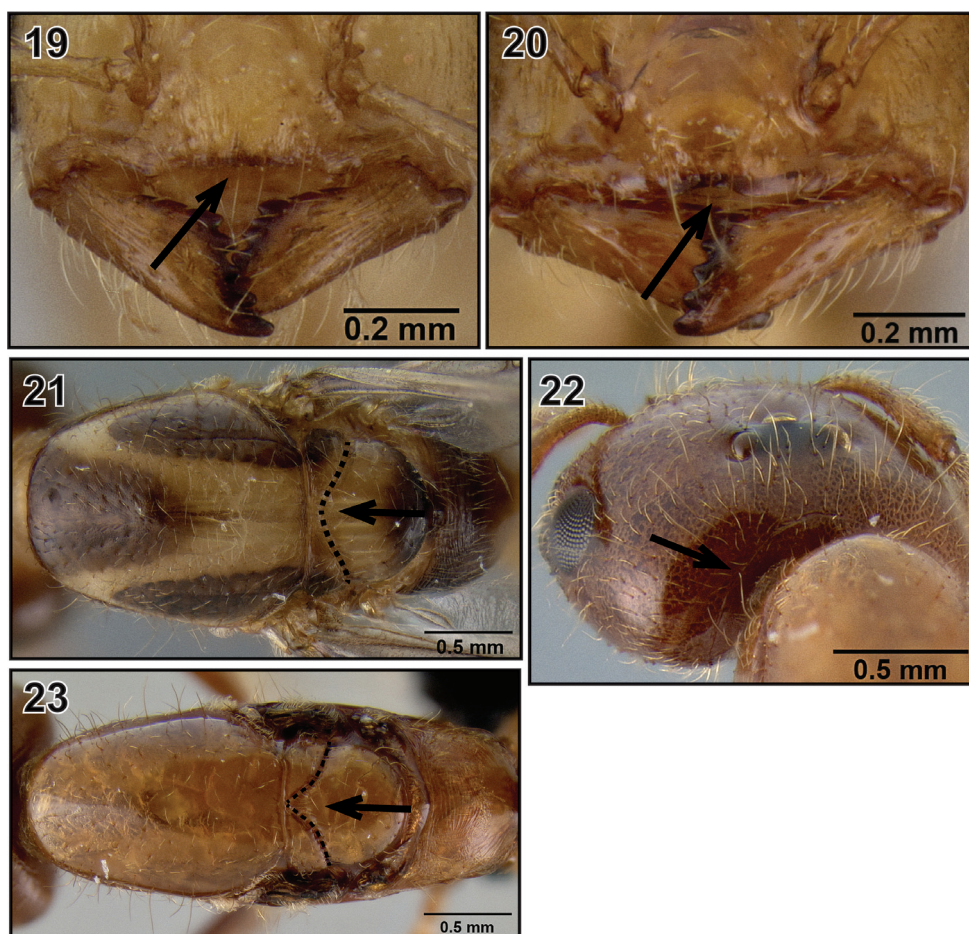
Key to the queens of *C. (Orthocrema)* species in the Malagasy region (except *C. telolafy* which is unknown)

- 1 Propodeal spines present **2**
- Propodeal spines absent **3**
- 2(1) Body size smaller (HW 0.89–1.03, WL 1.28–1.53); propodeal spines longer (SPI 0.04–0.14); clypeus lacking median notch (Figure 19); antennal scapes usually surpassing posterior margin of head ***C. madecassa***
- Body size larger (HW 1.10, WL 1.74); propodeal spines reduced to minute dents (SPI 0.02); clypeus with a median notch (Figure 20); antennal scapes just reaching posterior margin of head ***C. razana***



Figures 12–18. Species key to the workers of Malagasy *Crematogaster* (*Orthocrema*). **12** occipital carinae distinct (*C. madecassa*, CASENT0038498) **13** propodeum with lateral raised carinae (*C. madecassa*, CASENT0038498) **14** occipital carinae indistinct (*C. volamena*, CASENT0125748) **15** propodeum without lateral raised carinae (*C. volamena*, CASENT0125748) **16** clypeus with two median carinae (*C. madecassa*, CASENT0038498) **17** clypeus without median carinae (*C. razana*, CASENT1408782) **18 A** propodeal spines thin and acute **B** propodeal spines triangular **C** propodeal spines curved-triangular.

- 3(2) Body size very small (HW 0.80–0.89, WL 1.50–1.63); eyes large (OI 0.30–0.34)..... *C. rasoherinae*
- Body size large (HW 1.48–1.72, WL 2.61–2.70); eyes medium-sized (OI 0.23–0.27)..... 4
- 4(3) Head wider than long (CI 1.08); occipital carinae well pronounced (Figure 22); scuto-scutellar suture broadly meeting mesoscutum (Figure 21); dorsal face of propodeum short..... *C. volamena*
- Head longer than wide (CI 0.96); occipital carinae indistinct; scuto-scutellar suture acutely meeting mesoscutum (Figure 23); dorsal face of propodeum about as long as posterior face..... *C. mpanjono*



Figures 19–23. Species key to the queens of Malagasy *Crematogaster* (*Orthocrema*). **19** clypeus without median notch (*C. madecassa*, CASENT0040391) **20** clypeus with median notch (*C. razana*, CASENT0148782) **21** scuto-scutellar suture broadly meeting mesoscutum (*C. volamena*, CASENT0161415) **22** occipital carinae distinct (*C. volamena*, CASENT0161415) **23** scuto-scutellar suture acutely meeting mesoscutum (*C. mpanjono*, CASENT0067033).

***Crematogaster rasoherinae* Forel**

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

Figures 24–26

Crematogaster rasoherinae Forel, 1891: 194. Worker syntype(s) from MADAGASCAR: Tamatave (O'swald) [**Naturhist. Mus. Hamburg, not examined, destroyed during WWII**]. Forel, 1912: 164. Queen, male described. Combination in *C. (Neocrema)*: Santschi, 1918: 182; in *C. (Crematogaster)*: Wheeler, W.M. 1922: 1023; Combination in *C. (Orthocrema)*: Emery, 1922: 131; Combination in *C. (Mesocrema)*: Santschi, 1928: 33.

= *Crematogaster (Orthocrema) rasoherinae* var. *brunneola* Emery, 1922: 131. Replacement name for *Crematogaster rasoherinae* var. *brunnea* Forel, 1907: 79. Worker and queen syntypes from Madagascar: Andranohinaly (SW Madagascar) (Voeltzkow) [**MHNG, examined**]. [Junior primary homonym of *brunnea* Smith, F. 1857: 75.]. **Lectotype worker** by present designation: top specimen of 2 workers on one pin, CASENT0101836 (image on AntWeb). Combination in *C. (Mesocrema)*: Santschi, 1928: 33. **Syn. n.**

= *Crematogaster voeltzkowi* Forel, 1907: 78. Worker syntypes from Comoros: Anjouan (Voeltzkow) [**MHNG, examined**]. **Lectotype worker** by present designation: top specimen of 2 workers on one pin, CASENT0101615 (image on AntWeb). Combination in *C. (Neocrema)*: Santschi, 1918: 182 (misspelled as *woeltzkowi*); Comb. in *C. (Crematogaster)*: Wheeler, W.M. 1922: 1024; Comb. in *C. (Orthocrema)*: Emery, 1922: 131. **Syn. n.**

Type material. Syntypes not available for examination; these specimens were housed in the collection of the Naturhistorisches Museum in Hamburg and were destroyed during World War II (confirmation obtained 19.vii.2011, via e-mail communication with F. Wieland).

Neotype worker, by present designation: pinned, CASENT0120911, BLF16755, ex dead twig above ground; original locality label: Prov. Toamasina, Tamatave, 20m, 18°09.28'S, 49°24.76'E, 16.ii.2007, urban gardens, Fisher et al. BLF16755; deposited at CASC.

Other material examined (BBBC, CASC, MHNG, NHMB, PSWC, ZMBH, MCZC). MADAGASCAR: *Antsiranana*: Baie Sakalava: -12.27330, 49.39064, 10m (B.L.Fisher et al.); Montaigne Français: -12.32278, 49.33817, 180m (R.Harin'Hala); 7 km N Joffreville: -12.33333, 49.25000, 360m (R.Harin'Hala); 2km S Joffreville: -12.47639, 49.22222, 500m (G.Alpert); 7km SE Antsiranana: 12.31670, 49.33330, 80m (G.Alpert); R.S. Ambre: -12.46889, 49.24217, 325m (B.L.Fisher et al.); P.N. Montagne d'Ambre: -12.50035, 49.17500, 885m; -12.53444, 49.17950, 925m; -12.52028, 49.17917, 1125m (B.L.Fisher et al.); Nosy Bé, R.N.I. Lokobé: -13.41944, 48.33117, 30m (B.L.Fisher et al.); Nosy Bé, Lokobe Forest: -13.41640, 48.30720, 50m (G.Alpert); Nosy Bé, 5km E Marodokana: -13.36670, 48.30000, 50m (G.Alpert); R.S. Manongarivo: -13.93153, 48.45213, 370m (B.B.Blaimer); Ambondrobe:

-13.71533, 50.10167, 10m (B.L.Fisher et al.); P.N. Ankarana: -12.90889, 49.10983, 80m; -12.86361, 49.22583, 210m (B.L.Fisher et al.), P.N. Ankarana: -12.90056, 49.14722, 150m (G.Alpert); F Andavakoera: -13.11833, 49.23000, 425m (B.L.Fisher et al.); Rés. Analamerana: -12.74667, 49.49483, 60m (B.L.Fisher et al.); F Binara: -13.26333, 49.60333, 650–800m (B.L.Fisher et al.); 6.3 km S Ambanizana: -15.68131, 49.9580, 25m (B.L.Fisher et al.); 5.3 km SSE Ambanizana, 425m, -15.66667, 49.96667 (B.L.Fisher et al.); Nosy Mangabe: -15.49730, 49.76223, 5m (B.L.Fisher et al.); -15.50000, 49.76670, 200m (P.S.Ward); P.N. Marojejy: -14.43333, 49.78333, 450m (B.L.Fisher et al.); P.N. Masoala: -15.71333, 49.97167 (B.L.Fisher et al.); -15.72667, 49.95667, 150m (A.Dejean et al.); 84km SW Sambava on road to Andapa: -14.57730, 49.73940, 160m (W.L.&D.E.Brown); Vohemar: -13.35967, 50.00390, 16m (B.L.Fisher et al.); F Analabe: -13.08333, 49.90833, 30m (B.L.Fisher et al.); Forêt d'Ampondrabe: -12.97000, 49.70000, 175m (B.L.Fisher et al.); F Orangea: -12.25889, 49.37467, 90m (B.L.Fisher et al.); F Ampombofofo: -12.09949, 49.33874, 25m (B.L.Fisher et al.); Ampamakiambato: -13.97545, 48.15929, 145m (B.L.Fisher et al.); Forêt d'Anabohazo: -14.30889, 47.91433, 120m (B.L.Fisher et al.); Ankobahoba: -13.39166, 48.48249, 40m (B.L.Fisher et al.); 14km W Cap Est, Ambato: -15.29128, 50.33803, 150m (B.L.Fisher et al.); Andranomatàna: -13.14965, 48.91765, 28m (B.L.Fisher et al.); Tsihombe: -25.31833, 45.48367, 30m (B.L.Fisher et al.); Antalaha: -14.90130, 50.28095, 24m (B.L.Fisher et al.); 55km S Antalaha, Nosy Ngontsy: -15.26440, 50.48930, 50m (G.Alpert); 55km S Antalaha, Cap Est: -15.25640, 50.47940, 1m (G.Alpert); Ambohitsara, 10km SW Antalaha: -14.95000, 50.26670, 50m (G.Alpert); *Antananarivo*: R.S. Ambohitantely: -18.19800, 47.28150, 700m (B.L.Fisher et al.); *Fianarantsoa*: P.N. Ranomafana: -21.26650, 47.42017, 1020m (B.L.Fisher et al.); 3km W Ranomafana, nr Ifanadiana: -21.25000, 47.41670, 950m (P.S.Ward); Ranomafana, nr. Ifanadiana: -21.26670, 47.45000, 650m (P.S.Ward); 10km E Ranomafana: -18.99972, 48.95000, 50m (G.Alpert); R.S. Manombo: -23.01580, 47.71900, 30m (B.L.Fisher et al.); -23.02183, 47.72000, 36m (R.Harin'Hala); Mahabo [Rés. Forestière d'Agnalazaha]: -23.19383, 47.72300, 20m (B.L.Fisher et al.); F Ampitavananima: -23.12972, 47.71700, 34m (B.L.Fisher et al.); 8km E Kianjavato: -21.38860, 47.94360, 145m (G.Alpert); *Mahajanga*: PN Ankara-fantsika (F Tsimaloto): -16.22806, 47.14361, 135m (B.L.Fisher et al.); PN Ankara-fantsika: -16.31670, 46.81670 (L.A. Nilsson); Ambolomaiky: -15.85410, 46.74663, ca. 80m (B.L.Fisher et al.); Forêt Ambohimanga: -15.96267, 47.43817, 250m (B.L.Fisher et al.); PN Baie de Baly: -16.01000, 45.26500, 10m (B.L.Fisher et al.); P.N. Namoroka: -16.37667, 45.32667, 100m (B.L.Fisher et al.); P.N. Tsingy de Bemaraha: -19.13222, 44.81467, 100m; -18.70944, 44.71817, 150m (B.L.Fisher et al.); Mahavavy River: -16.05167, 45.90833, 20m (B.L.Fisher et al.); Rés. Forestière Beanka: -18.02649, 44.05051, 250m (B.L.Fisher et al.); F Tsimembo: -19.02139, 44.44067, 20m; -18.99528, 44.44350, 50m (B.L.Fisher et al.); S.F. Ampijoroa: -16.31944, 46.81333, ca. 40m; -16.31670, 46.81670, 80m; F Asondrodava: -17.96533, 44.03550, 6m (R.Harin'Hala); 3km S Namakia: -15.95611, 45.83556, 40m (G. Alpert); *Toamasina*: RS Ambatovaky: -16.81739, 49.29402, 360m (B.L.Fisher

et al.); F Ambatovy: -18.85083, 48.32000, 1075m (B.L.Fisher et al.); Rés. Betampona: -17.92400, 49.19967, 390m (B.L.Fisher et al.); 11km SE Ampasimanolotra (=Brickaville): -18.90000, 49.13330, 5m (P.S.Ward); 10km N Brickaville: -18.79194, 49.08667, 100m (G. Alpert); F Kalalao [Ile St.Marie]: -16.92250, 49.88733, 100m (B.L.Fisher et al.); F Ambohidena [Ile St.Marie]: -16.82433, 49.96417, 20m (B.L.Fisher et al.); F Ampanihy [Ile St.Marie]: -16.91117, 49.93917, 10m (B.L.Fisher et al.); F Sahafina: -18.81445, 48.96205, 100m; -18.81445, 48.96205, 140m (B.L.Fisher et al.); Mahavelona (Foulpointe): -17.66667, 49.50000, (A.Pauly); Manankinany: -17.03330, 49.53330 (L.A.Nilsson); Tanambao Nosibe: -17.89117, 49.45617, 15m (Blaimer&Raharimalala); Antaratasy: -17.76733, 49.47767, 25m (Blaimer & Raharimalala); Ampasina-Maningory: -17.21467, 49.40550, 20m (Blaimer & Raharimalala); Anosintany: -16.91117, 49.58867, 10m (Blaimer & Raharimalala); Maitsohely: -16.90617, 49.58683, 10m (Blaimer & Raharimalala); Fenoarivo: -17.38117, 49.41500, 10m (Blaimer & Raharimalala); Antetezambaro: -17.05283, 49.56700, 10m (Blaimer & Raharimalala); Mahambo: 17.48933, 49.45167, 10m (Blaimer & Raharimalala); Tamatave: -18.15467, 49.41267, 20m (B.L.Fisher et al.); Brickaville:-18.82183, 49.07017, ca. 25m (B.L.Fisher et al.); Analalava: -17.7095, 49.45400, 50m (B.L.Fisher et al.); Mahanoro: -19.89933, 48.80883, 15m (B.L.Fisher et al.); Vatomandry: -19.33283, 48.97950, 16m (B.L.Fisher et al.); Forêt d'Analava Mandrisy: -16.48567, 49.84700, 10m (B.L.Fisher et al.); S.F. Tampolo: -17.28250, 49.43000, 10m (B.L.Fisher et al.); Analalava: -17.693194, 49.46027, ca. 20m (R.Harin'Hala); *Toliara*: Mahafaly Plateau: -24.65361, 43.99667, 80m (B.L.Fisher et al.); F Mikea: -22.90367, 43.47550, 35m (R. Harin'Hala); Libanona Beach: -25.03883, 46.99600, 20m (B.L.Fisher et al.); F Petriky: -25.06167, 46.87000, 10m (B.L.Fisher); Ranobe: -23.03975, 43.61090, 30m (Frontier Project, MGF); Rés. Berenty (F Bealoka): -24.95694, 46.27150, 35m (B.L.Fisher et al.); Rés. Berenty (F Malaza): -25.00778, 46.30600, 40m; Rés. Berenty (F Anjapolo): -24.92972, 46.20967, 65m (B.L.Fisher et al.); Rés. Berenty: -25.02100, 46.30550, 35m, -25.00670, 46.30330, 85m (R.Harin'Hala), -25.01670, 46.30000, 35m (P.S.Ward), -24.98330, 46.30000, 30m; Miandrivazo: -19.52317, 45.4575, 80m (B.L.Fisher et al.); Morondava: -20.29650, 44.28150, ca. 10m (B.L.Fisher et al.); F Beroboka: -22.23306, 43.36633, 80m (B.L.Fisher et al.); F Tsinjoriaky: -22.80222, 43.42067, 70m (B.L.Fisher et al.); PN Tsimanampetsotsa: -24.10056, 43.76000, 25m; -24.04722, 43.75317, 40m (B.L.Fisher et al.); Ejeda: -24.3505, 44.51600, 250m (B.L.Fisher et al.); F Tsivory: -24.07083, 46.07533, 400m (B.L.Fisher et al.); Manatantely:-24.9815, 46.92567, 100m (B.L.Fisher et al.); 6.1 km 182°S Marovato: -25.58167, 45.29500, 20m (B.L.Fisher et al.); 3.4 km 190° S Marovato: -25.55972, 45.28250, 160m (B.L.Fisher et al.); 3.5 km 236° SW Marovato: -25.55389, 45.25583, 230m (B.L.Fisher et al.); P.N. Andohahela: -24.81694, 46.61000, 150m (R.Harin'Hala); -24.93683, 46.62667, 180m (R.Harin'Hala); -24.75850, 46.85370, 275m; -24.93000, 46.64550, 300m (B.L.Fisher et al.); P.N. Andohahela/parcel3: -25.01366, 46.64650, 160m; -25.01790, 46.65175, 170m; P.N. Andohahela/ parcel1: -24.94713, 46.67312, 400m; -24.94683, 46.67625, 440m (B.B.Blaimer); 5km NNW Isaka-Ivondro, Rés. Ando-

hahela: -24.75000, 46.85000, 280m (P.S.Ward); (P.S.Ward); 7km NW Ranopiso: -25.01670, 46.63330, 100m (P.S.Ward); 2.7km WNW 302° St.Luce: -24.77167, 47.17167, 20m (B.L.Fisher et al.); F Mandena: -24.95167, 47.00167, 20m (B.L.Fisher); Rés. Cap St.Marie: -25.58767, 45.16300, ca. 35m; -25.59444, 45.14683, 160m, -25.58167, 45.16833, 200m; (B.L.Fisher et al.); SW Madagascar, Andranohinaly: -23.27500, 43.97500 (Voeltzkow).

SEYCHELLES: Mahé Island: Morne Blanc: -4.65988, 55.43743, 480m; -4.65740, 55.43325, 660m (B.L.Fisher et al.); Petite Congo Rouge: -4.64514, 55.43364, 745m (B.L.Fisher et al.); Mont Copolia : -4.65121, 55.45835, 520m (B.L.Fisher et al.); Silhouette Island: Mont Dauban: -4.48126, 55.22641; 735m (B.L.Fisher et al.); Aldabra Atoll: Grande Terre Isl.: -9.43453, 46.45767, ca. 5m (S.M.Goodman); COMOROS: Mohéli: Ouallah: -12.30668, 43.66407, 275m; 12.30353, 43.66827, 500m; -12.29696, 43.67392, 680m; -12.29600, 43.67600, 750m (B.L.Fisher et al.); Madahali: -12.37421, 43.86857, 50m (B.L.Fisher et al.); Lac Boundouni: -12.37915, 43.85165, 25m (B.L.Fisher et al.); Grande Comore: Goudjoulachamle: -11.44826, 43.27373, 80m (B.L.Fisher et al.); Grillé: -11.47578, 43.34669, 805m; -11.47578, 43.34669, 995m (B.L.Fisher et al.); Karthala: -11.82699, 43.42950, 1000m (B.L.Fisher et al.); Domani: -11.51778, 43.28000, 5m (B.L.Fisher et al.); Itoundzou: -11.63136, 43.30434, 635m (B.L.Fisher et al.); Trou du Prophete: -11.38087, 43.31335, 10m (B.L.Fisher et al.); Anjouan: -12.22265, 44.28820, 10m; -12.25764, 44.38915, 20m; -12.18771, 44.35929, 65m; -12.29311, 44.51090, 440m; -12.30537, 44.45031, 500m (B.L.Fisher et al.); Anjouan (Voeltzkow); Hajoho: -12.12195, 44.48795, 10m (B.L.Fisher et al.); Lac Dzilandée: -12.22474, 44.43121, 900m (B.L.Fisher et al.); Mt. Ntringui: -12.19865, 44.41866, 740m; -12.22043, 44.42924, 1225m (B.L.Fisher et al.); MAYOTTE: Reserve forestière Majimbini: -12.76796, 45.18615, 525m (B.L.Fisher et al.); Mont Combani: -12.80632, 45.15314, 370m (B.L.Fisher et al.); Baie de Tsingoni: -12.79260, 45.10764, 5m (B.L.Fisher et al.); Hajangoua: -12.85492, 45.19889, 10m (B.L.Fisher et al.); Mont Benara: -12.87585, 45.15672, 425m (B.L.Fisher et al.); Sazile: -12.97839, 45.17261, 35m (B.L.Fisher et al.); Tanaraki: -12.75754, 45.0678, 10m (B.L.Fisher et al.); Reserve forestiere Sohoa: -12.80586, 45.10054, 20m (B.L.Fisher et al.); Gorgora Kandza: -12.86735, 45.20827, 65m (B.L.Fisher et al.).

Worker measurements (n=28). Neotype worker: HW 0.64; HL 0.61; EL 0.15; SL 0.45; WL 0.68; SPL 0.07; PTH 0.17; PTL 0.25; PTW 0.18; PPL 0.14; PPW 0.19; LHT 0.44; CI 1.05; OI 0.25; SI 0.74; SPI 0.10; PTHI 0.67; PTWI 0.73; PPI 1.41; LBI 1.53.

Other material. HW 0.51–0.63; HL 0.49–0.62; EL 0.12–0.15; SL 0.38–0.46; WL 0.52–0.65; SPL 0.00–0.10; PTH 0.11–0.16; PTL 0.16–0.24; PTW 0.13–0.19; PPL 0.10–0.14; PPW 0.14–0.21; LHT 0.35–0.44; CI 0.99–1.07; OI 0.21–0.27; SI 0.71–0.82; SPI 0.00–0.17; PTHI 0.60–0.72; PTWI 0.65–0.93; PPI 1.21–1.62; LBI 1.26–1.56.

Diagnosis. Workers of *Crematogaster rasoherinae* can be distinguished from all other Malagasy *Orthocrema* by the presence of small anterolateral denticles on the petiole and the rectangular shape of the same. Queens are distinct from all other species

by their rectangular petiole shape. In addition, the absence of propodeal spines distinguishes *C. rasoherinae* queens from *C. madecassa* and *C. razana*, whereas very small size (HW 0.80–0.89, WL 1.50–1.63) and large eyes (OI 0.30–0.34) easily separate them from *C. volamena* and *C. mpanjono*.

Worker description (Figures 24A–F). Very small species (HW 0.51–0.64, WL 0.52–0.68). Masticatory margin of mandibles with 4 teeth; clypeus with several weak vertical carinae; posterior margin of head in full face view usually laterally rounded, sometimes medially slightly depressed; occipital carinae well pronounced; antennal scapes usually just reaching, but not surpassing posterior margin of head; midline of eyes situated well above midline of head in full face view; eyes flush with head, not notably protruding.

Promesonotum laterally subangular, with mesonotum posterolaterally slightly marginate and metanotal groove bordered by weak carinae; in lateral view outline of promesonotum moderately convex; promesonotal suture usually absent; mesonotum with or without a distinct posterior face; metanotal groove with 2–3 median carinae of varying prominence; propodeal spines short (SPI < 0.17) or absent (most Comoros Isl. material), if present straight or upwards curved, in lateral view directed upwards, in dorsal view almost parallel and not diverging; dorsal face of propodeum very short; petiole in dorsal view rectangular, with dorsolateral margins weakly carinate or angular and small antero- and posterolateral denticles; subpetiolar process mostly developed as broad, rounded protuberance, sometimes as small angular dent; postpetiole more or less globular, merely impressed posteriorly, or with faint median impression; subpostpetiolar process often present as small, angular protrusion.

Head sculpture reduced, aciculate; mesosoma with promesonotum dorsally aciculate; meso- and metapleuron aciculate to areolate; propodeum with dorsal face carinulate or reticulate, posterior face shiny; dorsal face of petiole mostly reticulate; helcium dorsally finely areolate; postpetiole dorsally feebly reticulate; lateral and ventral face of petiole and postpetiole areolate or reticulate; face with 2–4 erect flexuous setae, and abundant short, subdecumbent pubescence; pronotum with 0–4 (most often 2) erect, stiff humeral setae, and 0–4 (usually 2) erect, stiff lateral setae on mesonotum, rarely also 2 erect setae present dorsally; mesosoma with scattered decumbent pubescence; petiole with a single stiff, erect seta on each posterolateral tubercle; postpetiole with a pair of erect dorsoposterior setae; abdominal tergites and sternites 4–7 with fairly abundant short erect pilosity (> 20 setae), which is more sparse on tergite 4 and usually present only towards posterior end, and with decumbent pubescence throughout.

Several color variants. Most widespread in Madagascar is a light to dark brown form; less common is a bicolored form with light brown or reddish head and mesosoma and dark gaster. On the Comoros islands, the Seychelles and Mayotte, *C. rasoherinae* is most often yellow or pale yellow colored, often with the posterior half of the gaster black. The typical brown Madagascar color form seems to be only present on the Seychelles.

Intermediate worker measurements (n=10). HW 0.73–0.84, HL 0.72–0.83, EL 0.18–0.23, SL 0.49–0.56, WL 0.83–1.03, SPL 0.06–0.15, PTH 0.18–0.23, PTL 0.29–0.37, PTW 0.23–0.30, PPL 0.18–0.23, PPW 0.27–0.34, LHT 0.50–0.57, CI

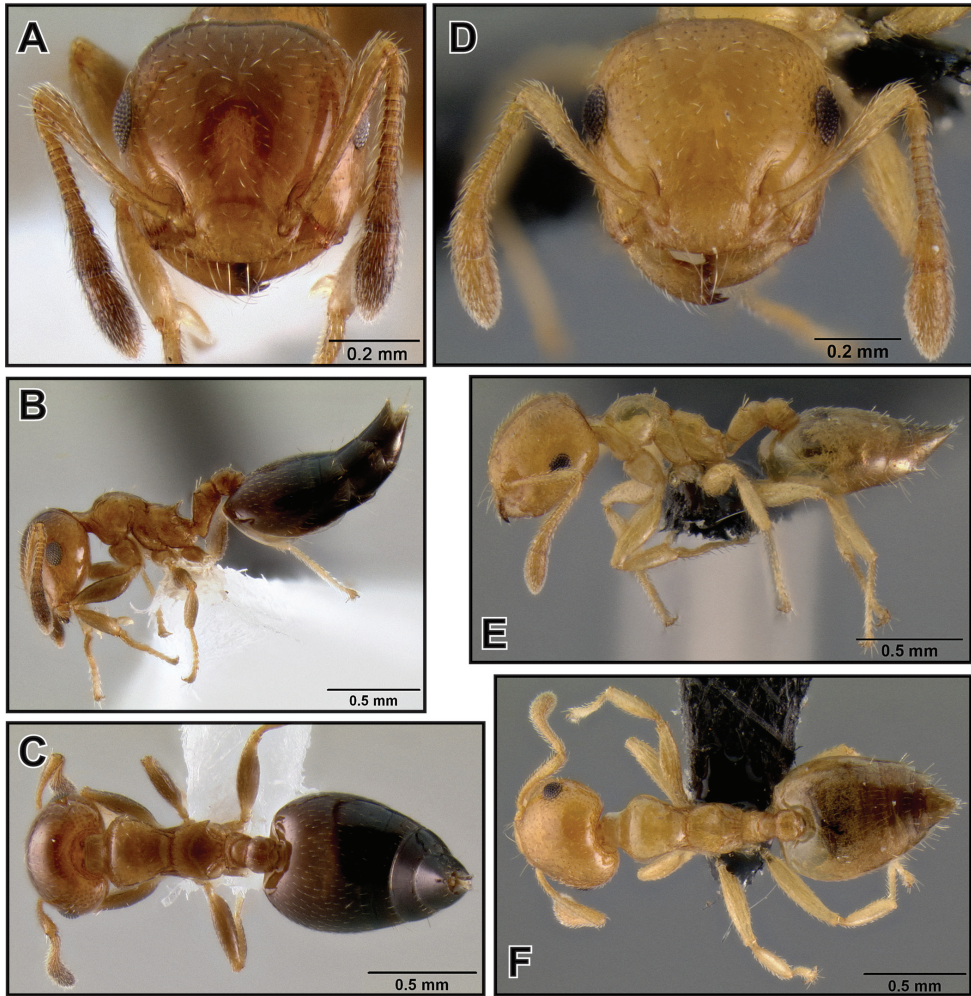


Figure 24. *Crematogaster rasoherinae*, workers. **A–C** form with propodeal spines (CASENT0193412) **A** full face **B** lateral **C** dorsal **D–F** form without propodeal spines (CASENT0147430) **D** full face **E** lateral **F** dorsal.

1.00–1.05, OI 0.24–0.30, SI 0.65–0.75, SPI 0.08–0.18, PTHI 0.56–0.67, PTWI 0.74–0.88, PPI 0.43–0.53, LBI 1.59–1.84.

Intermediate worker description (Figures 25A–E). Intermediate between workers and queens in size. Head, petiole and postpetiole characters similar to queens; ocelli present, but smaller than in queens; the mesonotum is to various extent raised and fused dorsally over pronotum and has wing attachment sutures; otherwise mesosomal characters more similar to worker characters, especially propodeum, and propodeal spines are present.

Queen measurements (n=10). HW 0.80–0.89, HL 0.79–0.88, EL 0.26–0.28, SL 0.51–0.56, MSNW 0.62–0.85, MSNL 0.70–0.90, WL 1.50–1.63, SPL 0.00, PTH

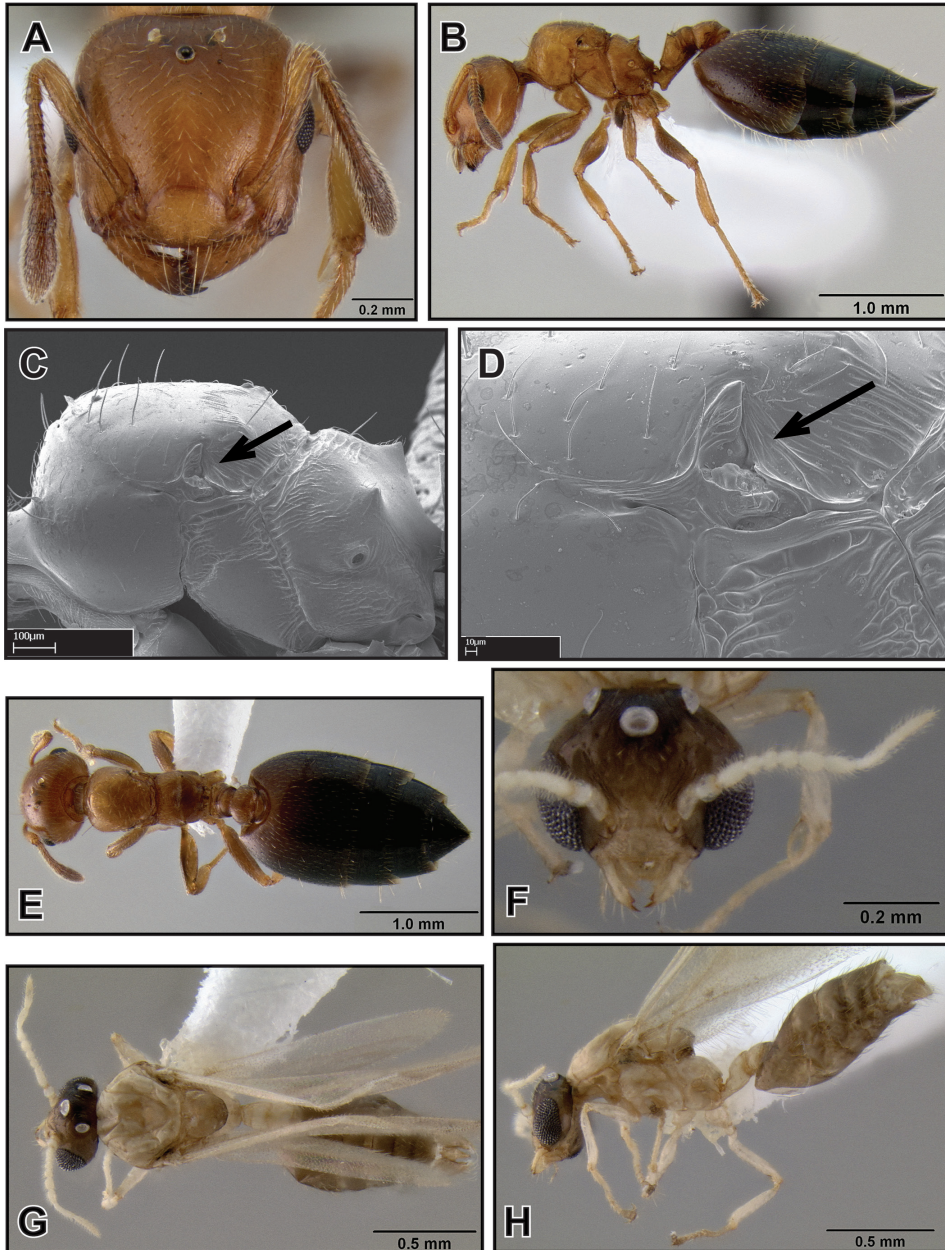


Figure 25. *Crematogaster rasoherinae*, intermorph and male. **A–E** intermorph (CASENT0193402) **A** full face **B** lateral **C** dorsolateral view of mesosoma (SEM) **D** close-up of mesosoma in dorsolateral view (SEM) **E** dorsal **F–G** male (CASENT0193414) **F** full face **G** dorsal **H** lateral.

0.20–0.24, PTL 0.35–0.43, PTW 0.26–0.31, PPL 0.21–0.28, PPW 0.31–0.37, LHT 0.62–0.70, CI 0.99–1.02, OI 0.30–0.34, SI 0.62–0.66, MSNI 1.72–1.91, SPI 0.13–0.16, PTHI 0.49–0.63, PTWI 0.62–0.75, PPI 1.30–1.63, LBI 2.19–2.48.

Queen description (Figures 26 A–C). Very small (HW 0.80–0.89, WL 1.50–1.63). With worker characters, except as follows. Masticatory margin of mandibles with 5 teeth. Antennal scapes not surpassing posterior margin of head, reaching only to about level of lateral ocelli; eyes large (OI 0.30–0.34), situated at midline of head in full face view; head shape quadrate (CI 0.99–1.02), posterior margin of head straight.

Mesosoma slender (MSNI 1.72–1.91, WL 1.50–1.63); mesoscutum in dorsal view oval, about half as wide as long; dorsal face of propodeum distinct, about half as long as posterior face; propodeal spines absent; petiole and postpetiole as in worker; anteroventral subpetiolar tooth present, but reduced with respect to worker.

Sculpture smooth and shiny throughout; erect pilosity generally more abundant, but finer than in workers: face with 4–6 longer erect setae and abundant shorter erect to suberect pilosity; mesonotum with abundant short, and scattered longer erect setae; petiole with one pair of long flexuous setae posterior to posterior denticles; postpetiole with flexuous pair of dorsoposterior setae and 2–4 additional long setae; petiole and postpetiole with abundant shorter pilosity throughout. Body color similar to respective workers.

Male measurements (n=5). HW 0.43–0.48, HL 0.34–0.37, EL 0.19–0.22, SL 0.05–0.08, MSNW 0.43–0.53, MSNL 0.38–0.49, WL 0.64–0.80, SPL 0.00, PTH 0.11–0.13, PTL 0.15–0.19, PTW 0.10–0.14, PPL 0.15–0.19, PPW 0.15–0.19, LHT 0.31–0.34, CI 1.19–1.33, OI 0.54–0.59, SI 0.15–0.21, MSNI 1.56–1.80, SPI 0.14–0.17, PTHI 0.64–0.74, PTWI 0.54–0.83, PPI 1.38–1.55, LBI 2.07–2.42.

Male description (Figures 25F–H). Very small (HW 0.43–0.48, WL 0.64–0.80). Masticatory margin of mandibles with 2 teeth; eyes very large (OI 0.54–0.59) and protruding, covering most of gena, and reaching anteriorly almost to clypeal margin; antennae 9–10-segmented (separation between 3rd and 4th funicular segment often absent or incomplete), scapes very short (SI 0.15–0.21), 2nd funicular segment globular, last 2 or 3 funicular segments compressed (this may be post mortem); head strongly wider than long (CI 1.19–1.33), mostly due to lateral extent of eyes; ocellar triangle extending to posterior head margin in full face view as a crown; occipital carinae distinct.

Mesosoma fairly slender (MSNI 1.56–1.80, WL 0.64–0.80); mesoscutum in dorsal view slightly wider than long; scutellum with two distinct faces: anterior face short and steeply sloping from mesoscutum, posterior face long and flat; scutellum in dorsal view oval and posteriorly rounded, but dorsoposterior margin carinate; dorsal face of propodeum about as long as posterior face; propodeal spines absent; petiole in dorsal view more or less rectangular, but carinae or denticles absent and all margins rounded, in lateral view petiole anteriorly tapering; anteroventral subpetiolar tooth absent; postpetiole globular, but dorsally somewhat compressed and flat, median impression absent; wings clear.

Sculpture smooth and shiny throughout; face with 2 longer erect setae close to ocelli and sparse short suberect pilosity; mesoscutum with scattered short erect or suberect pilosity; longer erect pilosity present on posterior part of scutellum; petiole with one pair of fine, erect setae; postpetiole with fine dorsoposterior setae. Head medium brown, mesosoma pale yellow, metasoma light brown.

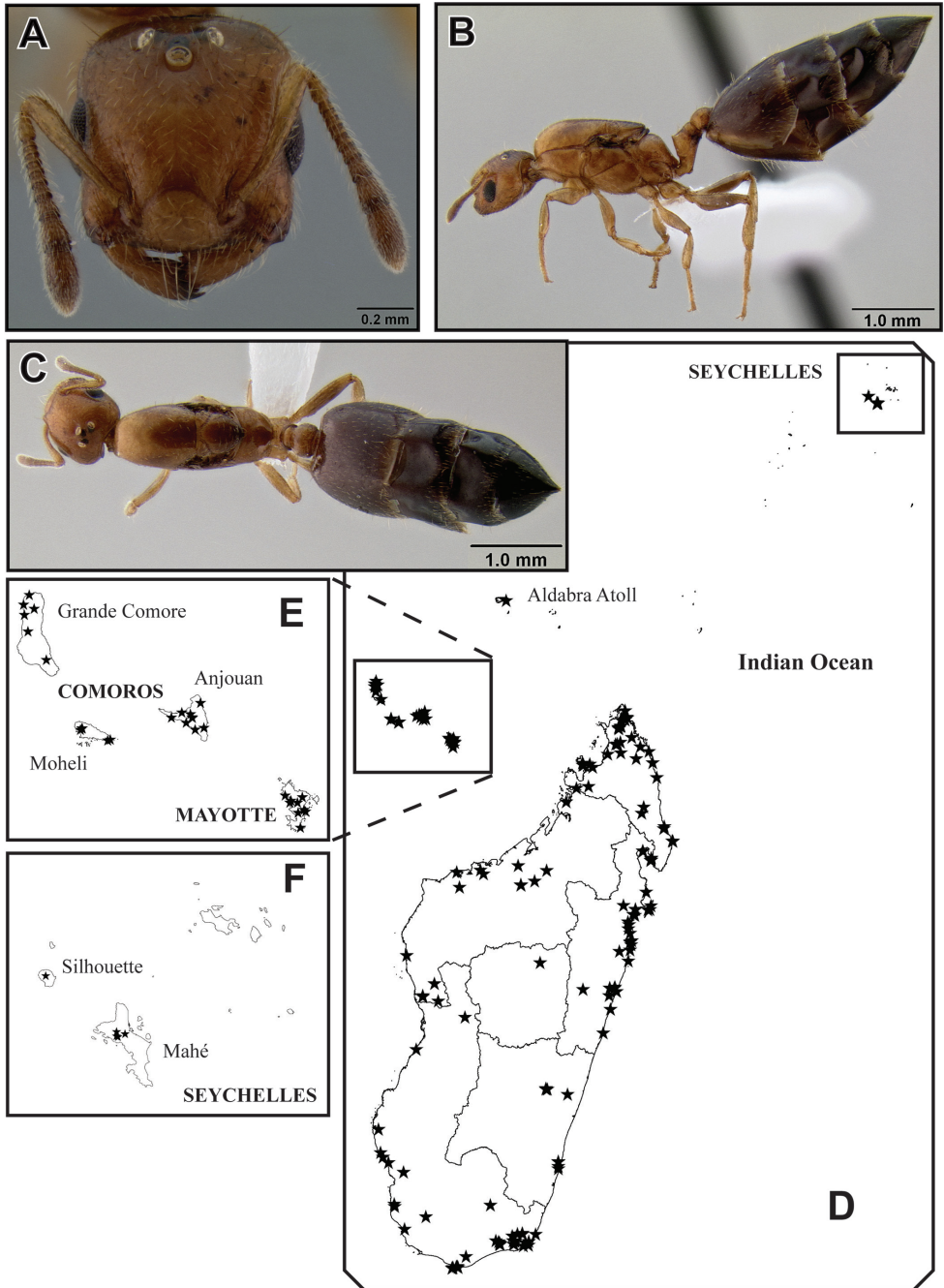


Figure 26. *Crematogaster rasoherinae*, queen and distribution. **A–C** queen (CASENT0193403) **A** full face **B** lateral **C** dorsal **D–F** distribution maps **D** Madagascar and Indian Ocean island overview **E** Comoros and Mayotte **F** Seychelles.

Distribution and biology. *Crematogaster rasoherinae* is the most widespread species of the Malagasy *Orthocrema*, and in fact it is one of the most abundant *Crematogaster* species in Madagascar and on a number of Indian Ocean islands (Figures 26 D–F). The species is distributed throughout all native forest habitats in Madagascar – rainforest, dry or spiny forest alike – and is also found in disturbed habitats and urban areas. It has been collected at elevations up to 1225m, but appears to be more common at lower elevations. In natural habitats this species is predominantly arboreal nesting, both in dead twigs as well as in live plant parts. However, ground nesting in rotten logs or branches does occur occasionally.

Biologically *C. rasoherinae* is interesting because of the presence of intermediate workers (i.e., individuals intermediate between workers and queens) (Figures 25 A–E) of unknown function in the colony. I have found intermediates in all four colonies that I collected of this species, with the highest number hereby being eight individuals in one nest. In all cases a normal, dealate queen also was present in the nest. None of the intermediates observed was winged and it seems likely that they are either entirely wingless or brachypterous. Scanning electron micrographs of the lateral mesosoma (Figures 25 C and D) show the presence of a rudimentary suture above the mesopleuron where in a normal queen the forewing attaches.

Discussion. An intriguing characteristic of *C. rasoherinae* is the morphological variability of this species on the Comoros Islands compared to the remainder of its distribution range. In Madagascar, the Seychelles and Mayotte this species always possesses propodeal spines. On the Comoros Islands in contrast, propodeal spines can be present (as in Figure 24B), reduced or entirely absent (as in Figure 24E). More specifically, all specimens examined from the island of Grand Comore have no, or very reduced propodeal spines, whereas on Anjouan and Moheli propodeal spines are mostly reduced or absent and present only in fewer individuals. This spine-polymorphism was presumably the basis of the description of the here synonymized *C. voeltzkowi*. Anjouan is the type locality for this species name and the syntype specimens represent the morphological form lacking the propodeal spines. Analysis of DNA sequence data from both the nuclear markers (see Figure 1) and ancillary mitochondrial data however clearly shows a lack of genetic divergence between the ‘armed’ and ‘unarmed’ forms in *C. rasoherinae*. The cause and maintenance of this intraspecific polymorphism remains to be investigated.

The syntype specimens of *C. rasoherinae* have been lost or destroyed during the times of World War II. Confirmation for this has been obtained via e-mail communication with the Naturhistorisches Museum Hamburg (F. Wieland, 19.vii.2011). I designate a neotype in this study to unequivocally ascertain the identity of the species *C. rasoherinae*, hereby selecting a worker specimen from or close to the original type locality in Madagascar, Tamatave [Toamasina, town]. In a large and taxonomically difficult genus such as *Crematogaster* type material is indispensable to clarify species identities. Although no closely resembling species is currently known, it is likely that a morphologically similar species could be discovered in the future, either in Madagascar or on the African mainland.

***Crematogaster madecassa*-group**

Worker diagnosis of the *Crematogaster madecassa*-group: *C. madecassa*, *C. telolafy*, *C. razana*. Very small species (HW 0.48–0.60, WL 0.44–0.69). Masticatory margin of mandibles with 4 teeth; posterior margin of head in full face view usually laterally rounded, sometimes medially slightly depressed; occipital carinae well pronounced; antennal scape length variable; midline of eyes situated well above midline of head in full face view; eyes large (OI 0.22–0.28) and distinctly protruding.

Pronotum laterally subangular; mesonotum laterally with distinct, raised carinae that are confluent with lateral carinae bordering metanotal groove and propodeum; in lateral view outline of promesonotum moderately convex; mesonotum transversely concave, without a distinct posterior face and gradually sloping into metanotal groove; metanotal groove in dorsal view constricted by bordering lateral carinae, propodeal spines short to medium-sized (SPI 0.10–0.26), form variable; dorsal face of propodeum very short; petiole in dorsal view ovo-rectangular, with dorsolateral margins increasingly carinate posteriorly, ending in small posterolateral denticles; subpetiolar process variable: from small, but distinct and acute tooth to reduced angular dent; postpetiole globular, faintly impressed posteriorly, no trace of median impression; subpostpetiolar process present or absent.

Sculpture overall reduced; head shiny; mesosoma dorsally mostly shiny, carinulate laterally; meso- and metapleuron mostly shiny, with some reticulations; dorsal face of propodeum carinulate, posterior face shiny; dorsal face of petiole shiny; helcium dorsally carinulate; postpetiole dorsally feebly reticulate; lateral and ventral face of petiole and postpetiole reticulate; face with 4–8 erect, long flexuous setae, and abundant shorter, subdecumbent pubescence; promesonotum usually with 4–6 erect, long flexuous setae: 2 humeral setae, and 2 setae at anterior and usually also 2 setae at posterior end of mesonotal carinae; additional long erect setae, and scattered shorter erect setae may be present dorsally on promesonotum; petiole with a single stiff, erect seta on each posterolateral tubercle; postpetiole with a pair of erect dorsoposterior setae; abdominal tergites and sternites 4–7 with fairly abundant, erect long pilosity (> 20 setae) and sparse decumbent pubescence throughout. Color pale to medium yellow, or yellowish-brown.

Queen diagnosis of the *Crematogaster madecassa*-group: *C. madecassa*, *C. razana* (*C. telolafy* unknown). Very small (HW 0.80–1.10, WL 1.28–1.74). With worker characters, except as follows. Masticatory margin of mandibles with 5 teeth; antennal scapes not, or just reaching posterior margin of head; eyes large (OI 0.29–0.37) and protruding, situated slightly above midline of head in full face view; head wider than long (CI 1.11–1.21) and widest just posterior to eyes, posterior margin of head straight.

Mesosoma more compact (MSNI 1.55–1.82, WL 1.28–1.74); mesoscutum in dorsal view almost or as wide as long; dorsal face of propodeum absent, and posterior face very sharply and almost vertically sloping; propodeal spines present, much shorter than in workers (SPI 0.02–0.14), sometimes reduced to minute dents; petiole and postpetiole as in workers.

Sculpture smooth and shiny throughout, except metapleuron and anteriormost part of propodeum carinulate; erect pilosity very abundant on head, dorsal side of

mesosoma and on metasoma, but finer and shorter than in workers; petiole with 1–3 pair(s) of long flexuous setae posterior to denticles; postpetiole with abundant erect pilosity. Color similar to respective workers, but often metasoma darker.

***Crematogaster madecassa* Emery**

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

Figures 27–28

Crematogaster sordidula var. *madecassa* Emery, 1895: 342. Worker and queen syntypes from MADAGASCAR: Diego-Suarez (Ch. Alluaud) [MSNG, examined]. Combination in *C. (Orthocrema)*: Wheeler, W.M. 1922:1024. Subspecies of *sordidula*: Wheeler, W.M. 1922:1024. Raised to species: Emery, 1912: 668; Emery, 1922:131.

Type material examined (MSNG). MADAGASCAR: *Antsiranana*: Diego-Suarez: [-12.26670, 49.28330] (Ch. Alluaud), CASENT0102053, CASENT0102054 and CASENT0101933. **Lectotype worker** by present designation: lower specimen of 2 workers on one pin, CASENT0102054 (image on AntWeb).

Other material examined (CASC, PSWC, MSNG, MCZC). MADAGASCAR: *Antsiranana*: Sakalava Beach: -12.26278, 49.39750, 10m (R. Harin'Hala); 7 km N Joffreville: -12.33333, 49.25000, 360m (R. Harin'Hala); R.S. Ambre: -12.46889, 49.24217, 325m (B.L.Fisher et al.); P.N. Montagne d'Ambre: -12.50035, 49.17500, 885m; -12.53444, 49.17950, 925m (B.L.Fisher et al.); R.S. Manongarivo: -13.96167, 48.43333, 400m; -13.97667, 48.42333, 780m; -13.99833, 48.42833, 1175m (B.L.Fisher et al.); Ampasindava, Ambilanivy: -13.79861, 48.16167, 600m (B.L.Fisher et al.); Nosy Bé, R.N.I. Lokobé: -13.41944, 48.33117, 30m (B.L.Fisher et al.); F Andavakoera: -13.11833, 49.23000, 425m (B.L.Fisher et al.); F Antsahabe: -13.21167, 49.55667, 550m (B.L.Fisher et al.); F Binara: -13.25500, 49.61667, 375m; -13.26333, 49.60333, 650–800m (B.L.Fisher et al.); F Analabe: -13.08333, 49.90833, 30m (B.L.Fisher et al.); F Bekaraoka: -13.16667, 49.71000; 150m (B.L.Fisher et al.); F Ampondrabe: -12.97000, 49.70000, 175m (B.L.Fisher et al.); Montagne d'Akirindro: -15.28833, 49.54833, 600m (B.L.Fisher et al.); 6.9 km NE Ambanizana: -15.56667, 50.00000, 825m (B.L.Fisher et al.); Montagne d'Anjanaharibe: -15.18833, 49.61500, 470–1100m (B.L.Fisher et al.); P.N. Marojejy: -14.43333, 49.78333, 450m; -14.43817, 49.77400, 488m; -14.43500, 49.76000, 775m (B.L.Fisher et al.); P.N. Marojejy [Manantenina]: -14.43667, 49.77500, 450m (B.L.Fisher et al.); R.N.I. Marojejy: -14.43583, 49.76056, 610m (G. Alpert); F Ambanitaza: -14.67933, 50.18367, 240m (B.L.Fisher et al.); F Betaolana: -14.52996, 49.44039, 880m (B.L.Fisher et al.); P.N. Ankarana: -12.86361, 49.22583, 210m (B.L.Fisher); F Ambato: -13.46450, 48.55167, 150m (B.L.Fisher); F Anabohazo: -14.30889, 47.91433, 120m (B.L.Fisher et al.); 30km N Antalaha, Amboangy, -14.66480, 50.19070, 130m (G. Alpert); *Fianarantsoa*: P.N. Andringitra: -22.23333, 47.0000, 825m (B.L.Fisher et al.); F Vevembe: -22.79100, 47.18183, 600m

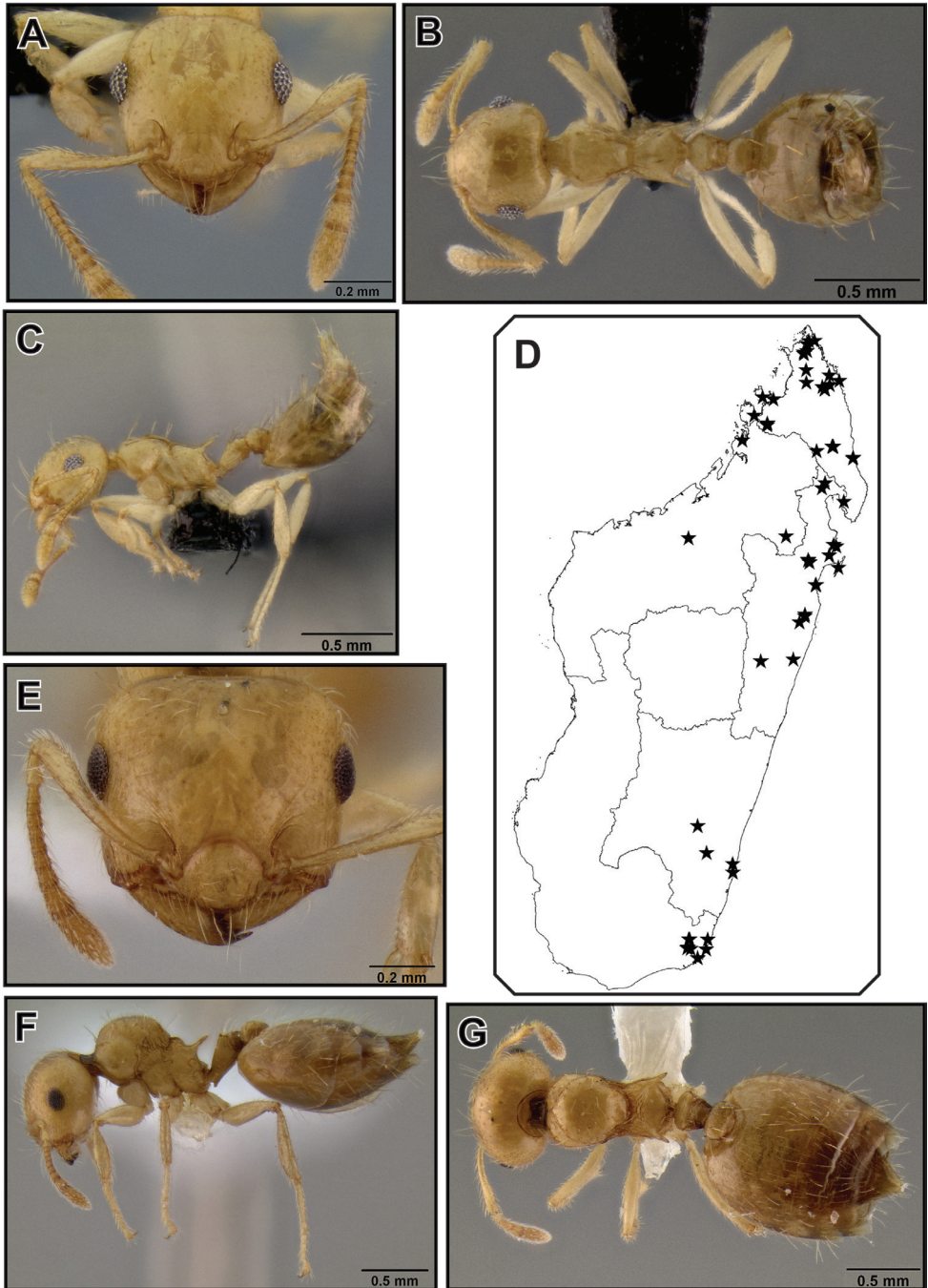


Figure 27. *Crematogaster madecassa*, worker, intermorph and distribution. **A–C** worker (CASENT0038498) **A** full face **B** dorsal **C** lateral **D** distribution **E–G** intermorph (CASENT0436247) **E** full face **F** lateral **G** dorsal.

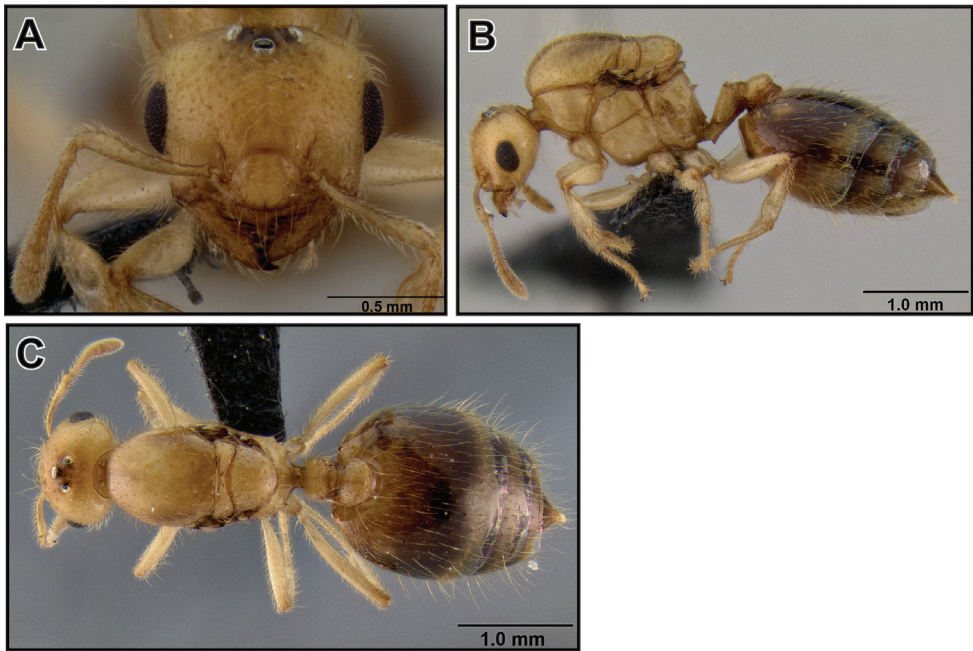


Figure 28. *Crematogaster madecassa*, queen. **A** full face, **B** lateral, **C** dorsal (CASENT0040391).

(B.L.Fisher et al.); Rés. Marotandrano: -16.28322, 48.81443, 865m (B.L.Fisher et al.); R.S. Manombo: -23.01580, 47.71900, 30m (B.L.Fisher et al.); Mahabo [Rés. Forestière d'Agnezalaha]: -23.19383, 47.72300, 20m (B.L.Fisher et al.); *Mahajanga*: PN Ankara-fantsika (Ampijora): -16.32083, 46.81067, 130m (B.L.Fisher et al.); *Toamasina*: P.N. Mananara-Nord: -16.45500, 49.78750, 225m (B.L.Fisher et al.); RS Ambatovaky: -16.81739, 49.29402, 360m; -16.77274, 49.26551, 450m; -16.81209, 49.29216, 460m; -16.77020, 49.26638, 470m; -16.76330, 49.26692, 520m (B.L.Fisher et al.); F Ambatovy: -18.84950, 48.29470, 1010m; F.C. Sandranantitra: -18.04833, 49.09167, 450m (B.L.Fisher et al.); Rés. Betampona: -17.92400, 49.19967, 390m; -17.88667, 49.20250, 520m (B.L.Fisher et al.); F Kalalao [Ile St.Marie]: -16.92250, 49.88733, 100m (B.L.Fisher et al.); F Sahafina: -18.81445, 48.96205, 100m; Rés. Ambodiriana: -16.67233, 49.70117, 125m (B.L.Fisher et al.); Forêt d'Analava Mandrisky: -16.48567, 49.84700, 10m (B.L.Fisher et al.); S.F. Tampolo: -17.28250, 49.43000, 10m (B.L.Fisher et al.); *Toliara*: F Ivohibe: -24.56900, 47.20400, 200m (B.L.Fisher et al.); P.N. Andohahela: -24.75850, 46.85370, 275m (B.L.Fisher et al.); 10km NW Enakara, Rés. Andohahela: -24.56667, 46.81667, 430m; 11km NW Enakara, Rés. Andohahela: -24.56667, 46.83333, 800m (B.L.Fisher); 6km SSW Eminiminy, Rés. Andohahela: -24.75000, 46.78330, 500m (P.S.Ward); 9km SSW Eminiminy, Rés. Andohahela: -24.73330, 46.80000, 330m (P.S.Ward); 2.7km WNW 302° St.Luce: -24.77167, 47.17167, 20m (B.L.Fisher et al.); F Mandena: -24.95167, 47.00167, 20m (B.L.Fisher).

Worker measurements (n=21). Lectotype worker: HW 0.54; HL 0.51; EL 0.13; SL 0.43; WL 0.54; SPL 0.13; PTH n.a.; PTL 0.17; PTW 0.16; PPL 0.10; PPW 0.17; LHT 0.40; CI 1.05; OI 0.26; SI 0.85; SPI 0.23; PTHI n.a.; PTWI 0.95; PPI 1.67; LBI 1.36.

Other material. HW 0.48–0.60; HL 0.43–0.51; EL 0.10–0.14; SL 0.37–0.51; WL 0.44–0.63; SPL 0.08–0.14; PTH 0.09–0.14; PTL 0.14–0.22; PTW 0.12–0.22; PPL 0.09–0.14; PPW 0.13–0.21; LHT 0.33–0.52; CI 1.00–1.12; OI 0.22–0.27; SI 0.85–1.01; SPI 0.17–0.26; PTHI 0.55–0.72; PTWI 0.78–1.04; PPI 1.35–1.98; LBI 1.22–1.48.

Diagnosis. Workers of *C. madecassa* can be distinguished from all other species treated here except *C. telolafy* by the presence of two distinct vertical carinae on the clypeus (Figure 16). From workers of *C. telolafy*, *C. madecassa* workers are distinguishable by their longer, more spiniform propodeal spines (Figure 18A) and longer antennal scapes. Queens of *C. madecassa* can be easily identified from queens of most species (*C. rasoherinae*, *C. volamena*, *C. mpanjono*) by the presence of propodeal spines. *C. madecassa* queens can be distinguished from *C. razana* queens by the absence of a median clypeal notch (present in *C. razana* queens). Note however that queens of *C. telolafy* are currently unknown and could be very similar morphologically to *C. madecassa* queens.

Worker description (Figure 26A–C). Very small species (HW 0.48–0.60, WL 0.44–0.63), with characters of the *C. madecassa*-group, in addition to the following. Clypeus with two distinct median vertical carinae; antennal scapes well surpassing posterior margin of head.

Metanotal groove constricted to less than half as wide as pronotal width; propodeal spines medium-sized (SPI 0.17–0.26) and straight, usually thin and acute, in lateral view directed upwards, in dorsal view moderately diverging; subpostpetiolar process usually present, often as acute minute tooth.

Promesonotum usually with 6 erect, long flexuous setae: 2 humeral setae, and 2 setae each at anterior and posterior end of mesonotal carinae. Color pale to medium yellow.

Intermediate worker measurements (n=2). HW 0.82–0.85, HL 0.73–0.78, EL 0.18–0.19, SL 0.55–0.59, WL 0.89–1.01, SPL 0.20, PTH 0.18–0.19, PTL 0.31–0.33, PTW 0.27–0.28, PPL 0.19, PPW 0.28–0.31, LHT 0.60, CI 1.09–1.12, OI 0.24, SI 0.75, SPI 0.20–0.22, PTHI 0.59, PTWI 0.86, PPI 1.46–1.66, LBI 1.48–1.68.

Intermediate worker description (Figures 27E–G). Intermediate between workers and queens in size. Head, petiole and postpetiole characters similar to queens; ocelli present, but smaller than in queens; mesonotum is to various extent raised and fused dorsally over pronotum and has wing attachment sutures; otherwise mesosomal characters more similar to worker characters.

Queen measurements (n=11). HW 0.87–1.03, HL 0.72–0.86, EL 0.24–0.32, SL 0.54–0.62, MSNW 0.66–0.92, MSNL 0.72–0.98, WL 1.28–1.53, SPL 0.06–0.21, PTH 0.19–0.26, PTL 0.38–0.49, PTW 0.30–0.39, PPL 0.21–0.28, PPW 0.34–0.42, LHT 0.65–0.81, CI 1.11–1.21, OI 0.29–0.37, SI 0.68–0.76, MSNI 1.55–1.87, SPI 0.04–0.14, PTHI 0.45–0.61, PTWI 0.68–0.91, PPI 1.42–1.69, LBI 1.87–2.08.

Queen description (Figure 28A–C). Very small (HW 0.87–1.03, WL 1.28–1.53), with characters of the *C. madecassa*-group, in addition to the following.

Mesosoma more compact (MSNI 1.55–1.87, WL 1.28–1.53), mesoscutum in dorsal view almost as wide as long; propodeal spines present, much shorter than in workers (SPI 0.04–0.14).

Male unknown.

Distribution and biology. *Crematogaster madecassa* is fairly widespread throughout the rainforests and littoral forests of northern, eastern and southeastern Madagascar (Figure 27D) and is found up to medium elevations (highest record from 1175m). It occurs widely in sympatry with *C. rasoherinae*, and at a few localities also with *C. volamena*, *C. mpanjono* and *C. telolafy*. There is evidence that *C. madecassa* nests both on the ground and arboreally, as collections have been made from rotten logs, as well as from dead twigs above the ground. As in *C. rasoherinae* (see above), intermediate workers are found in *C. madecassa* (Figure 27E–F).

***Crematogaster telolafy* sp. n.**

urn:lsid:zoobank.org:act:CC5E14B0-2EE5-42D7-847D-C7530A977114

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

Figure 29

Type locality. MADAGASCAR: *Toliara*: P.N. Zombitse: -22.84333, 44.71000, 770m, tropical dry forest, sifted litter, 5–9.ii.2003, B.L.Fisher et al..

Type specimens. **holotype** worker: pinned, CASENT0032779, BLF07510(19), sifted litter; original locality label: MADG'R: Prov. Toliara, P.N. Zombitse, 19.8 km 84°E Sakaraha 770m, 5–9.ii.2003, 22°50.6'S, 44°42.6'E, Fisher et al. BLF7510; deposited at CASC.

4 paratype workers: #1: pinned, CASENT0473872, BLF04605(29), spiny forest/thicket, ex dead tree stump; original locality label: MADG'R: Prov. Toliara, Kirindy, 15.5 km 64 ENE Marofandilia, 28.xi.–3.xii.2001, 100m 20°03'S, 44°40'E, Fisher et al. BLF4605; deposited at SAMC. #2: pinned, CASENT0473867, BLF04605(7), same habitat and label data as #1; deposited at MHNG. #3: pinned, CASENT0419808, BLF4434(7), tropical dry forest, ex rotten log; original locality label: MADG'R: Prov. Mahajanga, P.N. Tsingy de Bemaraha, 10.6 km 123°ESE Antsalova, 150m 18°43'S, 44°43'E, 16–20.xi.2001, Fisher et al. BLF4434; deposited at MCZC. #4: pinned, CASENT0193950, BLF04434(7), same habitat and label data as #3; deposited at UDC.

Other material examined (CASC). MADAGASCAR: *Fianarantsoa*: P.N. Isalo: -22.31333, 45.29167, 500m; (B.L.Fisher et al.); F Analalava: -22.59167, 45.12833, 700m (B.L.Fisher et al.); *Mahajanga*: F Tsimembo-19.02139, 44.44067, 20m (B.L.Fisher et al.); P.N. Tsingy de Bemaraha: -19.14194, 44.82800, 50m; -19.13222, 44.81467, 100m; -18.70944, 44.71817, 150m (B.L.Fisher et al.); *Toliara*: R.S. Ambohijanahary: -18.26667, 45.40667, 1050m (B.L.Fisher et al.); Kirindy: -20.04500, 44.66222, 100m (B.L.Fisher et al.); P.N. Zombitse: -22.84333, 44.71000, 770m; -22.88650, 44.69217, 840m (B.L.Fisher et al.); P.N. Andohahela: -24.75850, 46.85370, 275m (B.L.Fisher et al.).

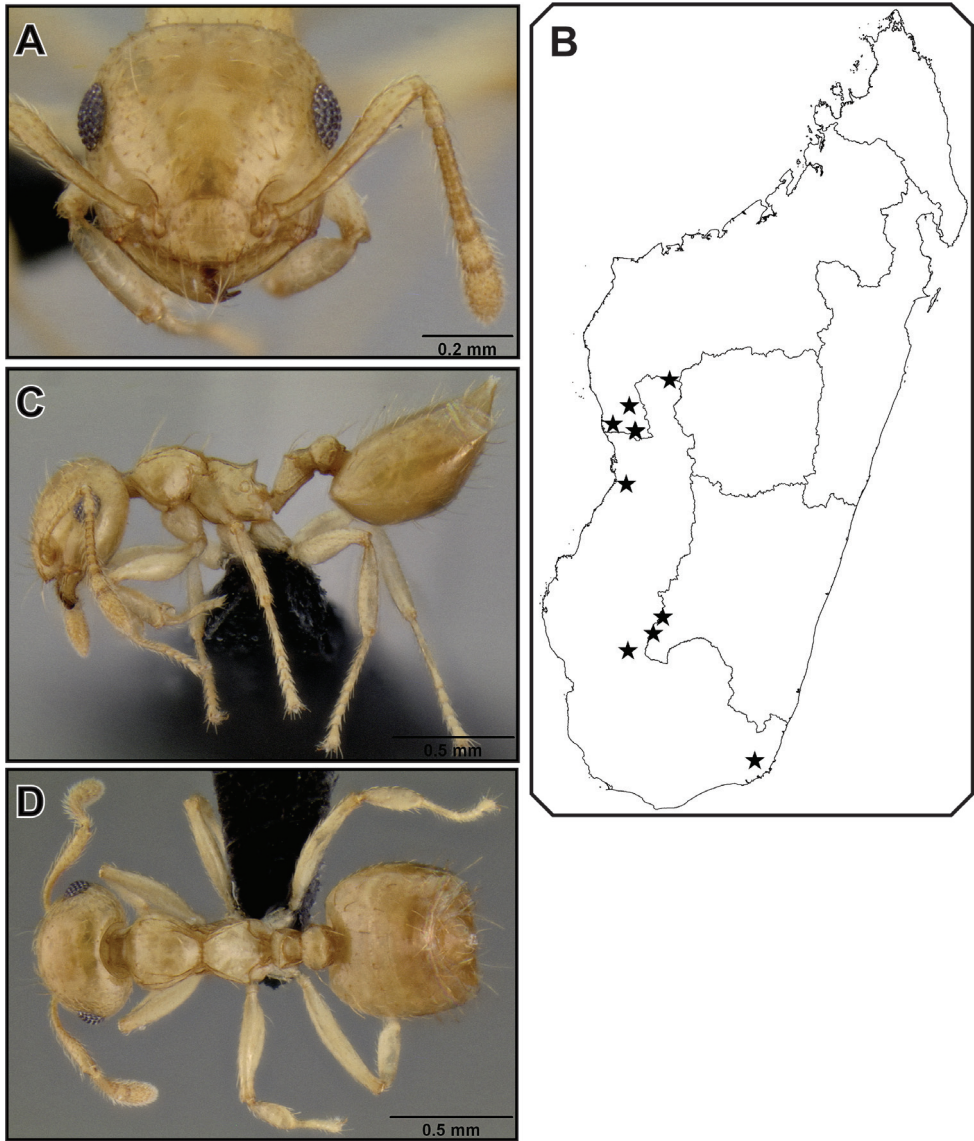


Figure 29. *Crematogaster telolafi*, worker and distribution. **A** full face **B** distribution **C** lateral **D** dorsal (CASENT0032779).

Worker measurements (n=16). Holotype: HW 0.58; HL 0.55; EL 0.15; SL 0.44; WL 0.58; SPL 0.07; PTH 0.13; PTL 0.20; PTW 0.17; PPL 0.13; PPW 0.18; LHT 0.45; CI 1.06; OI 0.27; SI 0.80; SPI 0.13; PTHI 0.64; PTWI 0.82; PPI 1.34; LBI 1.29.

Other material. HW 0.50–0.58; HL 0.47–0.56; EL 0.12–0.14; SL 0.39–0.46; WL 0.52–0.69; SPL 0.06–0.11; PTH 0.10–0.15; PTL 0.17–0.22; PTW 0.14–0.17; PPL 0.10–0.13; PPW 0.15–0.19; LHT 0.38–0.48; CI 1.02–1.09; OI 0.23–0.28; SI

0.78–0.87; SPI 0.10–0.19; PTHI 0.51–0.70; PTWI 0.67–0.89; PPI 1.22–1.60; LBI 1.24–1.67.

Diagnosis. Workers of *Crematogaster telolafy* can be differentiated from all other Malagasy *Orthocrema* species except *C. madecassa* by the presence of two distinct vertical carinae on the clypeus (Figure 16). From *C. madecassa*, which shares this feature, *C. telolafy* workers are distinguished by the form (triangular) and the shorter length of their propodeal spines (Figures 18B and C), and by the shorter antennal scape. Queens of *C. telolafy* are unknown, but are expected to be morphologically similar to *C. madecassa* queens.

Worker description (Figure 29A,C–D). Very small species (HW 0.50–0.58, WL 0.52–0.69), with characters of the *C. madecassa*-group, in addition to the following. Clypeus with two distinct median vertical carinae; antennal scapes reaching, or barely surpassing posterior margin of head.

Metanotal groove constricted to less than half as wide as pronotal width; propodeal spines short to medium-sized (SPI 0.10–0.19), usually in form of acute triangular points, sometimes more elongate and spiniform, distinctly directed upwards in lateral view, in dorsal view parallel or moderately diverging; subpostpetiolar process usually present, often as acute minute tooth.

Promesonotum usually with 6 erect, long flexuous setae: 2 humeral setae, and 2 setae each at anterior and posterior end of mesonotal carinae. Color pale to medium yellow.

Queen, male and intermediate (if existing) unknown.

Distribution and biology. No colony collections of *C. telolafy* have been made that could give clues on the biology of this species. It has been collected by methods of litter sifting, malaise, pitfall and pan traps, as well as beating low vegetation. *Crematogaster telolafy* is distributed mainly in the dry and spiny forests of southern and western Madagascar at low elevations (Figure 29B), with some notable exceptions of records from remnant patches of western rainforest, e.g. Rés. Ambohijanahary, or gallery forest such as exists in the Isalo region. This species is allopatric with the closely related *C. madecassa* (see above), except for a narrow sympatry or parapatry in the Andohahela region, where one collection of *C. telolafy* has been made in low elevation rainforest. Otherwise *C. telolafy* occurs in sympatry only with *C. rasoherinae* among the species treated here.

Etymology. This species is named for the triangular form of its propodeal spines, as “telolafy” is the Malagasy word for triangle. This name should be treated as a noun in apposition.

***Crematogaster razana* sp. n.**

urn:lsid:zoobank.org:act:F8F5FEA8-5783-46B8-A9A8-8DFF42EBB778

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

Figure 30

Type locality. MADAGASCAR: *Toliara*: R.S. Kalambatritra: -23.4185, 46.4583, 1365m, grassland, under stone; 8.ii.2009; B.L.Fisher et al..

Type specimen. holotype worker: pinned, CASENT0149655, BLF21485; original locality label: MADG'R: *Toliara*: R.S. Kalambatritra: 23.4185°S, 46.4583°E, 1365m; grassland, 8.ii.2009; B.L.Fisher et al. BLF#; deposited at CASC.

Other material examined (CASC). MADAGASCAR: *Toliara*: R.S. Kalambatritra: -23.45373, 46.45773, 1345m; -23.4185, 46.4583, 1365m (B.L.Fisher et al.); P.N. Andohahela: -24.9300, 46.6455, 300m (B.L.Fisher et al.).

Worker measurements (n=3). Holotype: HW 0.54; HL 0.50; EL 0.13; SL 0.37; WL 0.53; SPL 0.07; PTH 0.12; PTL 0.18; PTW 0.15; PPL 0.12; PPW 0.16; LHT 0.38; CI 1.08; OI 0.26; SI 0.74; SPI 0.14; PTHI 0.68; PTWI 0.86; PPI 1.31; LBI 1.40.

Other material. HW 0.49–0.56; HL 0.45–0.52; EL 0.12–0.14; SL 0.35–0.40; WL 0.45–0.54; SPL 0.05–0.07; PTH 0.10–0.12; PTL 0.15–0.19; PTW 0.14–0.16; PPL 0.08–0.11; PPW 0.14–0.17; LHT 0.34–0.40; CI 1.07; OI 0.26–0.27; SI 0.76–0.77; SPI 0.11–0.13; PTHI 0.64–0.67; PTWI 0.86–0.92; PPI 1.46–1.70; LBI 1.32–1.37.

Diagnosis. A combination of protruding eyes and raised sharp lateral carinae on the propodeum (Figure 13) separates workers of *C. razana* from workers of *C. rasoherinae* and the *C. volamena*-group. From other species within the *C. madecassa*-group it can be identified by the lack of median vertical carinae on the clypeus (Figure 17) and the absence of long setae on the posterior end of the lateral mesonotal carinae. *Crematogaster razana* queens are diagnosed by a combination of the presence of very short propodeal spines, large protruding eyes (OI 0.31), and the presence of a median clypeal notch (Figure 20).

Worker description (Figures 30A–C). Very small species (HW 0.49–0.56, WL 0.45–0.54), with characters of the *C. madecassa*-group, in addition to the following. Clypeus lacking median vertical carinae; antennal scapes just reaching posterior margin of head.

Metanotal groove constricted to about half the width of pronotum; propodeal spines short (SPI 0.11–0.14), in form of acute triangular points, distinctly directed upwards in lateral view, in dorsal view moderately diverging; subpostpetiolar process absent.

Face with no more than 4 erect, long flexuous setae; promesonotum with 4 erect, long flexuous setae; 2 humeral setae, and 2 setae at anterior end of mesonotal carinae (posterior setae absent). Color yellow to yellowish-brown.

Queen measurements (n=1). HW 1.10, HL 0.91, EL 0.28, SL 0.65, MSNW 0.94, MSNL 0.98, WL 1.74, SPL 0.04, PTH 0.30, PTL 0.45, PTW 0.41, PPL 0.28, PPW 0.46, LHT 0.83, CI 1.21, OI 0.31, SI 0.71, MSNI 1.77, SPI 0.02, PTHI 0.66, PTWI 0.92, PPI 1.65, LBI 2.09.

Queen description (Figures 30E–G). Very small (HW 1.10, WL 1.74), with characters of the *C. madecassa*-group, in addition to the following. Clypeus with a median notch; antennal scapes just reaching posterior margin of head.

Mesosoma more compact (MSNI 1.77, WL 1.74); mesoscutum in dorsal view about as wide as long; propodeal spines reduced to minute dents (SPI 0.02).

Petiole with one pair of long flexuous setae posterior to denticles.

Male and intermediate (if existing) unknown.

Distribution and biology. *Crematogaster razana* has only been collected at two localities in southern Madagascar (Figure 30B). One of these sites is a dry forest (west-

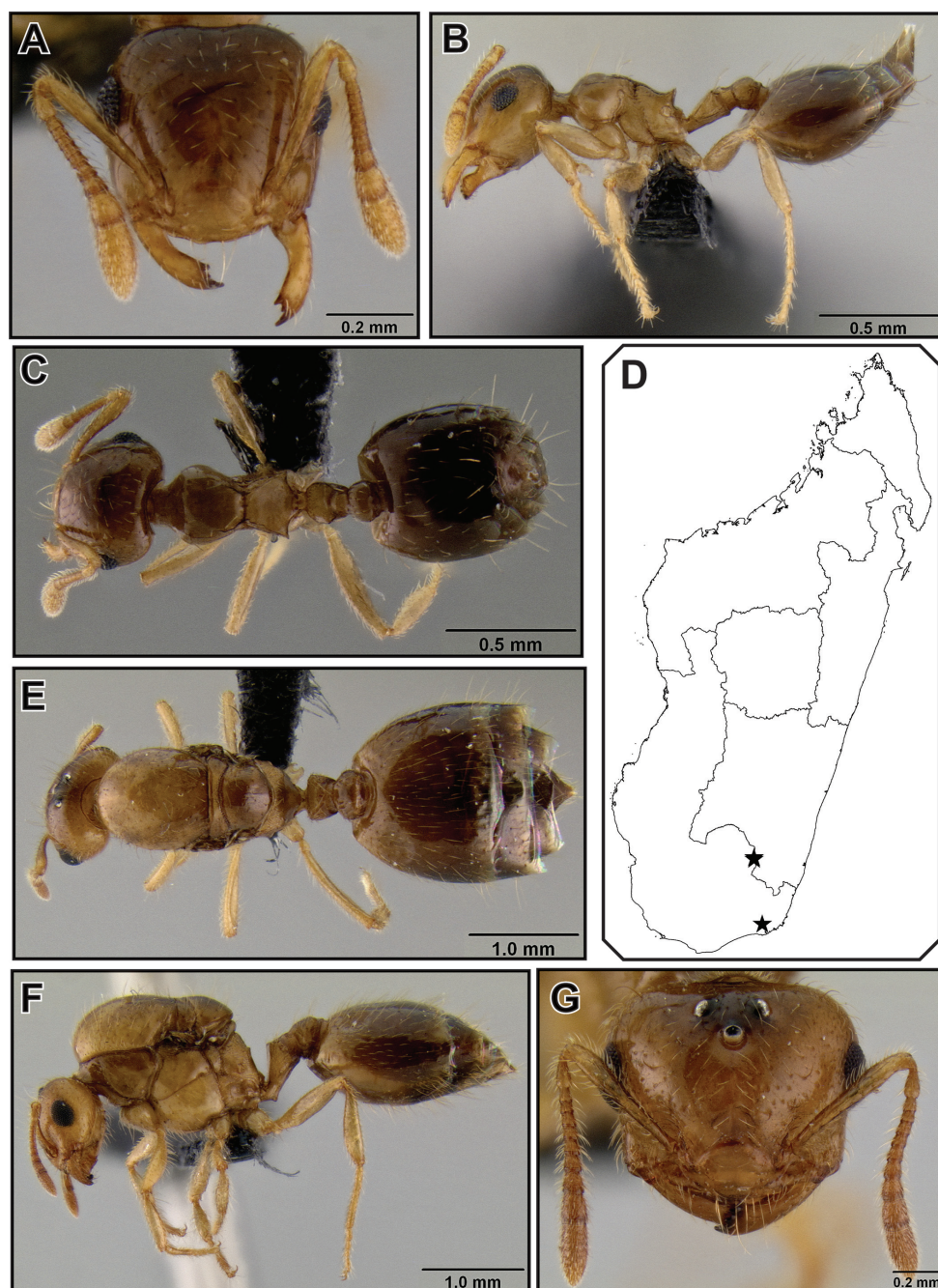


Figure 30. *Crematogaster razana*, worker, queen and distribution. **A–C** worker (CASENT0149655) **A** full face **B** lateral **C** dorsal **D** distribution **E–G** queen (CASENT0148782) **E** dorsal **F** lateral **G** full face.

ern slopes of P.N. Andohahela), whereas the other collections were made in a montane grassland habitat (R.S. Kalambatritra). Since the few collections of this rare species have been made mostly on the ground (under stone, pitfall trap or on low vegetation), I assume that *C. razana* is ground-nesting. This species is sympatric with *C. rasoherinae* and parapatric or narrowly sympatric with both *C. madecassa* and *C. telolafy* in the Andohahela massif.

Etymology. The Malagasy word “razana” means ancestor and alludes to the isolated distribution of this species and its phylogenetic position within the *C. madecassa*-group. This name should be treated as a noun in apposition.

***Crematogaster volamena*-group**

Worker diagnosis of the *Crematogaster volamena*-group: *C. volamena*, *C. mpanjono*.

Very small to medium sized species (HW 0.51–0.98, WL 0.56–0.92). Masticatory margin of mandibles with 4 teeth; clypeus with or without several irregular vertical carinae; posterior margin of head in full face view laterally subangular, often medially slightly depressed; occipital carinae indistinct; antennal scapes just barely (small workers) or not reaching (larger workers) posterior margin of head; midline of eyes situated well above midline of head in full face view; eyes small (0.18–0.22) and fairly flush with head.

Pronotum laterally subangular; in lateral view, anterior part of mesonotum often angular or denticulate, posteriorly at least weakly carinate until meeting metanotal groove; in lateral view outline of promesonotum fairly flat; dorsal face of mesonotum flat, posterior face distinct or indistinct; metanotal groove very constricted by bordering lateral carinae, a third as wide as pronotal width; propodeal spines short (SPI 0.06–0.12), upwards directed sharp points; length of dorsal face of propodeum about a third of posterior face; petiole in dorsal view ovo-rectangular, dorsolateral margins angulate, ending in small posterolateral denticles; subpetiolar process variable, from well pronounced acute tooth to reduced angular dent; postpetiole short and broad, appearing bilobed, with diffuse, broad median impression; subpostpetiolar process absent.

Sculpture overall reduced; head shiny to aciculate; mesosoma dorsally mostly shiny, meso- and metapleuron mostly shiny, rugulose in some parts; dorsal and posterior face of propodeum shiny with some carinulae; dorsal face of petiole shiny to carinate; helcium dorsally reticulate; postpetiole dorsally shiny; lateral and ventral face of petiole and postpetiole feebly reticulate; face with very abundant silken erect to suberect pilosity of variable length, usually hereof 6–12 longer setae; promesonotum with at least 6 erect, long flexuous setae: 2 humeral setae, 2 setae at anterior end of mesonotum and 2 setae on mesonotal tubercles or denticles; additional long erect setae, and scattered shorter erect setae may be present dorsally on promesonotum; longer, erect pilosity present or absent from propodeum; petiole with a single flexuous setae on each posterolateral tubercle; postpetiole with a pair of long flexuous dorsoposterior setae, and several shorter setae dorsally and laterally; abdominal tergites and sternites 4–7 with dense erect pilosity (> 50 setae) of

medium length, interspersed with a subdecumbent shorter pubescence. Color, pale or golden yellow, or medium brown.

Queen diagnosis of the *Crematogaster volamena*-group: *C. volamena*, *C. mpanjono*.

Large (HW 1.48–1.72, WL 2.61–2.70). With worker characters, except as follows. Masticatory margin of mandibles with 5 teeth. Antennal scapes not surpassing posterior margin of head, reaching to about level of median or lateral ocelli; occipital carinae well pronounced or indistinct; eyes medium-sized to large (OI 0.23–0.27), situated at midline of head in full face view; head wider than long or slightly longer than wide, posterior margin of head straight.

Mesosoma compact to slender (MSNI 1.64–1.77, WL 2.61–2.70); propodeal spines absent; petiole oval or subquadrate and lacking denticles; postpetiole broad, but lacking median impression; broad subpetiolar process present, but lacking distinct tooth.

Head sculpture aciculate or carinulate-aciculate; sculpture on mesosoma and metasoma aciculate, except dorsal face of propodeum transversely carinulate and metapleuron carinulate. Erect pilosity somewhat less abundant than in workers, but denser on mesoscutum and scutellum; petiolar and postpetiolar pilosity as in workers. Color brown with yellow markings on meso-, metasoma and legs, or reddish brown.

***Crematogaster volamena* sp. n.**

urn:lsid:zoobank.org:act:916726B2-C7EB-49E0-BB6A-012F0C775E13

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

Figures 31–32

Type locality. MADAGASCAR: *Toliara*: Forêt Ivohibe: -24.56900, 47.20400, 200m, rainforest, malaise trap, 2.-4.xii.2006, B.L.Fisher et al.

Type specimens. holotype worker: pinned, CASENT0125748, BLF15448, malaise trap; original locality label: MADG'R: Toliara, Forêt Ivohibe, 200m, 24°34.14S, 47°12.24E, 2–4.xii.06, rainforest, Fisher et al. BLF15448; deposited at CASC.

4 paratype workers: #1: pinned, CASENT0128455, BLF15450, sifted litter (leaf mold, rotten wood); same locality data as holotype; deposited at SAMC. #2: pinned, CASENT0488904, BLF08006(23), beating low vegetation, rainforest; original locality label: MADG'R: Prov. Toamasina, Mont. Anjanaharibe, 18.0 km, 21° NNE Ambinanitelo 470m 15°11.3'S, 49°36.9'E, 8–12.iii.2003 Fisher et al. BLF8006; deposited at MHNG. #3: pinned, CASENT0071334, BLF12557, malaise trap; original locality label: MADG'R: Prov. Toamasina, P.N. Mananara-Nord, 16°27.3'S, 49°47.25'E, 225m, 14.xi.2005, malaise, rainforest, Fisher et al. BLF12557; deposited at MCZC. #4: pinned, CASENT0488765, BLF8251(4), beating low vegetation; original locality label: MADG'R: Prov. Toamasina, Mont. Akirindro 7.6 km 341° NNW Ambinanitelo 15°17.3'S, 49°32.9'E 600m, 17–21.iii.2003, Fisher et al. BLF8251; deposited at UCDC.

Other material examined (CASC, MCZC). MADAGASCAR: *Antsiranana*: P.N. Montagne d'Ambre: -12.52830, 49.17250, 1046m (D.Lees et al.); 6.9 km NE Ambanizana: -15.56667, 50.00000, 825m (B.L.Fisher et al.); 6.3 km S Ambaniza-

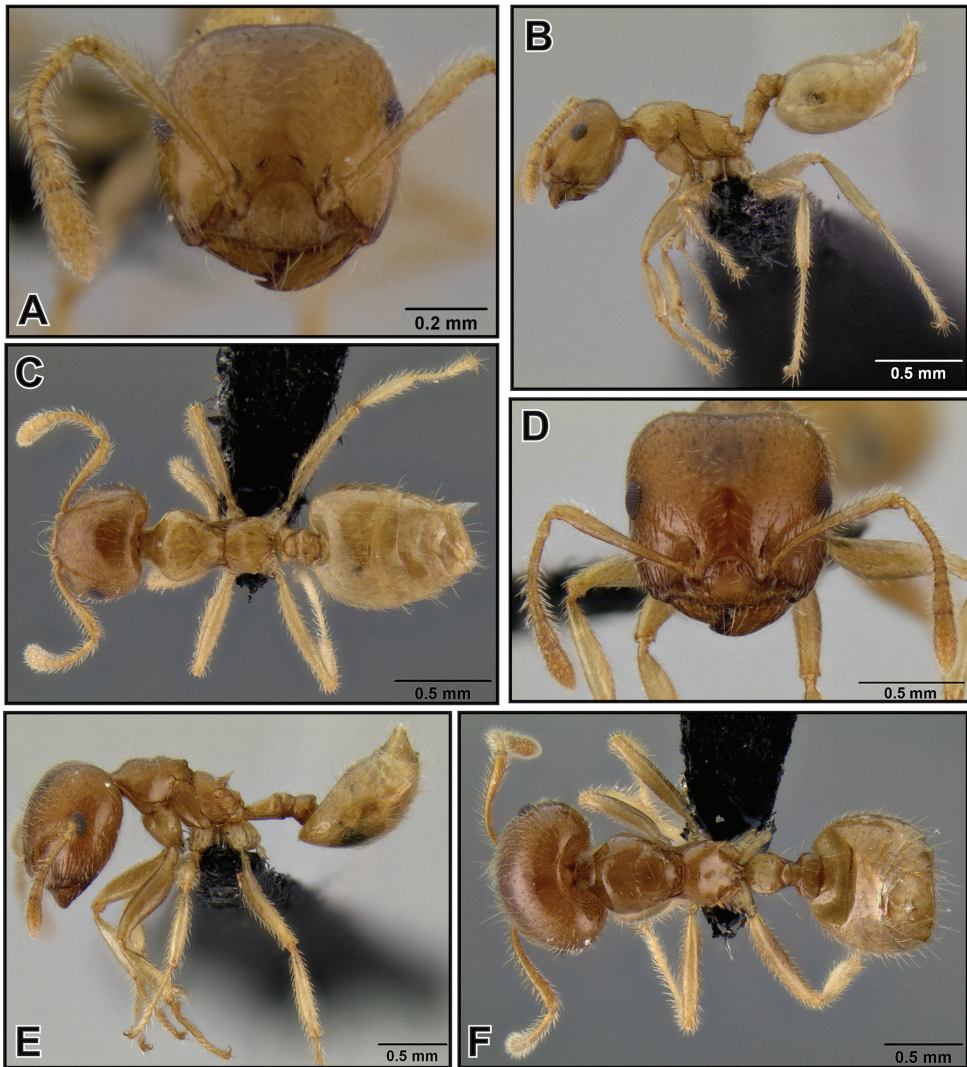


Figure 31. *Crematogaster volamena*, workers. **A–C** smaller worker (CASENT0125748) **A** full face **B** lateral **C** dorsal **D–F** larger worker (CASENT0122851) **D** full face **E** lateral **F** dorsal.

na: -15.68131, 49.9580, 25m (B.L.Fisher et al.); 5.3 km SSE Ambanizana, 425m, -15.66667, 49.96667 (B.L.Fisher et al.); Montagne d'Anjanaharibe: -15.18833, 49.61500, 470m (B.L.Fisher et al.); P.N. Marojejy: -14.43333, 49.78333, 450m; -14.43817, 49.77400, 488m; -14.43500, 49.76000, 775m (B.L.Fisher et al.); R.N.I. Marojejy: -14.43583, 49.76056, 610m (G. Alpert); *Fianarantsoa*: F Ampitavananima: -23.12972, 47.71700, ca. 35m (B.L.Fisher et al.); *Toamasina*: R.S. Ambatovaky: -16.77468, 49.26551, 355m; -16.81745, 49.29250, 400m; -16.77550, 49.26427, 430m; -16.77274, 49.26551, 450m; -16.76912, 49.26704, 475m; -16.76330, 49.26692, 520m (B.L.Fisher et al.); P.N. Mananara-Nord: -16.45500, 49.78750,

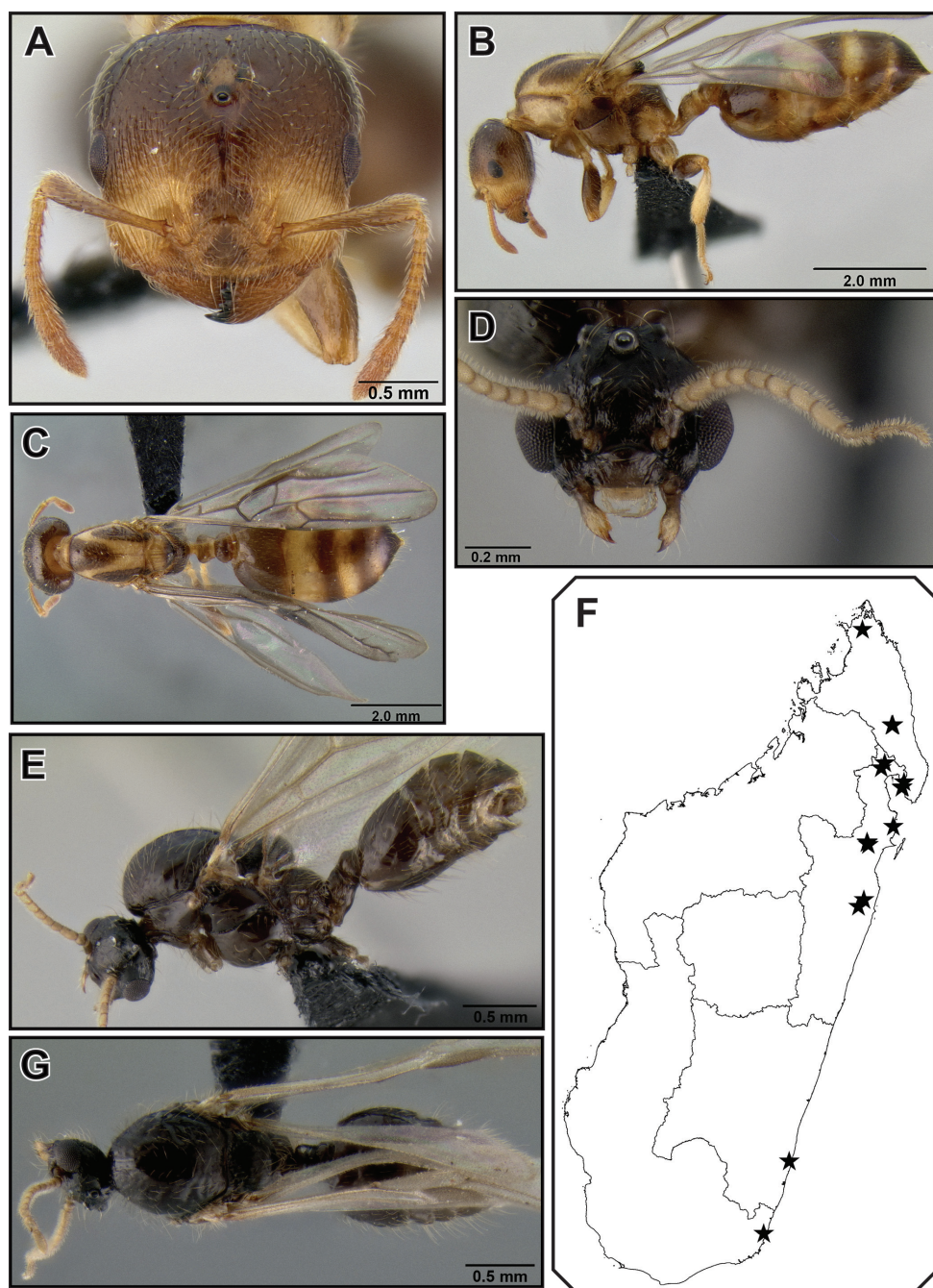


Figure 32. *Crematogaster volamena*, queen, male and distribution. **A–C** queen (CASENT0161415) **A** full face **B** lateral **C** dorsal **D–E, G** male (CASENT0162852) **D** full face **E** lateral **G** dorsal **F** distribution.

225m (B.L.Fisher et al.); F.C. Sandranantitra: -18.04833, 49.09167, 450m (B.L.Fisher et al.); Rés. Betampona: -17.91801, 49.20074, 500m (B.L.Fisher et al.); *Toliara*: F Ivohibe: -24.56900, 47.20400, 200m (B.L.Fisher et al.).

Worker measurements (n=20). **Holotype:** HW 0.62; HL 0.59; EL 0.11; SL 0.50; WL 0.66; SPL 0.06; PTH 0.13; PTL 0.20; PTW 0.20; PPL 0.10; PPW 0.21; LHT 0.49; CI 1.04; OI 0.19; SI 0.85; SPI 0.09; PTHI 0.65; PTWI 0.99; PPI 2.07; LBI 1.35.

Other material. HW 0.66–0.98; HL 0.62–0.95; EL 0.12–0.18; SL 0.50–0.66; WL 0.68–0.92; SPL 0.05–0.09; PTH 0.13–0.19; PTL 0.21–0.30; PTW 0.21–0.30; PPL 0.11; PPW 0.20–0.32; LHT 0.42–0.72; CI 1.03–1.13; OI 0.18–0.22; SI 0.73–0.84; SPI 0.06–0.12; PTHI 0.50–0.72; PTWI 0.82–1.08; PPI 1.43–2.13; LBI 1.25–1.71.

Diagnosis. Workers of *C. volamena* are diagnosed most easily by their indistinct occipital carinae (Figure 14), the non-protruding and small eyes and the absence of raised, sharp lateral carinae on the propodeum (Figure 15). All these characteristics are shared with the much rarer, but closely resembling *C. mpanjono*, from which it cannot be distinguished reliably based on the worker caste. *Crematogaster volamena* has slightly longer propodeal spines than *C. mpanjono*, and the propodeum is lacking longer erect pilosity. The two species are not known to co-occur, and therefore their distributions (compare Figures 32F and 33D) can help in distinguishing between them. Queens of *C. volamena* are readily separated from *C. mpanjono* queens by virtue of their well pronounced occipital carinae (Figure 22) and a scuto-scutellar suture that is broadly meeting the mesoscutum (Figure 21, compare with Figure 23). From the remaining Malagasy *Orthocrema* queens, *C. volamena* queens are differentiated by the absence of propodeal spines and their large size (HW 1.72, WL 2.61).

Worker description (Figures 31A–F). Very small to medium sized species (HW 0.62–0.98, WL 0.66–0.92), with characters of the *C. volamena*-group, in addition to the following. Clypeus with several (up to 6), irregular vertical carinae.

Mesonotum transversely concave between lateral carinae.

Head sculpture aciculate; longer, erect pilosity absent from propodeum. Color golden yellow or (more rarely) medium brown.

Queen measurements (n=1). HW 1.72, HL 1.60, EL 0.37, SL 0.90, MSNW 1.28, MSNL 1.59, WL 2.61, SPL 0.00, PTH 0.39, PTL 0.67, PTW 0.61, PPL 0.43, PPW 0.65, LHT 1.21, CI 1.08, OI 0.23, SI 0.56, MSNI 1.64, SPI 0.15, PTHI 0.59, PTWI 0.91, PPI 1.50, LBI 2.16.

Queen description (Figures 32A–C). Large (HW 1.72, WL 2.61), with characters of the *C. volamena*-group, in addition to the following. Antennal scapes reaching to about level of median ocelli; occipital carinae well pronounced; eyes medium-sized (OI 0.23); head wider than long (CI 1.08).

Mesosoma compact (MSNI 1.64, WL 2.61); mesoscutum in dorsal view oval; scuto-scutellar suture broadly meeting mesoscutum; dorsal face of propodeum short but distinct, posterior face sloping abruptly; petiole in dorsal view oval; wings smoky.

Head sculpture carinulate-aciculate. Color brown with yellow markings on meso-, metasoma and legs.

Male measurements (n=1). HW 0.68, HL 0.52, EL 0.26, SL 0.11, MSNW 0.73, MSNL 0.75, WL 1.44, SPL 0.00, PTH 0.19, PTL 0.31, PTW 0.22, PPL 0.15, PPW 0.26, LHT n.a., CI 1.30, OI 0.50, SI 0.21, MSNI 1.93, SPI 0.62, PTHI 0.62, PTWI 0.71, PPI 1.71, LBI n.a.

Male description (Figures 32 D,E–G). Small (HW 0.68, WL 1.44). Masticatory margin of mandibles with 2 teeth; eyes large (OI 0.50) and protruding, situated slightly below midline of head, and not approaching clypeal margin; antennae 11–12-segmented (separation between 3rd and 4th funicular segment is incomplete in the examined specimen), scapes very short (SI 0.21), 2nd funicular segment globular, last 2 or 3 funicular segments compressed (this may be post mortem); head strongly wider than long (CI 1.30), mostly due to lateral extent of eyes; ocellar triangle extending to posterior head margin in full face view like a crown; occipital carinae distinct.

Mesosoma compact (MSNI 1.93, WL 1.44); mesoscutum in dorsal view as wide as long; scutellum with only one long and flat dorsal face, in dorsal view oval-shaped and posteriorly rounded, dorsoposterior margin not carinate; dorsal face of propodeum about as long as posterior face; propodeal spines absent; petiole in dorsal view oval, carinae or denticles absent and all margins rounded, in lateral view petiole anteriorly tapering; anteroventral subpetiolar tooth absent; postpetiole fairly globular, median impression absent; wings clear.

Head sculpture rugulose, mesoscutum aciculate, scutellum longitudinally carinate, petiole and postpetiole rugulose-shiny; face with fairly abundant longer erect pilosity; mesoscutum with dense long erect pilosity; posterior part of scutellum with sparse long pilosity; petiole and postpetiole without distinct dorsoposterior setae, but abundant erect pilosity laterally. Color dark brown.

Distribution and biology. *Crematogaster volamena* is currently known from about 10 localities along the eastern rainforest belt in Madagascar (Figure 32F). Here the species occurs in low- to mid-elevation rainforest or littoral forest. *Crematogaster volamena* appears to be a generalist in terms of nesting preferences, as it has been collected both nesting arboreally in dead twigs and on the ground in rotten logs. Scant natural history information exists, but noteworthy is a size variation in workers of this species that is reminiscent of a major-minor distinction in other ant genera. The larger workers (Figures 31D–F) have a distinctly enlarged head and more powerful mandibles compared to regular workers (Figures 31A–C), and they are more rarely seen throughout collections. These individuals do not share the attributes of the intermediates described here for *C. rasoherinae* and *C. madecassa*, such as presence of ocelli, or a queen-like modified mesosoma.

Etymology. This species is named for the golden yellow coloration that most of its workers possess, as “volamena” means “gold” in Malagasy. This name should be treated as a noun in apposition.

***Crematogaster mpanjono* sp. n.**

urn:lsid:zoobank.org:act:7A4E5257-126C-460D-B9A4-7C52CB2D62F1

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

Figure 33

Type locality. MADAGASCAR: *Antsiranana*: R.S. Manongarivo: -13.96167, 48.43333, 400m, rainforest, beating low vegetation, 18.xi.1998, B.L.Fisher.

Type specimen. holotype worker: pinned, CASENT0193889, BLF01998(12)-1; original locality label: MADG'R: Prov. Antsiranana: R.S. Manongarivo 10.8km 229°SW Antanambao 400m 13°57.7'S 48°26.0'E, 18.xi.1998, B.L.Fisher#1998(12)-1; deposited at CASC.

Other material examined (CASC). MADAGASCAR: *Antsiranana*: R.S. Manongarivo: -13.96167, 48.43333, 400m (B.L.Fisher); Nosy Bé, R.N.I. Lokobé: -13.41944, 48.33117, 30m (B.L.Fisher et al.); Nosy Bé, Antsirambazaha: -13.41345, 48.31130, 143m (Lees & Ranaivosolo); *Toamasina*: F Ambohidena [Ile St.Marie]: -16.82433, 49.96417, 20m (B.L.Fisher et al.).

Worker measurements (n=4). Holotype: HW 0.61; HL 0.56; EL 0.11; SL 0.48; WL 0.65; SPL 0.06; PTH 0.15; PTL 0.22; PTW 0.19; PPL 0.13; PPW 0.21; LHT 0.46; CI 1.09; OI 0.20; SI 0.85; SPI 0.09; PTHI 0.69; PTWI 0.88; PPI 1.62; LBI 1.40.

Other material. HW 0.51–0.78; HL 0.51–0.78; EL 0.10–0.15; SL 0.43–0.54; WL 0.56–0.86; SPL 0.04–0.05; PTH 0.11–0.16; PTL 0.17–0.27; PTW 0.16–0.23; PPL 0.09–0.15; PPW 0.19–0.22; LHT 0.39–0.56; CI 1.02–1.04; OI 0.19–0.20; SI 0.72–0.85; SPI 0.06–0.07; PTHI 0.60–0.63; PTWI 0.87–1.03; PPI 1.46–2.03; LBI 1.42–1.52.

Diagnosis. Workers of *C. mpanjono* are diagnosed from all Malagasy *Orthocrema*, except the closely related *C. volamena*, by a combination of the following: indistinct occipital carinae (Figure 14), non-protruding and small eyes and the absence of raised, sharp lateral carinae on the propodeum (Figure 15). All these characteristics are shared with the much more common *C. volamena*, from which it cannot be distinguished reliably based on the worker caste. *Crematogaster mpanjono* has slightly shorter propodeal spines than *C. volamena*, and often a long erect pilosity is present on the propodeum. The distributions of these two species (compare Figures 32F and 33D) aid in distinguishing between them, as they are not known to co-occur. Queens of *C. mpanjono* are easily separated from *C. volamena* queens by virtue of the scuto-scutellar suture that is acutely meeting the mesoscutum (Figure 23, compare with Figure 21) and the indistinct occipital carinae. From the remaining Malagasy *Orthocrema* queens, *C. mpanjono* queens are diagnosable by the absence of propodeal spines and by their larger size (HW 1.48, WL 2.70).

Worker description (Figures 33A–C). Very small to small species (HW 0.51–0.78, WL 0.56–0.86), with characters of the *C. volamena*-group, in addition to the following. Clypeus with or without several short vertical carinae.

Mesonotum usually denticulate, then weakly carinate until meeting metanotal groove; posterior face of mesonotum indistinct, gradually sloping into metanotal groove.

Head sculpture shiny to aciculate; propodeum often with longer erect pilosity. Color yellow to pale yellow.

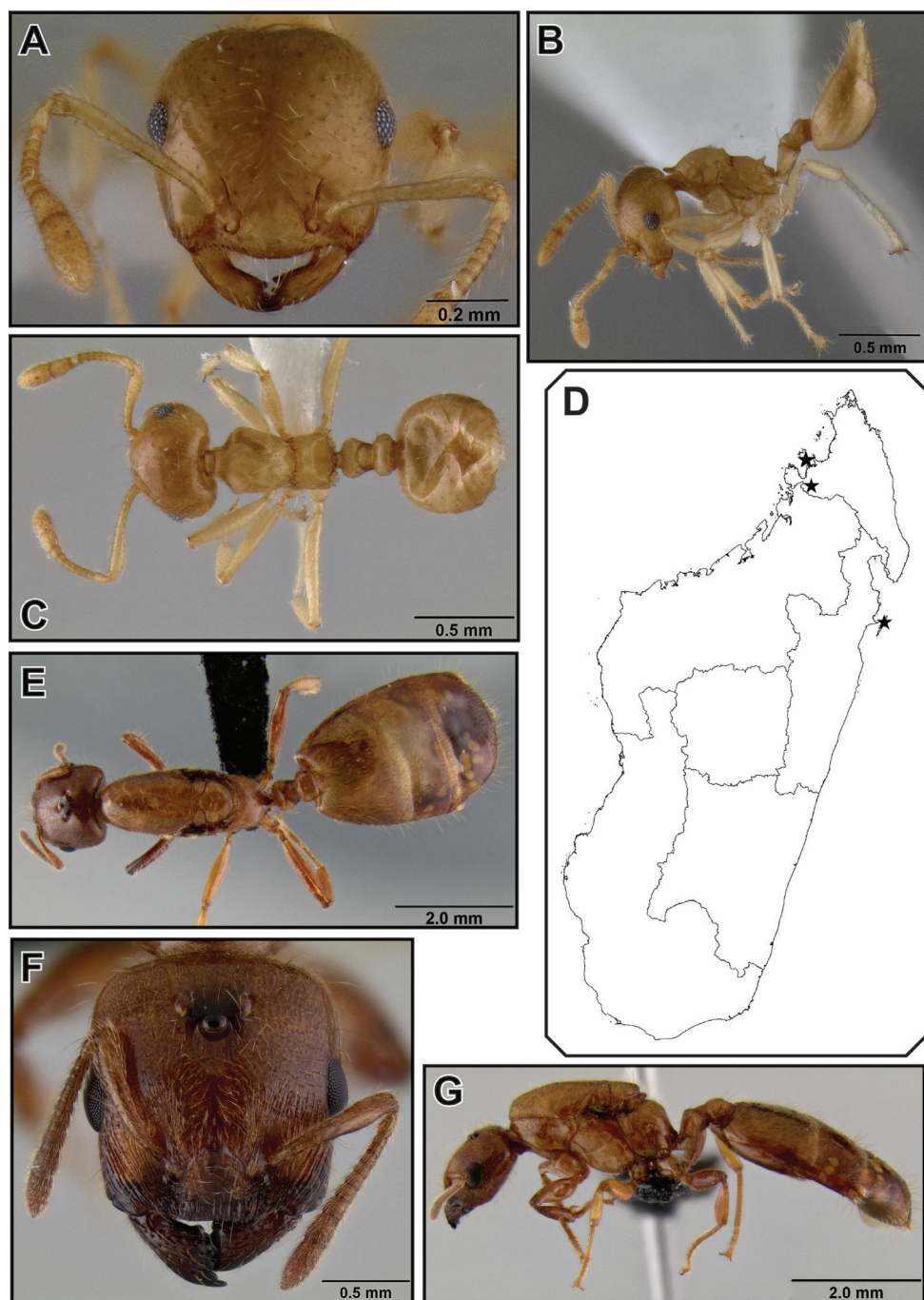


Figure 33. *Crematogaster mpanjono*, worker and queen. **A–C** worker (CASENT0193889) **A** full face **B** lateral **C** dorsal **D** distribution **E–G** queen (CASENT0067033) **E** dorsal **F** full face **G** lateral.

Queen measurements (n=1). HW 1.48, HL 1.52, EL 0.42, SL 0.81, MSNW 1.04, MSNL 1.53, WL 2.70, SPL 0.00, PTH 0.39, PTL 0.51, PTW 0.51, PPL 0.39, PPW 0.53, LHT 1.07, CI 0.96, OI 0.27, SI 0.53, MSNI 1.77, SPI 0.00, PTHI 0.78, PTWI 1.01, PPI 1.35, LBI 2.52.

Queen description (Figures 33E–G). Medium-sized (HW 1.48, WL 2.70), with characters of the *C. volamena*-group, in addition to the following. Antennal scapes reaching to about level of lateral ocelli; occipital carinae indistinct; eyes larger (OI 0.27); head slightly longer than wider (CI 0.96).

Mesosoma slender (MSNI 1.77, WL 2.70); mesoscutum in dorsal view elongate; scuto-scutellar suture acutely meeting mesoscutum; dorsal face of propodeum about as long as posterior face, the latter sloping abruptly; petiole subquadrate.

Head sculpture mostly aciculate, carinulate below eyes. Color reddish brown.

Male unknown.

Distribution and biology. Only one nest collection of this species (a queen and a nanitic worker) from an arboreal root pocket exists. Therefore next to nothing is known about the biology of *C. mpanjono*. The known distribution records of this rare ant show a macrohabitat preference for lowland rainforests of the north-western Sambirano region (Nosy Bé, R.S. Manongarivo) or eastern littoral rainforest (F Ambohidena) (Figure 33D). These disjunct records from north-western Madagascar and the east coast island Ile St.Marie are peculiar and could point to incomplete distribution records for this species. In any case, although the Ambohidena population has not been sampled for nuclear genetic data, the conspecificity of these disjunct populations is supported by the COI barcoding data. *Crematogaster mpanjono* occurs in sympatry with the widespread *C. rasoherinae* and *C. madecassa*.

Etymology. The Malagasy word “mpanjono” means “fisher” or “fisherman”. The name for this rare ant species is dedicated to B. L. Fisher and his ant diversity and conservation efforts in Madagascar. This name should be treated as a noun in apposition.

Discussion

The species diversity of Malagasy *Crematogaster* (*Orthocrema*) has been tripled in the context of this revisionary work, adding four new species to two already described and here well supported species. Another result that was strongly supported by the molecular part of this study is the presence of three phylogenetically distinct lineages of Malagasy *Orthocrema* (Figure 1). The relationships between the *C. madecassa*- and *C. volamena*-group remain weakly supported, similarly to results of a larger analysis (Blaimer, in prep.). The molecular data, as well as distinctive morphological differences indicate that these two species-groups do not constitute a monophyletic group. One can therefore assume they reached Madagascar through independent colonization events.

In analogy to previous taxonomic studies on the genus in Madagascar (Blaimer 2010; in prep.), a widespread species, *Crematogaster rasoherinae*, has been found to have synonymic names. Widespread species in *Crematogaster* are prone to this “over-

naming” as they can show strong gradual geographic variation. Discrete polymorphisms, as in the case of the entirely unarmed form of *C. rasoherinae* on the Comoros Islands, are presumably much rarer, but another case of strong polymorphism has just been described for queens of *Crematogaster ranaivalonae* Forel in Madagascar (Blaimer 2012). In either species the causes and selective forces maintaining these different morphotypes remain to be investigated.

Similar to previous work on Malagasy *Crematogaster* (Blaimer 2010), the new species described here have very restricted distributions and suggest adaptation to narrow environmental niches. Madagascar is well known for its highly endemic species assemblages (Goodman and Benstead 2005), but, similar to other biodiversity hotspots in the world, habitat destruction is posing a constant threat especially to these locally endemic taxa. For instance, one of the three localities at which the newly described *C. mpanjono* occurs is a currently unprotected parcel of littoral forest, Ambohidena on Ile de St. Marie (see Goodman 1993). Littoral forests represent one of the most threatened vegetation types in Madagascar (Consiglio et al. 2006) and forests in Madagascar that are not under protection are inexorably shrinking further (Brooks et al. 2002; Allnutt et al. 2008). Although one new endemic ant species will not be sufficient to motivate protection of forests such as Ambohidena, adding and tallying these numbers across a breadth of taxa, as was achieved recently by Kremen et al. (2008), will aid tremendously in ongoing efforts to define priorities for the expansion of the protected area network in Madagascar. In particular arthropod taxonomists are lagging behind in describing Madagascar’s incredibly diverse fauna. The present study offers a small contribution to fill this gap.

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A revision of the genus *Kasabister* Mazur (Histeridae, Histerinae, Exosternini)

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Abstract

We revise the four species of *Kasabister* Mazur, 1972, one of which, *Kasabister barrigai* **sp. n.**, is described as new. The other species in the genus are *K. rubellus* (Erichson, 1834), *K. ferrugineus* (Kirsch, 1873) and *K. carinatus* (Lewis, 1888). The species are principally known from the subtropics of South America, with one in Central America. Lectotypes are designated for *K. rubellus* and *K. ferrugineus*, and a key is provided for all the species. Ants of the genus *Solenopsis* Westwood, mainly *S. invicta* Buren and *S. saevissima* (Smith), are documented as hosts of three of the four species.

Keywords

Histeridae, Exosternini, *Kasabister*, myrmecophily, *Solenopsis*, Neotropical Region

Introduction

The genus *Kasabister* Mazur, 1972, was initially described for a single species, now known as *K. rubellus* (Erichson, 1834), and assigned to the myrmecophilous and termitophilous subfamily Haeteriinae. Later, two other species originally described in other genera

(*Epierus ferrugineus* Kirsch, 1873, and *Phelister carinatus* Lewis, 1888) were moved here, and the entire genus was moved to Histerinae: Exosternini (Mazur 1997). This dynamic taxonomic history underscores the enigmatic nature of this genus, and its affinities within the tribe remain unclear. Similarly, little is known about the biology of these species, although it has become clear that they live as guests in the nests of fire ants of the genus *Solenopsis* Westwood. These ants are a major nuisance as a result of invasion into many tropical and subtropical climates (Hölldobler and Wilson 1990). It is therefore important to better understand the commensal predators that may play a role in controlling ant populations.

This paper represents the first installment of an ongoing revision of all the species of New World Exosternini. The fauna is large and complex, with the limits of most genera poorly understood. *Kaszabister* is among the more straightforward and clearly monophyletic groups, and preliminary analyses (Caterino et al. in prep) indicate that it lies outside any other named genus. Thus we are confident in retaining its status as a genus.

Materials and methods

The morphological terminology used is that defined by Wenzel and Dybas (1941), supplemented by Helava et al. (1985), Ôhara (1994) and Lawrence et al. (2011). Following histerid conventions, total body length is measured from the anterior margin of the pronotum to the posterior margin of the elytra (to exclude preservation variability in head and pygidial extension), while width is taken at the widest point, generally near the elytral humeri. Type material of all valid species was examined by one or more of the authors. Photographic imaging was done using a Visionary Digital's 'Passport' portable imaging system, which incorporates a Canon D7 with MP-E 65mm 1–5X macro zoom lens. Images were stacked using Helicon Focus software. SEM imaging was done on a Zeiss EVO 40 scope, with most specimens sputter coated with gold. Photographs of all type specimens are available through the Encyclopedia of Life (www.eol.org).

Specimens from the following institutions were utilized:

BMNH	The Natural History Museum, London, UK
CHAT	The Alexey Tishechkin Collection, Santa Barbara, USA
CHND	The Nicolas Dégallier Collection, Paris, France
CHPK	The Piet Kanaar Collection, Leiden, The Netherlands
CHSM	The Slawomir Mazur Collection, Warsaw, Poland
DBIA	University of Brasilia, Distrito Federal, Brazil
EMEC	The Essig Museum of Entomology, Berkeley, USA
FMNH	The Field Museum, Chicago, USA
FSCA	Florida State Collection of Arthropods, Gainesville, USA
HNHM	Hungarian Natural History Museum, Budapest, Hungary
INBI	Instituto Nacional de Biodiversidad, San Jose, Costa Rica

MACN	Museo de Ciencias Naturales “Bernardino Rivadavia”, Buenos Aires, Argentina
MNHN	Museum National d’Histoire Naturelle, Paris, France
NMNH	National Museum of Natural History, Washington, USA
SMTD	Staatlichen Museum für Tierkunde, Dresden, Germany
ZHMB	Museum für Naturkunde, Berlin, Germany

Taxonomy

Genus *Kaszabister* Mazur, 1972

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

Kaszabister Mazur, 1972: 189.

Type species. *Kaszabister mahunkai* Mazur, 1972 (now regarded as a junior synonym of *K. rubellus* (Erichson, 1834)), original designation.

Diagnosis. *Kaszabister* can be easily separated from other Neotropical Exosternini by its strongly carinate frontal stria (Fig. 3); epipleural, subhumeral, and dorsal elytral striae 1 apically carinate and convergent to posterolateral corner (Fig. 1B, 2A); and narrow, edentate meso- and metatibiae which bear only a few small spines (Figs 1B, 2A, 4). The narrowly depressed lateral pronotal margin is also rare in other genera (Figs 1A, 2B).

Description. Body length 1.7–2.3mm, width 1.3–1.7mm, oval or oblong, more or less convex, reddish brown, glabrous. **Head:** Frons bordered by a prominent, moderately to strongly carinate frontal stria; antennae inserted under the rim of the frons in front of eyes; antennal scape slightly setose; antennal club oval, tomentose, lacking sutures or annuli, with small oval subapical sensoria on upper and lower surfaces; epistoma flat to convex, bordered by striae or carinae; labrum short, broad, rounded at sides and emarginate at middle; mandibles with strong furrows along lower outer margins and very weak subapical teeth on incisor edge; gena setose and weakly depressed; gular sutures impressed; submentum with numerous fringed setae, projecting slightly between maxillary bases; mentum about one-fourth broader than long, sides rounded, tapering apically, margin faintly emarginate; palpi relatively short, with truncate apices. **Pronotum:** pronotum widest at base, sides rounded, anterior angles acute; prescutellar impression absent; gland openings annulate, situated about one-third from anterior margin, behind inner edge of eye on each side; with 3 pores along each side; marginal stria complete, continuous with anterior marginal stria; lateral stria absent. **Elytra:** Dorsal striae of elytra simple or carinate, variously abbreviated; dorsal stria 1, subhumeral striae, and epipleural stria carinate and convergent apically. **Prosternum:** Antennal cavities of the prosternum visible in ventral view, located in the anterior angles of pronotum; prosternal lobe short, broad, reaching hypomerion laterally, with marginal stria at least medially; base of prosternal keel weakly emarginate; with complete carinate striae diverging

anterad and posterad, not joined. **Mesoventrite:** Disk flat, weakly projecting at middle, with complete marginal stria; mesometaventral stria present, angulate forward onto mesoventral disk. **Metaventrite:** Metaventral disk with postcoxal and lateral striae, both extending laterad toward metepisternum. **Abdomen:** Propygidium short, moderately convex, with annulate gland openings in anterolateral corners; pygidium lacking apical stria; abdominal ventrite 1 with one or two lateral striae; ventrites 2–5 with or without posterior marginal striae. **Legs:** Protrochanter with seta; protibia lacking teeth, but with 8–10 stout marginal spines; protibial spurs short, strong; protarsus with fine ventral spines, pretarsal claws simple and equal; meso- and metatrochanters lacking setae; meso- and metatibiae nearly parallel-sided, the former with few weak marginal spines; meso- and metatarsomeres with single pair of apicoventral setae. **Male:** Eighth tergite with accessory sclerites, shallowly narrowly incised at subtruncate apex, with basal membrane attachment distad basal emargination; ventral apodemes of 8th tergite broadly rounded, not meeting at midline; 8th sternite approximately parallel-sided, halves not joined along midline, with apical guides gradually more strongly elevated toward apices; 9th tergite with median emargination deep, ventral apodemes situated just behind midpoint, strongly toothed; spiculum gastrale (9th sternite) narrowed in distal two-thirds, with thin apical arms and short median apical flanges; halves of 10th tergite well developed, separated along midline. **Female:** Eighth tergite forming a single, apically emarginate plate; 8th sternite divided into two lateral plates, with thin, separate basal baculi which are articulated with the disk of S8; 9th sternite present, elongate, connected to apex of S8; tenth tergite present, without basal apodemes; valvifers elongate, enlarged basally; coxites with two strong and one weak inner tooth; gonostyle present, free, setose; bursa copulatrix small; spermatheca short, sclerotized, forming a ventral concave disk over oviduct; spermathecal gland attached at base of spermatheca, elongate, gradually expanded to apex.

Distribution. The distribution of the species of this genus is interestingly discontinuous, with three species concentrated in subtropical South America, and a single species from Central America, with few records from the northern half of South America.

Key to species

- 1 Postmetacoxal striae of the first ventrite joined in an arch along the anterior margin (Fig. 4A); lateral metaventral stria terminating about one-third metaventral length behind the mesometaventral suture (Fig. 4A); frontal stria descending onto epistoma only, without stria across anterior margin of frons (Fig. 3A); southern Brazil, Paraguay, Argentina... ***Kaszabister barrigai* sp. n.**
- Postmetacoxal striae not joined in an anterior arc; lateral metaventral stria reaching (Fig. 4B, D) or nearly reaching (Fig. 4C) mesometaventral suture; frontal stria variable **2**
- 2 Abdominal ventrites 2–5 lacking posterior marginal stria (Fig. 4D); southern Mexico to Costa Rica..... ***Kaszabister carinatus* (Lewis, 1888)**
- Abdominal ventrites 2–5 with posterior marginal stria (Figs 4A–C)..... **3**

- 3 Frontal stria complete and evenly arcuate across frons (Fig. 3B); epistoma convex; lateral stria of metaventrite reaching mesometaventral suture (Fig. 4B); Peru, Brazil, Uruguay, Argentina***Kaszabister ferrugineus* (Kirsch, 1873)**
- Frontal stria not evenly arcuate, descending onto epistoma as a weak marginal carina (Fig. 3C); epistoma depressed; lateral stria of metaventrite abbreviated about one-fourth behind mesometaventral suture (Fig. 4C); southern Brazil, Uruguay, Argentina..... ***Kaszabister rubellus* (Erichson, 1834)**

***Kaszabister barrigai* sp. n.**

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

Figs 1, 2A, 3A, 4A, 6A–B, 7 (map)

Type material. Holotype: male: “BRAZIL: State of Mato Grosso, Rondonópolis Co., Rondonópolis” / “R. Beasley, 14.VII.72, Floated from ant nest #169” / “Caterino/ Tishechkin Exosternini Voucher EXO-00255 / HOLOTYPE *Kaszabister barrigai* Dégallier et al. des. 2012”; deposited in FSCA. **Paratypes** (109): **ARGENTINA: Cordoba:** Alta Gracia, La Granja, Sierras de Córdoba, 10.i.1925 (1: MACN); same locality and date, “debajo de una piedra en el medio de las *Solenopsis*” (1: MACN); **ARGENTINA:** “on grapes (fruit) from Argentina, Kennedy, N.Y., 22.iv.1935” (1: NMNH); **BRAZIL: Mato Grosso:** Mato Grosso, Buriti, 20.vii.1972, floated from ant nest (3: FSCA); Mato Grosso, Cáceres, 5.vii.1972, floated from ant nest (6: FSCA); Mato Grosso, Cuiabá, Parque de Exposição, 30.v.1972, floated from ant nest (7: FSCA); same label data but 1.vi.1972 (12: FSCA); same label data but 6.vi.1972 (5: FSCA); same label data but 7.vi.1972 (3: FSCA); same label data but 13.vi.1972 (1: FSCA); same label data but 14.vi.1972 (4: FSCA); same label data but 14.vi.1972 (6: FSCA); same label data but 20.vi.1972 (13: FSCA); same label data but 22.vi.1972 (1: FSCA); Mato Grosso, Fazenda of Augusto Miller, 10 km N Chapada dos Guimarães, 21.v.1972, floated from ant nest (1: FSCA); Mato Grosso, Mato Grosso Co., 25.vii.1972, floated from ant nest (6: FSCA); Mato Grosso, Poconé, 23.iv.1972, floated from ant nest (9: FSCA); Mato Grosso, Pontes e Lacerda, 3.vii.1972, floated from ant nest (1: FSCA); 12 specimens from Mato Grosso, Rondonópolis, 14.vii.1972, floated from ant nest (12: FSCA); same label data but 15.vii.1972 (2: FSCA); Mato Grosso, Rosario Oeste, 13.vii.1972, floated from ant nest (3: FSCA). **São Paulo:** São Paulo, São Paulo, xii.1972, from fire ant nests (6: FSCA); São Paulo, Vargem Grande [do Sul], 1.xii.1972 (1: FMNH, 2: NMNH); São Paulo, Vargem Grande do Sul, 17.iii.1972, nest of *Solenopsis saevissima* gp. (1: FMNH); São Paulo, Varzea Grande, 9.ii.1972 (1: FSCA); same label data but 1.xii.1972 (2: FSCA). **PARAGUAY: San Pedro:** San Pedro, Cororó, x.1979 (1: CHND).

Diagnostic description. Length 1.9–2.3mm; width 1.5–1.7mm; Frontal stria descending onto epistoma as a strong carina, epistoma strongly depressed, depression broader than in *K. rubellus*; fourth dorsal elytral stria present in apical half to two-thirds; inner subhumeral elytral stria present in apical two-thirds; fifth elytral stria generally absent; sutural stria present in apical half; elytral ground punctures denser and

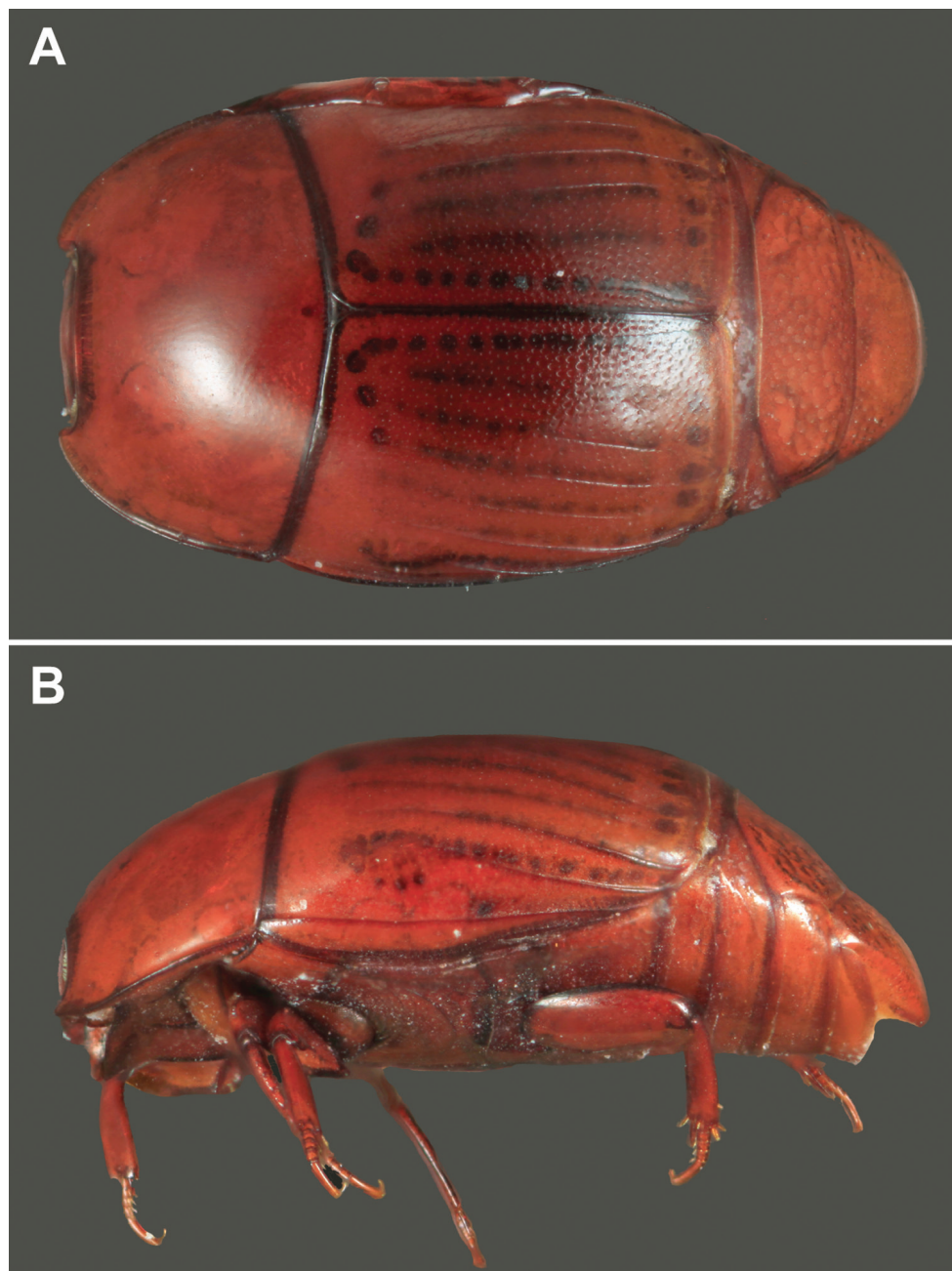


Figure 1. Habitus photos of *Kaszabister barrigai* sp. n. **A** Dorsal **B** Lateral.

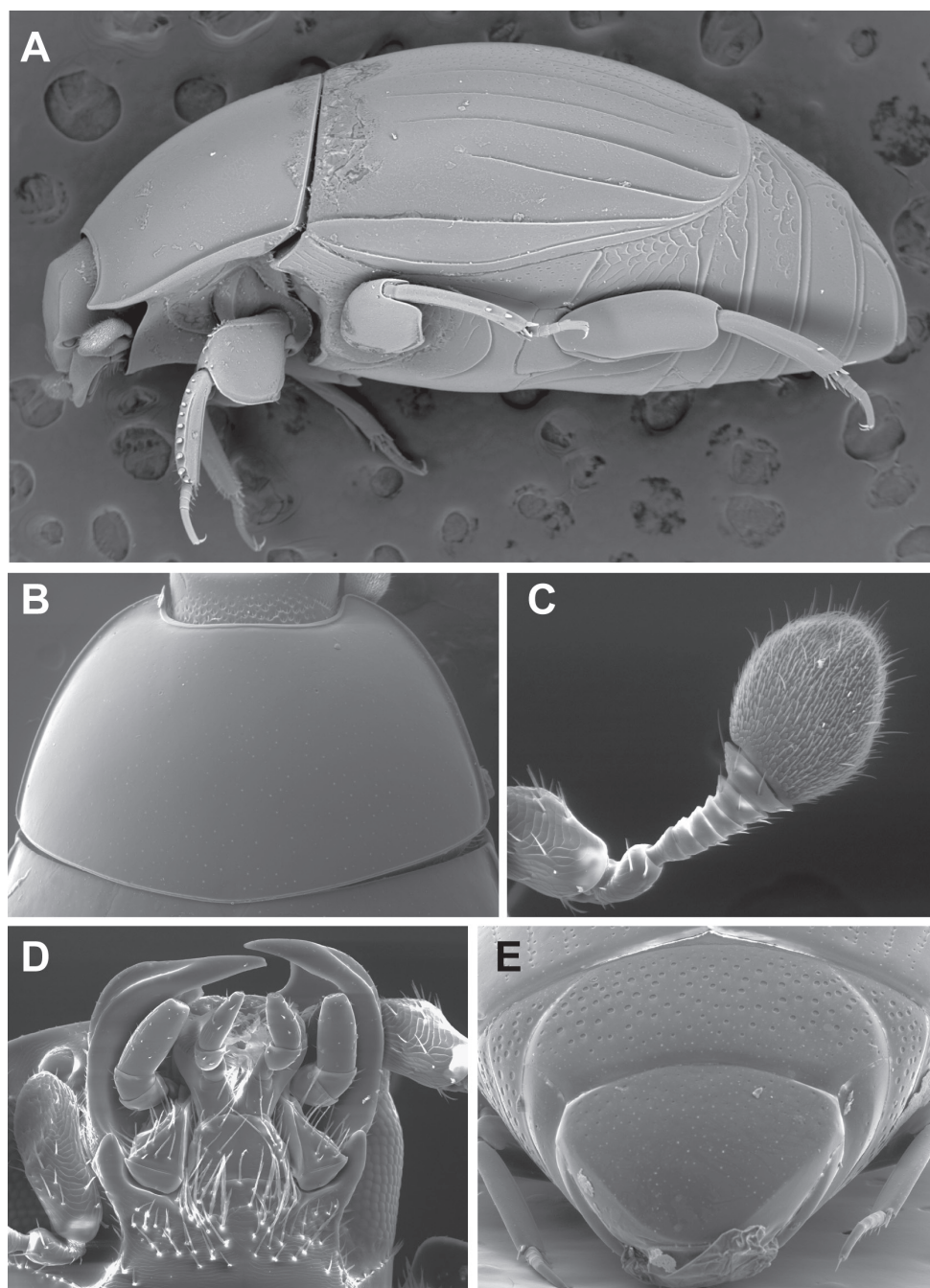


Figure 2. Generic characters of *Kaszabister*. **A** Lateral habitus of *K. barrigai* showing carinate and convergent dorsolateral elytral striae **B** Pronotum of *K. carinatus* **C** Antenna of *K. carinatus* **D** Mouthparts of *K. carinatus* **E** Propygidium and pygidium of *K. carinatus*.

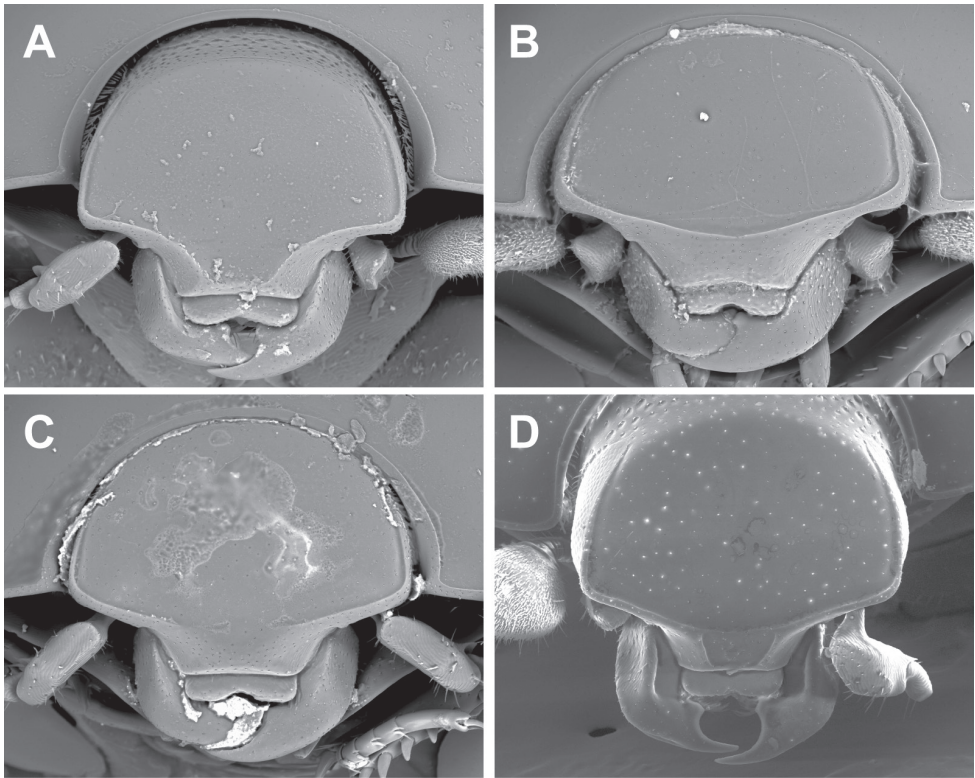


Figure 3. Anterior view of head. **A** *Kaszabister barrigai* **B** *K. ferrugineus* **C** *K. rubellus* **D** *K. carinatus*.

more uniformly distributed; mesometaventral stria arched forward to between one-half to one-third from anterior mesoventral margin; lateral metaventral stria strongly abbreviated mediad, ending about one-third from mesometaventral margin; inner post-metacoxal striae forming a complete, narrow arc across anterior margin of abdominal ventrite 1; abdominal ventrites 2–4 with apical marginal stria. **Male:** Aedeagus narrow, elongate, swollen toward base, flattened apically in lateral view.

Distribution. Known principally from the Brazilian states of Mato Grosso and São Paulo, with one record each from Argentina and Paraguay, and a single specimen found in an Argentinian grape shipment at Kennedy Airport, New York, USA.

Biology. While the majority of the type specimens say merely that they were collected from ‘ant nest’, there is little doubt that the hosts were *Solenopsis* Westwood, probably *Solenopsis invicta* Buren, 1972, the focus of the work of collectors Lennartz and Whitcomb (Allen et al. 1974, Buren et al. 1974). Other records specify ‘fire ants’, *Solenopsis* sp., and ‘*Solenopsis saevissima* group’ as hosts.

Etymology. This species is named for the notable Chilean collector Juan Enrique Barriga-Tuñón, who provided us with one of the first known examples of the species.

Remarks. Specimens labelled as ‘São Paulo, Varzea Grande’ most probably came from Vargem Grande do Sul in the same state. We were not able to find any place

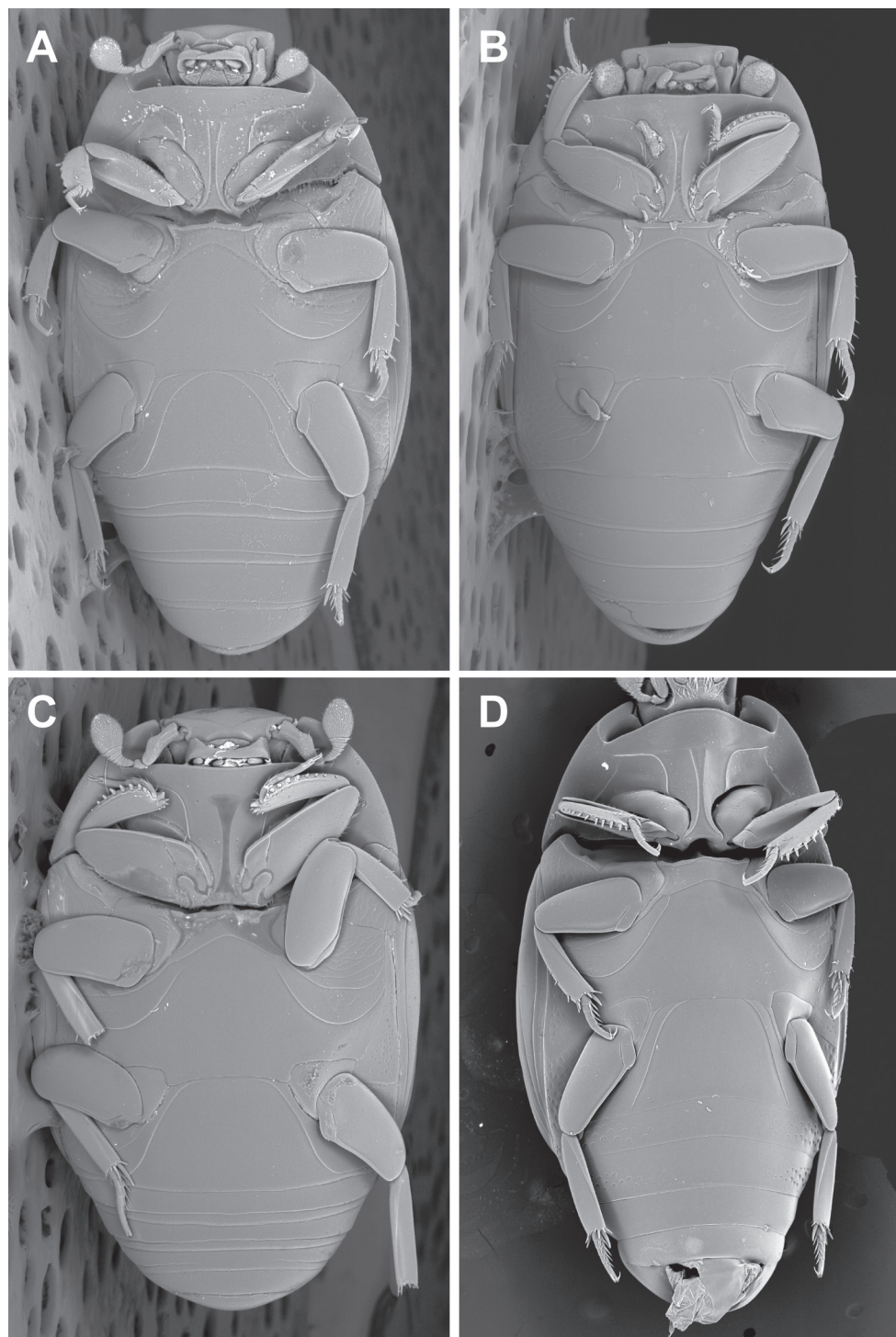


Figure 4. Ventral habitus. **A** *Kaszabister barrigai* **B** *K. ferrugineus* **C** *K. rubellus* **D** *K. carinatus*.

called Varzea Grande in São Paulo. On the other hand, there is a town of this name that is a part of greater Cuiabá, the capital of Mato Grosso, where the fire ant researchers who collected specimens from Mato Grosso and São Paulo were apparently based. But given that we have seen specimens collected on the same day, 1.xii.1972, in ‘São Paulo, Vargem Grande’ (3) and ‘São Paulo, Varzea Grande’ (1), we suspect confusion and mislabeling for the latter locality.

***Kaszabister carinatus* (Lewis, 1888)**

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

Figs 2B–E, 3D, 4D, 6G–H, 9 (map)

Phelister carinatus Lewis, 1888: 194.

Kaszabister carinatus: Mazur (1997: 31).

Type material. Holotype (“one example”; Lewis, 1888) of undetermined sex: “Cerro Zunil, 4–5000 ft. Champion” / “Sp. figured.” / “B.C.A., Col., II, (1). *Phelister*” / “*Phelister carinatus* Lewis Type” / “Type” [red circle] / “HOLOTYPE N. Dégallier 2007”; BMNH.

Other material: **MEXICO: Chiapas:** Mpio. Trinitaria, Lagunas de Montebello, 4–31.viii.1991, FIT (1: FMNH); **Michoacan:** San Jose Purua, vi.1965 (1: CHSM); ‘Mexico, A.G.’ (1: BMNH). **COSTA RICA: Alajuela:** RNVS Caño Negro, 18–30.xi.1992, 5–28.ii.1995 (2: INBI); **Guanacaste:** Est. Los Almendros, 4–16.ix.1994 (1, INBI); **Heredia:** Est. Biol. La Selva, 2.5 km S Puerto Viejo, 24.vi.2003, at light (1: EMEC); **Limón:** Cerro Cocori, iii.1993, iv.1993, v.1993 (3: INBI); Rio Sardinas, RNFS Barra del Colorado, 6–14.iv.1994 (1: INBI); Sect. Cerales de la Rita, 3 km N. del Puente Rio Suerte, Ruta Puerto Lindo, iii.1996 (1: INBI); Reventazon Evene, Hamburg Farm, 2.i.1932 (1: NMNH); P.N. Tortuguero, Est. Cuatro Esquinas, ix.1992 (1: INBI); **Puntarenas:** P.N. Corcovado, Est. Sirena, Send. Espavel, 19.iv.2001 (1: INBI); **San Jose:** San Jose, ix.1935 (1: CHND).

Diagnosis. Frontal stria continuous across front and connected to epistomal striae, epistoma flat; fourth dorsal elytral stria complete and arched to suture; inner subhumeral elytral stria usually present only in apical half; fifth and sutural elytral striae weak, often just series of punctures, but generally present in apical one-third; elytral ground punctures sparser and markedly reduced laterad fourth elytral stria; mesometaventral stria arched forward to about one-half from mesoventral margin; lateral metaventral stria reaching mesometaventral margin, but distinctly mediad junction of mesometaventral and postmesocoxal striae; inner postmetacoxal striae somewhat variable, but never forming a complete arc across anterior margin of abdominal ventrite 1; abdominal ventrites 2–4 completely lacking apical marginal stria; aedeagus of moderate width, more strongly tapered basally than apically, with ventral curvature only marked nearer apex.

Distribution. This species is restricted to Central America, from southern Mexico to Costa Rica.

Remarks. No specimens bear any host data.

***Kaszabister ferrugineus* (Kirsch, 1873)**

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

Figs 3B, 4B, 5, 6C–D, 8 (map)

Epierus ferrugineus Kirsch, 1873: 137.

Phelister ferrugineus: Lewis (1905: 47).

Kaszabister ferrugineus: Mazur (1997: 31).

Phelister marginicollis Lewis, in litteris: Bruch (1914: 309).

Phelister marginicollis Bruch, 1914 (sic!): Mazur (1997: 31), as *nomen nudum*.

Type material. Lectotype, herein designated for the purposes of establishing a unique and unambiguous type, as the original description omitted any indication of number of specimens studied: of undetermined sex: [Peru:] “Pozuzu, M. Kirsch” / “*Epierus ferrugineus*” / “Staatl. Museum für Tierkunde, Dresden” / “LECTOTYPE Dégallier & Mazur, 2007” / “*Kaszabister ferrugineus* (Kirsch, 1873); SMTD.

Other material. **ARGENTINA: Buenos Aires:** Buenos Aires, 30.vii.1917, 9.vii.1923, 5.viii.1923 (4: MACN, NMNH); La Plata, viii.1912, nest of *Solenopsis saevissima* (2: NMNH); Rosas – F. C. Sud (7: NMNH); San Fernando, viii.1960 (1: NMNH). **Mendoza:** Mendoza, 20.x.1907 (1: ZMHB). **BRAZIL: ‘Bahia’** (4: ZMHB). **Distrito Federal:** Brasília, IBGE Ecological Reserve, 24.vi.1987, 13.v.1987, 7.vi.1987, 20.i.1998 (6: CIZUB, CHAT, CHND). **Mato Grosso:** Arenópolis, 22.viii.1972 (23: FSCA); Cáceres, 5.vii.1972 (1: FSCA); Cuiabá, 19.vi.1972 (1: FSCA); Mato Grosso Co., 25.vii.1972 (1: FSCA); Poconé, 23.iv.1972 (1: FSCA); Rondonópolis, 14–15. vii.1972 (3: FSCA); Rosario Oeste, 14.vii.1972 (1: FSCA). **Pará:** Belém, 2.vi.1985, flotation of the *Solenopsis saevissima* nest (identified by W. L. Overal) (1: CHND). **Rondônia:** Guajará Mirim, 1.ix.1972 (1: FSCA). **São Paulo:** São Simão, Usina Sta. Clara, 5.ix.1973 (3: FMNH). **URUGUAY: Artigas:** Ruta 30, km 45, 12.xii.1962, nest of *Solenopsis saevissima* (1: CHSM).

Diagnosis. Frontal stria straight to evenly arcuate across front, not descending onto epistoma; fourth dorsal elytral stria complete and arched to suture; inner subhumeral elytral stria present in apical two-thirds; fifth elytral stria variable, from absent to present in apical one-half; sutural stria present in apical half; elytral ground punctures sparser and markedly reduced laterad fourth elytral stria; mesometaventral stria arched forward to about one-third from mesoventral margin; lateral metaventral stria reaching mesometaventral margin, nearly or fully meeting mesometaventral stria and postmesocoxal stria; inner postmetacoxal striae not forming a complete arc across anterior margin of abdominal ventrite 1, ending close to metacoxa; abdominal ventrites 2–4 with apical marginal stria; aedeagus rather short, parallel-sided, with apex subtruncate.

Distribution. Known from Argentina (Mendoza, Buenos Aires), Brazil (Bahia, Distrito Federal, Mato Grosso, Pará, Rondônia and São Paulo), Peru (Huanuco) and Uruguay (Artigas).

Biology. As for *K. barrigai*, many records of *K. ferrugineus* from ‘ant nests’ almost certainly refer to *Solenopsis invicta* as host, while a few other labels specify *S. saevis-*

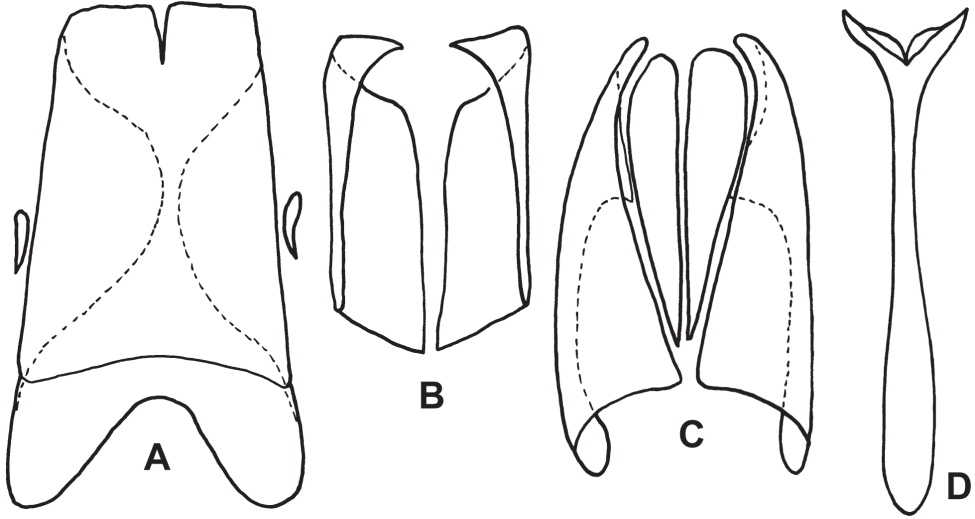


Figure 5. Male genitalia of *Kaszabister ferrugineus*. **A** 8th tergite (with accessory sclerites) **B** 8th sternite **C** 9th and 10th tergites **D** Spiculum gastrale (=9th sternite).

sima (Smith). One specimen from Bahia in the Lewis collection bears a label “with an *Aphaenogaster*” (Formicidae). However, no host specimen is present for verification.

Remarks. Mazur (1997) cites “*Phelister marginicollis* Bruch, 1914” as “nom. nud. - syn. nov., Wenzel in litt.”. Bruch (1914: 309) cites this as “*Phelister marginicollis* Lew. in litteris”. This appears to have been a species that Lewis intended to describe based on Bruch’s specimens, and he indicated such to Bruch. Specimens labeled “*P. marginicollis* Lewis” are present in the BMNH and NMNH. However, for whatever reason, the species was never formally published, so it is indeed a nomen nudum. In Bruch’s later works (e.g., 1935) he apparently realized that the species was not properly described and omitted it from his catalog.

***Kaszabister rubellus* (Erichson, 1834)**

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

Figs 3C, 4C, 6E–F, 7 (map)

Epierus rubellus Erichson, 1834: 163.

Kaszabister rubellus: Mazur (1984: 304).

Kaszabister mahunkai Mazur, 1972: 189. Synonymized by Mazur (1984).

Type material. *Epierus rubellus*: **Lectotype** herein designated for the purposes of establishing a unique and unambiguous type, as the original description omitted any indication of number of specimens studied: of undetermined sex: “*rubellus* Er., Carap[ava]. Sellow” / “48997” / “Zool. Mus. Berlin” / “*Kaszabister rubellus* (Erich-

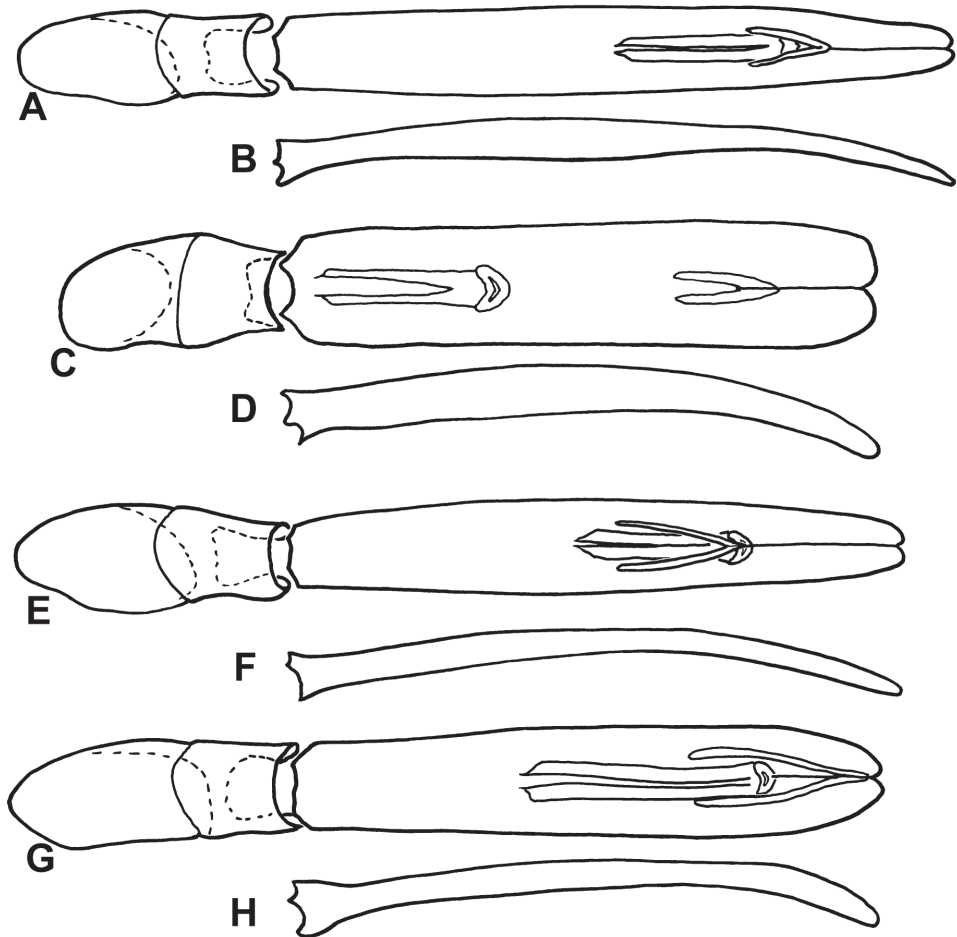


Figure 6. Male genitalia of *Kaszabister*. **A** Dorsal view of aedeagus of *K. barrigai* **B** Lateral view of aedeagus of *K. barrigai* **C** Dorsal view of aedeagus of *K. ferrugineus* **D** Lateral view of aedeagus of *K. ferrugineus* **E** Dorsal view of aedeagus of *K. rubellus* **F** Lateral view of aedeagus of *K. rubellus* **G** Dorsal view of aedeagus of *K. carinatus* **H** Lateral view of aedeagus of *K. carinatus*.

son) LECTOTYPE N. DEGALLIER"; ZMHB. *Kaszabister mahunkai*: holotype: "Hungarian Soil-Zool. Exp., ARGENTINA: Prov. Córdoba, Fanti, Sierra de Córdoba, 11.I.1966" / "Nr. P-B.325 leg. Mahunka" / "Holotype 1972. *Kaszabister mahunkai* Mazur." / "HOLOTYPUS" / "Compared with META-Types *Epierus rubellus* Er., R. L. Wenzel '73" / "*Kaszabister rubellus* (Er.) (= *mahunkai* Mazur), RLW '73" (HNHM).

Other material. ARGENTINA: **Buenos Aires:** Balcarce, iv.1957 (1: NMNH); Rosas – F.C. Sud, with *Solenopsis* (6: NMNH). BRAZIL: **Paraná:** Rio Negro, with *Solenopsis* (1: BMNH); **Rio Grande do Sul:** Vallée de la Ferradura, Canela, 20.x.1989, from nest of *Solenopsis* sp. (1: CHND); **Santa Catarina:** Nova Teutonia, v.1937 (1: FMNH); 31.x.1948, with *Solenopsis* (2: FMNH); 2–3.xi.1948, with *Solenopsis* (2: FMNH); 11–

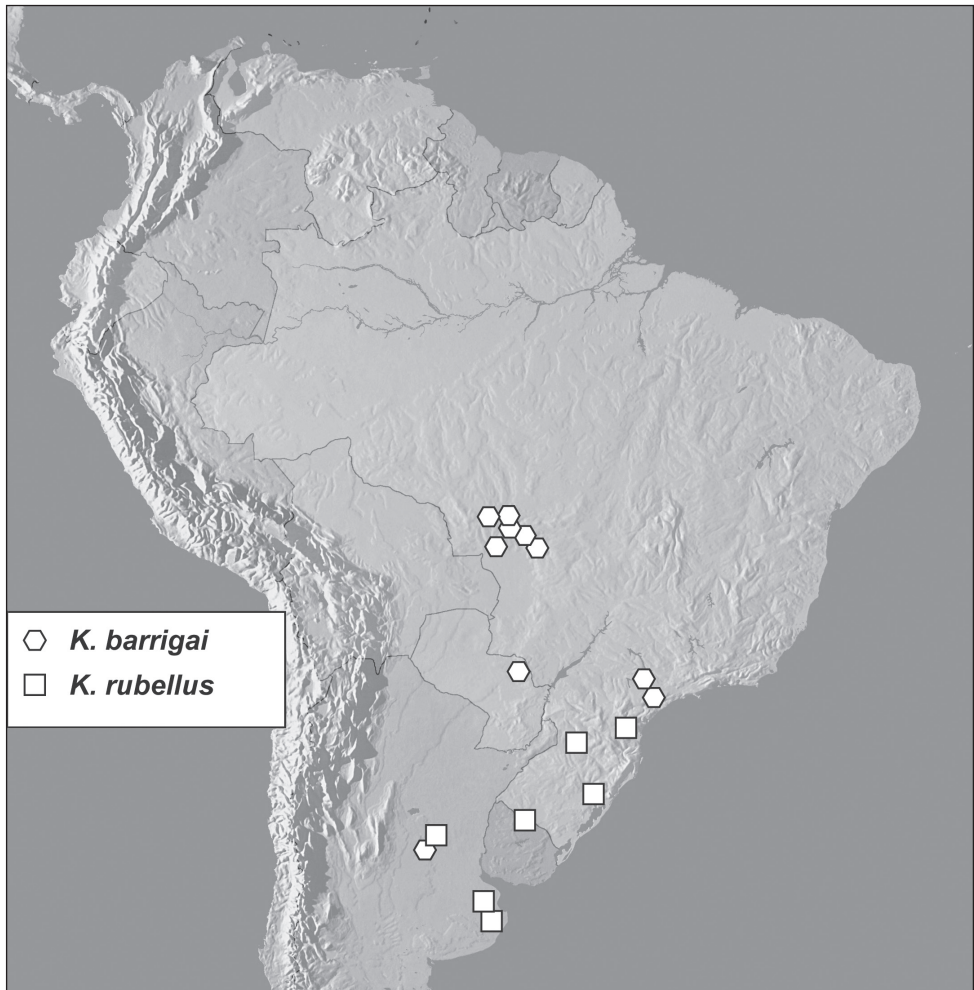


Figure 7. Map showing distributional records of *Kaszabister barrigai* and *K. rubellus*.

14.xi.1948, with *Solenopsis* (2: FMNH); xii.1948 (1: FMNH); 6.vi.1950 (1: FMNH); 6.vii.1950 (1: FMNH); 2.viii.1950, with *Solenopsis* (4: FMNH); 26.viii.1950 (5: FMNH); 28.viii.1950, with *Solenopsis* (4: FMNH); 1.ix.1950 (1: FMNH); 3.ix.1950, with *Solenopsis* (1: FMNH); 6.ix.1950, with *Solenopsis* (2: FMNH); 7.ix.1950, with *Solenopsis* (1: FMNH); 18.ix.1950 (1: FMNH); 20.ix.1950, with *Solenopsis* (1: FMNH); 23.ix.1950 (1: FMNH); 4–5.x.1950, with *Solenopsis* (2: FMNH); 21.vii.1951 (1: FMNH); 24.vii.1951, with *Solenopsis* (1: FMNH); 31.vii.1951, with *Solenopsis* (8: FMNH); 17.viii.1951 (4: FMNH); 22.viii.1951 (1: FMNH); 5.ix.1951 (1: FMNH); 4.x.1951 (4: FMNH); 6–30.viii.1951, with *Solenopsis* (5: FMNH); 10.iv.1952, with *Solenopsis* (1: FMNH); 18.iv.1952, with *Solenopsis* (3: FMNH); 10.v.1952, with *Solenopsis* (1: FMNH); 10.v.1952, with *Solenopsis* (FMNH); 30.vii.1952, with *Solenopsis* (5: CHPK, CHSM, FMNH); 3.viii.1952, with *Solenopsis* (1: FMNH); 7.viii.1952,

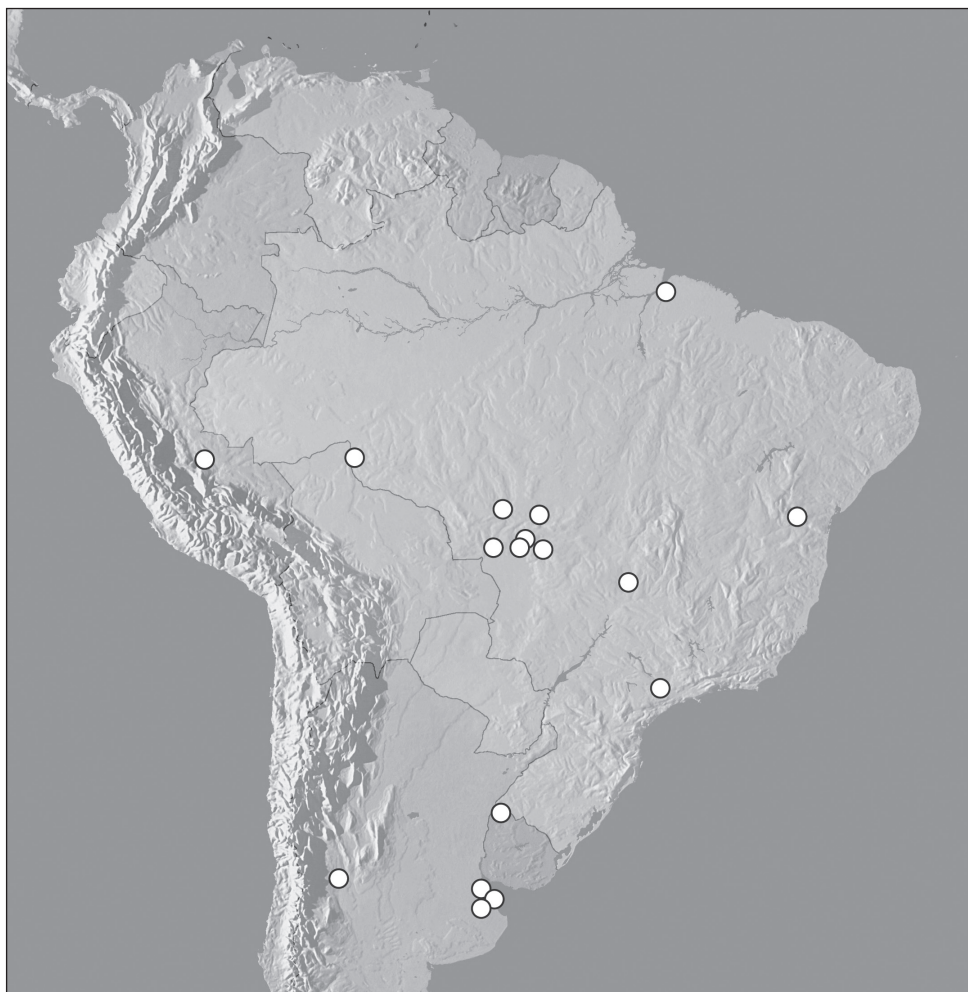


Figure 8. Map showing distributional records of *Kaszabister ferrugineus*.

with *Solenopsis* (2: FMNH); 15.viii.1952 (1: FMNH); viii.1952, with *Solenopsis* (48: FMNH); ix.1952 (1: FMNH); vi.1954 (2: CHSM); vii.1954, (2: CHSM); xi.1956 (1: FMNH); '**Bresil**' (1: MNHN). **URUGUAY: Rivera:** Rivera, Escuela Agraria, 18.ii.1962, nest of *Acromyrmex lundii* (Guérin-Méneville) (1: FMNH).

Diagnosis. Frontal stria descending onto epistoma as a weak carina, epistoma moderately depressed, depression narrower than in *K. barrigai*; fourth dorsal elytral stria present in apical half to two-thirds; inner subhumeral elytral stria present in apical two-thirds; fifth and sutural elytral striae strongly reduced or absent; elytral ground punctures sparser and markedly reduced laterad fourth elytral stria; mesometaventral stria somewhat variable, arched forward to one-half to one-third from mesoventral margin; lateral metaventral stria weakly abbreviated mediad, ending about one-fourth to one-fifth metaventral length from mesometaventral margin, mesometaventral stria

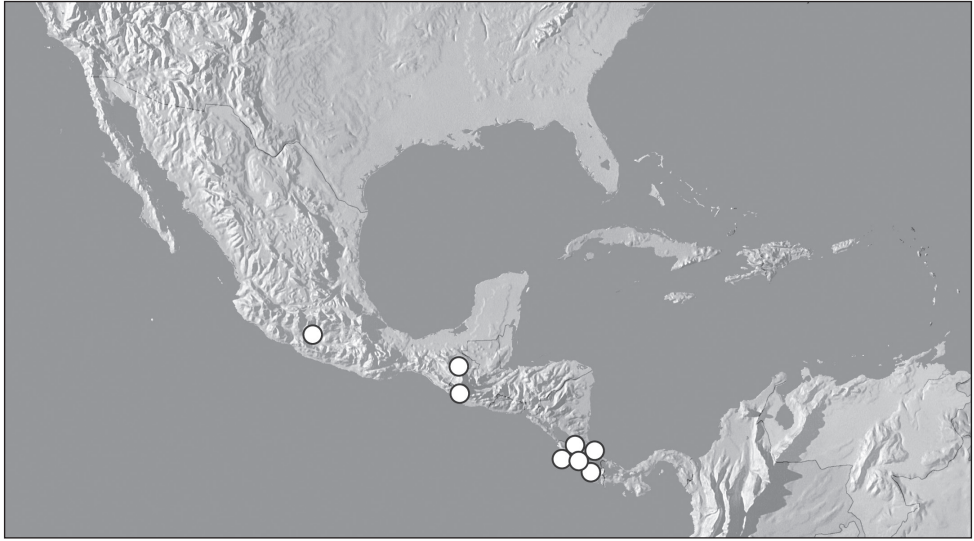


Figure 9. Map showing distributional records of *Kaszabister carinatus*.

continuous with postmesocoxal stria; inner postmetacoxal striae nearly forming a complete arc across anterior margin of abdominal ventrite 1 (though often evanescent at very middle), this arc broader (closer to coxae) than in *K. barrigai*; abdominal ventrites 2–4 with apical marginal stria; aedeagus narrow, approximately evenly tapered basally and apically; flatter (in lateral view) than in other species.

Distribution. Known from Brazil (Paraná, Rio Grande do Sul, Santa Catarina), Argentina (Buenos Aires, Córdoba), Uruguay (Rivera).

Biology. Most specimens from Santa Catarina bear labels indicating collection with unspecified *Solenopsis*. The singleton from Uruguay indicates collection from a nest of *Acromyrmex lundii*.

Remarks. The synonymy of *K. mahunkai* Mazur with *Epierus rubellus* Erichson was originally designated by Mazur (1984) (citing “Wenzel, in litt.”). We have not studied the type of *K. mahunkai* first-hand, but Ottó Merkl of the HNHM very kindly compared the type specimen with our descriptions, keys and figures, and had no doubt that the synonymy is valid. His study also confirmed that Wenzel had compared types of *K. mahunkai* and *E. rubellus* side-by-side in coming to his original conclusion that the two were conspecific.

Discussion

Collecting records indicate that most of the species are strongly or exclusively associated with fire ants in the *Solenopsis saevissima* species group (excepting *K. carinatus* for which no ecological data is available). Most specimens appear to have been washed out of host mounds, and there have been no reported observations of any behavioral

interactions of the *Kaszabister* beetles and their hosts. As all known histerids are predaceous (Kovarík and Caterino 2005), there can be little doubt that the beetles prey on their hosts, probably the larvae and pupae. From some focused collecting it appears that the density of these beetles can be relatively high, and it's conceivable that they provide a significant level of natural control of fire ant populations. Significant interest and resources have focused on introduction of parasitic flies as natural enemies of invasive fire ants in the United States (Callcott et al. 2011). None, to our knowledge, has considered predaceous myrmecophilous beetles. It should also be noted here that, although not as common a host as *Eciton* Latreille, *Solenopsis* does host other neotropical histerid genera, including *Hippeutister* Reichensperger and *Procolonides* Reichensperger (Helava et al. 1985, Kovarik and Caterino 2005, Caterino and Tishechkin 2008).

Myrmecophily is a common phenomenon in Histeridae, with two entire large subfamilies (Haeteriinae and Chlamydopsinae) composed almost entirely of myrmecophiles (Kovarík and Caterino 2005). Outside these major groups, however, there have been numerous independent acquisitions of myrmecophilous habits in nearly all other major taxa. In Exosternini myrmecophily has arisen in both Old and New World genera, including *Paratropus* Gerstaecker, *Coelocraera* Marseul, *Phelister* Marseul, *Pseudister* Bickhardt and *Tribalister* Horn. Specialized myrmecophily is often associated with a suite of morphological specializations (Helava et al. 1985, Kovarik and Caterino 2005). Of these, only exaggerated striae/carinae (frontal, pronotal, elytral) present themselves in *Kaszabister*.

Kaszabister exhibits a largely disjunct distribution, with very few records from a large area of northern South America. At this point it seems most likely that this relates to sampling effort. The vast majority of existing specimens have resulted from direct sampling of *Solenopsis* colonies, which has generally been focused on those areas with species that have become invasive elsewhere, primarily in southern Brazil. At the same time, fairly intensive passive trapping (flight intercept trapping and pitfall trapping) in some of these areas has resulted in no specimens (Vaz-de-Mello unpublished data, Flechtmann unpublished data). So although other parts of South America have seen significant trapping, by ourselves and others, there has been relatively little effort to collect in the appropriate ant colonies. So it remains to be seen whether *Kaszabister* is really more widespread but undetected in South America. This situation is very similar to that of *Hippeutister* (Histeridae: Haeteriinae), with species known from Central America and southern Brazil (Caterino and Tishechkin 2008). Dedicated collecting efforts in *Solenopsis* nests elsewhere may well turn up additional species in both these groups.

An extensive collecting of *Kaszabister* in host ant colonies in 1972 in Mato Grosso has revealed some interesting facts about sympatry and syntopy of its species. Out of nine localities where *K. barrigai* was collected, at six *K. ferrugineus* was also found. Moreover, collecting colony codes reveal that both species have been collected in the same nests at Cáceres, Cuiabá, Mato Grosso Co., and Poconé. At the six localities where both species were found *K. barrigai* was much more common, outnumbering *K. ferrugineus* by 100 to eight specimens. The situation at another locality, Arenapolis, was completely reversed: 23 specimens of *K. ferrugineus* were found in three nests there but no *K. barrigai* specimens are known from that site. Although nothing else known about

this remarkable syntopy, the abundance patterns are suggestive of either interspecific competition, or very fine habitat and/or host preferences. *Kaszabister ferrugineus* and *K. rubellus* are also known to co-occur in at least one location; both were collected at Rosas, Argentina, represented by seven and six specimens, respectively. However, due to poor labeling, it is unclear whether they coexist microsympatrically or simultaneously, e.g. in the same colony or at the same time. This would be interesting to explore further.

The phylogenetic position of *Kaszabister* within Exosternini has never been addressed. Ongoing analyses suggest a relationship with another inquiline and enigmatic genus, *Mecistostethus* Marseul, together as sister or near sister to the large genus *Operclippygus* Marseul. However, some of the morphological characters these share may be convergences related to myrmecophily. Final analyses remain ongoing, and a confident result with respect to *Kaszabister* will probably have to await the availability of molecular sequence data.

Acknowledgments

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First report of the exotic blue land planarian, *Caenoplana coerulea* (Platyhelminthes, Geoplanidae), on Menorca (Balearic Islands, Spain)

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Abstract

In April 2009 two specimens of a terrestrial flatworm were collected from under a rock in an orchard at Ciutadella de Menorca on the easternmost Balearic island of Menorca (Spain). Their external morphology suggested that both specimens belonged to the invasive blue planarian *Caenoplana coerulea*, a species which is native to eastern Australia. Sequence data of a fragment of the mitochondrial cytochrome *c* oxidase subunit I (COI) and of the entire 18S ribosomal RNA confirm its identification. This is one of the first records of the species in Europe where it has only been found in one locality in the United Kingdom, France and NE Spain.

Keywords

Terrestrial flatworm, 18S rDNA, COI, introduction, molecular identification, Balearic Islands, Spain, Europe

Introduction

Several species of terrestrial planarian are known as invasive, exotic species in soils of the northern hemisphere. For instance, in North America and the British Isles about a dozen species of exotic terrestrial planarians have been introduced (Jones 1988; Jones and Boag 1996; Ogren and Kawakatsu 1998). Many of these introduced exotic species are predators of earthworms, isopods and snails (e.g. Ogren 1995; Fiore et al. 2004; Sugiura et al. 2006; Iwai et al. 2010; Sugiura 2010). As such, these flatworms may pose a threat to local biodiversity (Santoro and Jones 2001). Because of this, and in view of their rapid dispersal as well as their wide distribution, these introduced exotic terrestrial flatworms are of serious agricultural and nature conservation concern.

The impacts of introduced exotic terrestrial flatworms may be especially detrimental in islands and archipelagos that support an endemic invertebrate fauna. This is illustrated by the terrestrial flatworm *Platydemus manokwari* De Beauchamp, 1962, which has been introduced in many Pacific islands (e.g. Eldredge and Smith 1995) and is considered a cause of the rapid decline of endemic land snails on these islands (Chiba 2003; Okochi et al. 2004; Ohbayashi et al. 2005; Sugiura et al. 2006; Sugiura 2009; Sugiura and Yamaura 2010). Therefore the species is of serious concern in the conservation of the unique land snail fauna of archipelagos and therefore has been included in the list of the world's 100 worst invasive alien species (see http://www.issg.org/worst100_species.html, Lowe et al. 2000). Hence, in order to develop strategies to reduce further spread and to control their impacts on local invertebrates, rapid and accurate identifications of exotic terrestrial flatworms are essential.

Against this background, we here report for the first time the occurrence of the invasive blue land planarian *Caenoplana coerulea* Moseley, 1877 in the Balearic Islands (Menorca, Spain). Its identification was confirmed by DNA sequence analysis of the entire nuclear 18S ribosomal RNA (18S rDNA) gene and of a portion of the mitochondrial cytochrome *c* oxidase subunit 1 (COI) gene.

Materials and methods

In April 2009 two specimens of a terrestrial flatworm were collected by hand under a rock in an orchard at Ciutadella de Menorca on the easternmost Balearic island of Menorca (Spain, 39°57'00"N, 03°51'00"E; Figures 1 and 2). Both specimens (labelled '1957' and '1958') were stored in 100% ethanol.

Genomic DNA was extracted using the NucleoSpin® Tissue Kit (Machery-Nagel, Düren, Germany). A 424 bp fragment of the COI gene was amplified using the primer pair flatCOIL and flatCOIH (modified from Bessho et al. 1997; Table 1). PCR was performed in a total volume of 25 µl, containing 2 µl of DNA and 0.2 µM of each primer, and using the Qiagen® Multiplex PCR Kit with HotStarTaq® DNA polymerase and a final concentration of 3 mM MgCl₂. The PCR profile was 15 min at 95 °C followed by 35 cycles of 45 s at 95 °C, 45 s at 50 °C and 1 min at 72 °C, and with a final

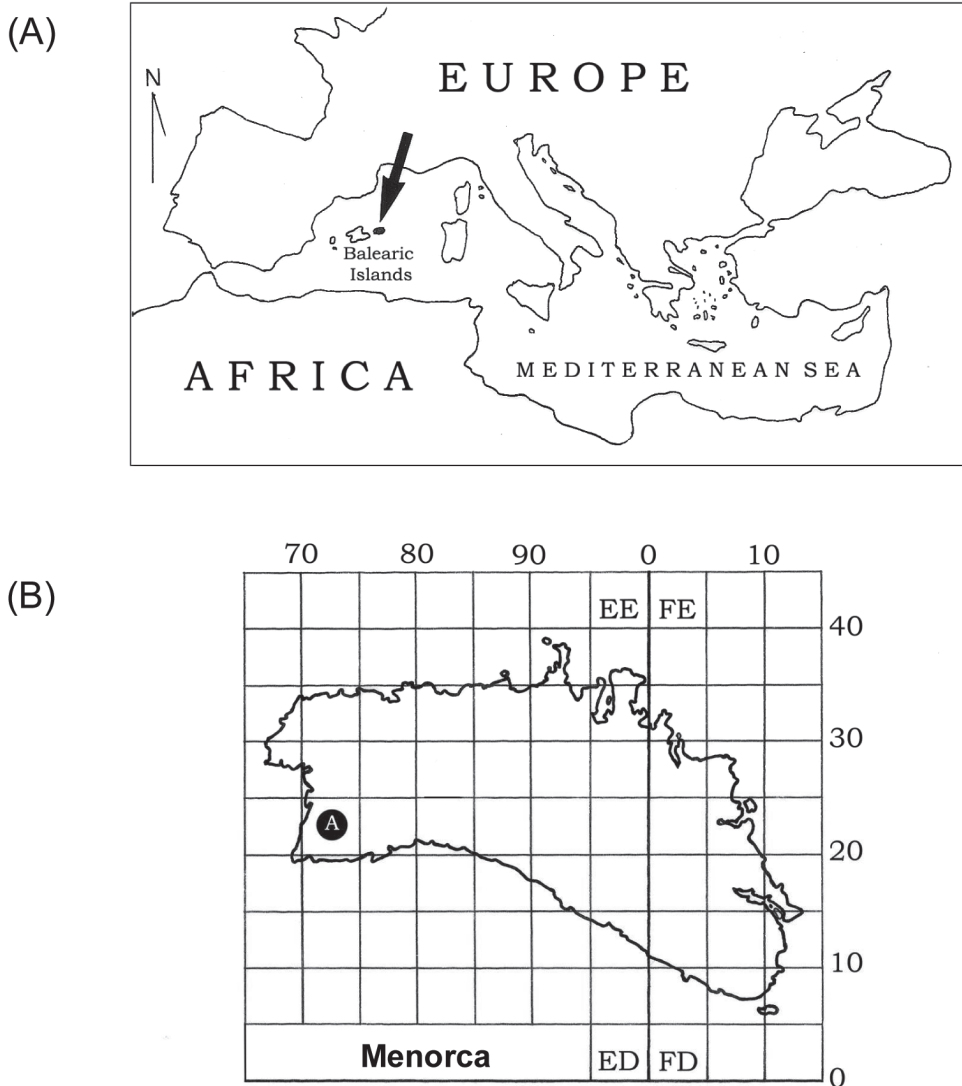


Figure 1. (A) Location of the Balearic Islands in the Mediterranean Sea. Menorca is in black and indicated by an arrow. (B) Detailed map of Menorca: the locality where *Caenoplana coerulea* was found is indicated with the letter A.

extension step of 10 min at 72 °C. The entire 18S rDNA gene was amplified using the primer pair 4F18S and 16R18S (Winnepenninckx et al. 1994, Table 1). PCR was performed in a total volume of 25 µl containing 2 µl of DNA, 0.2 µM of each primer, 200 µM of each dNTP, 0.62 units of Taq DNA polymerase (Qiagen) and mQ-H₂O. Triclad flatworms are known to have two types of 18S rDNA genes (Type I and II) (Carranza et al. 1996, 1999). Therefore, 18S rDNA PCR products were cloned using

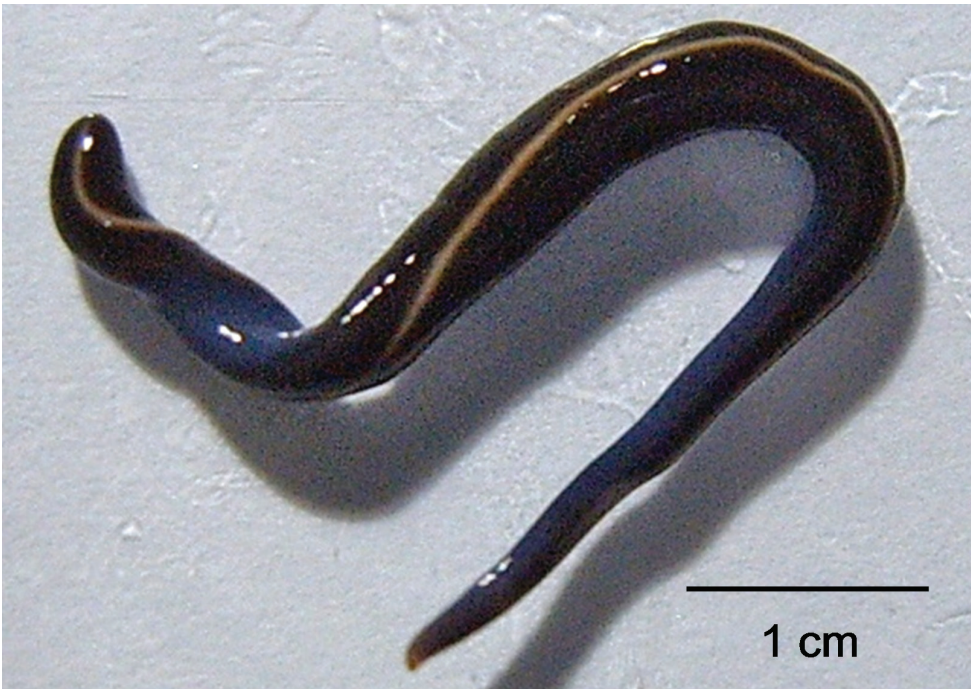


Figure 2. One of the two specimens of *Caenoplana coerulea* collected on Menoca.

Table 1. Forward (F) and reverse (R) primers used for amplification and sequencing of the mitochondrial cytochrome *c* oxidase subunit I (COI) and the nuclear 18S ribosomal RNA (18S rDNA) genes of the two *Caenoplana* specimens in this study.

Name	Sequence 5'-3'	Source
COI:		
F: flatCOIL	GCAGTTTTTGGTTTTTTGGACATCC	modified from Bessho et al. (1997)
R: flatCOIH	GAGCAACAACATAATAAGTATCATG	modified from Bessho et al. (1997)
18S rDNA:		
F: 4F18s	CTGGTTGATYCTGCCAGT	Winnepenninckx et al. (1994)
R: 10R18S	TTGGYRAATGCTTTTCGC	Winnepenninckx et al. (1994)
F: 9F18S	CGCGGTAATTCCAGCTCCA	Winnepenninckx et al. (1994)
R: 3R18S	GACGGGCGGTGTGTRC	Winnepenninckx et al. (1994)
F: 14F18S	ATAACAGGTCTGTGATGCCC	Winnepenninckx et al. (1994)
R: 16R18S	CYGCAGGTTACCTACRG	Winnepenninckx et al. (1994)

TOPO TA Cloning® Kit for Sequencing (Invitrogen) following the suppliers’ instructions. Fifteen colonies of each specimen were amplified as described above.

All PCR products were purified using NucleoFast 96 PCR plates (Macherey-Nagel, Düren, Germany) and bidirectionally sequenced using the BigDye Terminator

v1.1 chemistry on an ABI 3130xl automated capillary DNA sequencer (Life Technologies). For the sequencing of 18S rDNA several internal primers were used (Table 1). Sequences were visually inspected and aligned in SeqScape v2.5 (Life Technologies). COI and 18S rDNA sequences from other flatworm species of the Continenticola (see e.g. Álvarez-Presas et al. 2008, Sluys et al. 2009) were imported from GenBank (See Appendix). Sequence data sets were aligned in MAFFT v6.861 (Kato and Toh 2008) and trimmed at 296 bp for the COI and at 1765 bp for the 18S rDNA fragment. From the Menorca specimens only 18S rDNA clones that yielded sequences without ambiguous positions were retained for further analyses.

Two tree reconstruction methods were implemented: Neighbor-Joining (NJ) (Saitou and Nei 1987) and Maximum Likelihood (ML). The most appropriate nucleotide substitution models for ML were selected using JMODELTEST v0.1.1 (Posada 2008). These were the GTR+G model for the COI fragment and the GTR+I+G model for the 18S rDNA fragment. NJ trees were made in MEGA v5.0 (Tamura et al. 2007) using K2P distances and with complete deletion of indels. ML trees were made in PAUP* v4.0b10 (Swofford 2002) using a heuristic search with the tree-bisection-reconnection branch-swapping algorithm and random addition of taxa. Trees were rooted with *Bdelloura candida* (Girard, 1850) (Maricola, family Bdellouridae). Branch support was assessed via nonparametric bootstrapping using 1000 bootstrap replicates for NJ or 200 bootstrap replicates for ML (Felsenstein 1985). Only nodes with bootstrap values of $\geq 70\%$ were retained and considered meaningful (Hillis and Bull 1993). P-distances were calculated with MEGA v5.0.

Both specimens have been deposited in the collections of the Royal Belgian Institute of Natural Sciences, Brussels, under catalogue number IG.32062. DNA sequences have been deposited in GenBank under accession numbers JQ639215-JQ639227 (for 18S rDNA) and JQ514564 (for COI).

Results and discussion

The dorsal dark blue ground-colour with a thin median dorsal stripe, the intense blue colour of the ventral side, and eyes that are arranged in a single row around the anterior tip and which do not extend dorsally, suggest that the two specimens belong to the species of blue land planarian, *Caenoplana coerulea* Moseley, 1877 (Geoplanidae). This is corroborated by our phylogenetic analysis of the COI and 18S rDNA genes. Both individuals had the same COI haplotype; as in other triclads, there were two different intra-individual types of 18S rDNA (Carranza et al. 1996, 1999). We found five type I and eight type II 18S rDNA variants. Figures 3–4 show the phylogenetic trees inferred from the COI and 18S rDNA data, respectively. The COI haplotype of the Menorcan specimens clustered with strong support with a haplotype of *C. coerulea* from the UK (GenBank accession number DQ666030), from which it differed by only one, ambiguous position (i.e. a G for DQ666030, while 'N' for the Menorcan haplotype). The mean P-distance between the COI haplotype from Menorca and the other *C. coerulea* haplo-

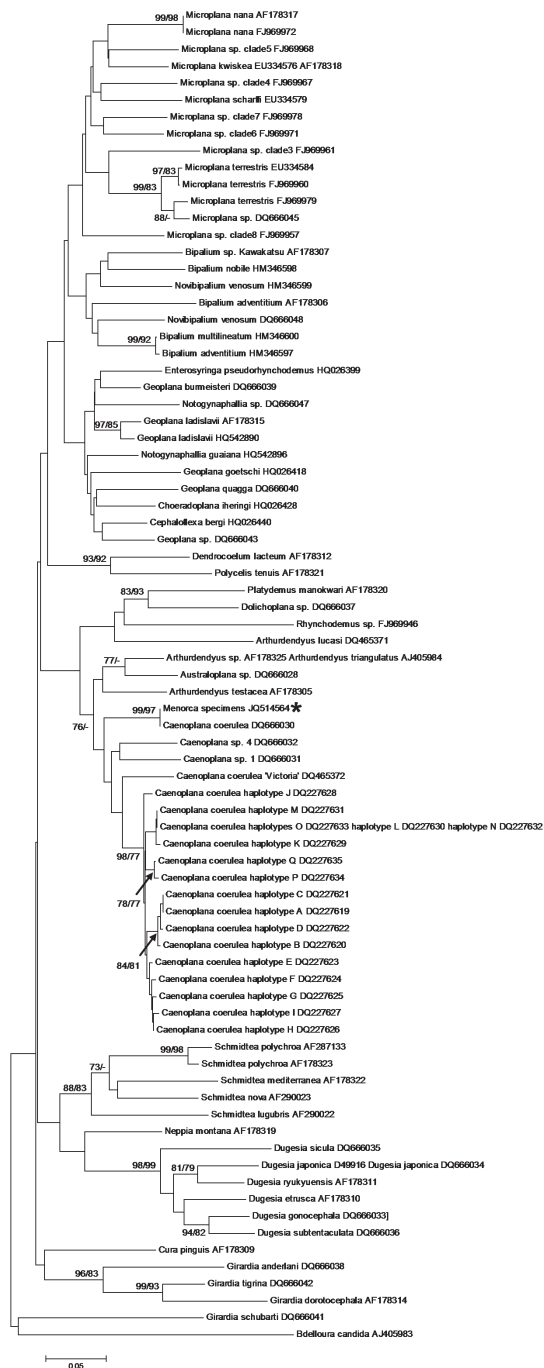


Figure 3. Neighbor-Joining and ML tree of the 296 bp dataset of the mitochondrial cytochrome *c* oxidase subunit I gene (COI). The haplotype of the Menorcan specimens is indicated with an asterisk. Bootstrap values $\geq 70\%$ for the NJ and ML trees are given as NJ/ML and are shown at the nodes. – indicates that the node was not supported by the analysis.

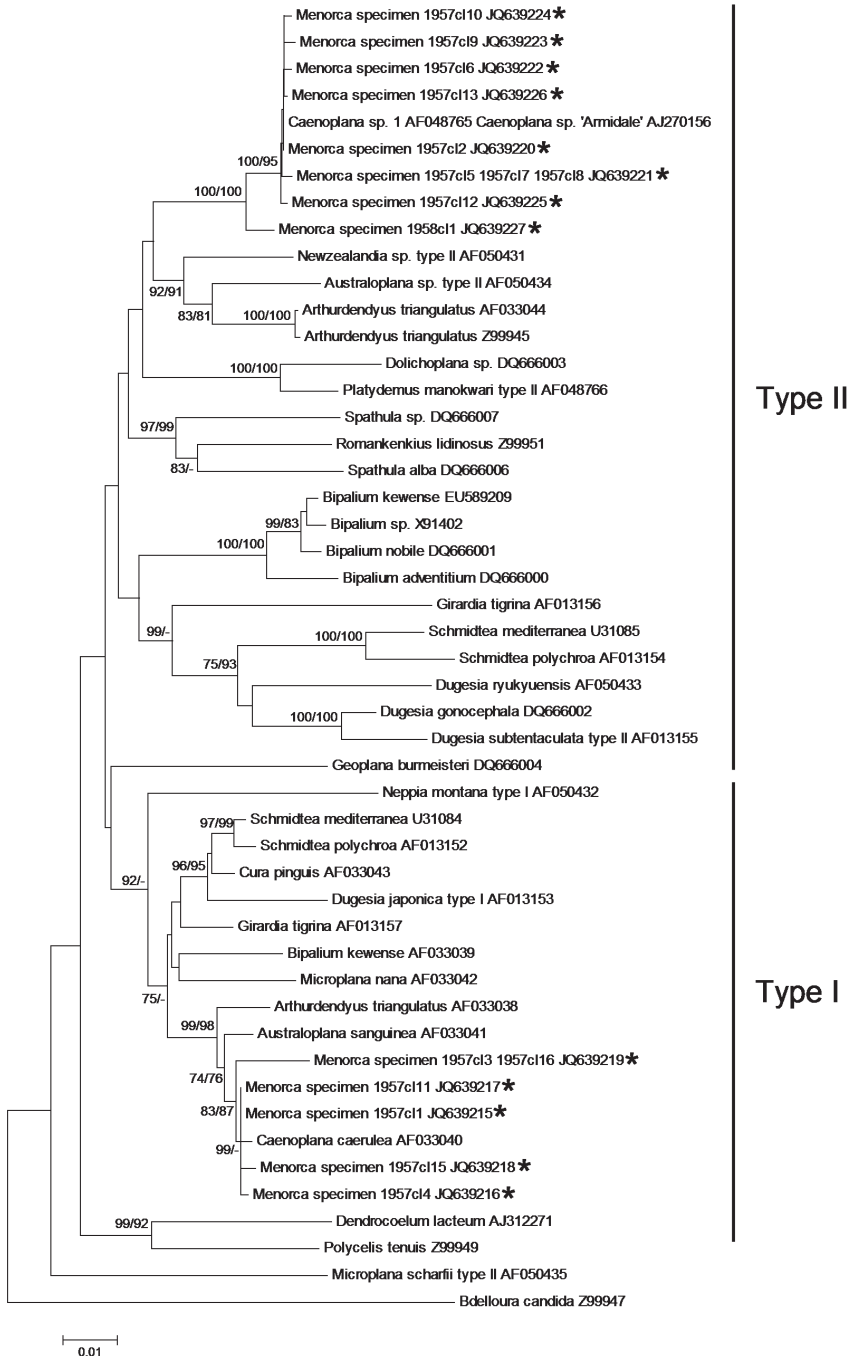


Figure 4. Neighbor-Joining and ML tree of the 1765 bp dataset of the nuclear 18S rDNA gene. The clones (cl) of the Menorcan specimens '1957' and '1958' are indicated with an asterisk. Bootstrap values $\geq 70\%$ for the NJ and ML trees are given as NJ/ML and are shown at the nodes. – indicates that the node was not supported by the analysis. Note that the clades of the type I and type II 18S rRNA variants are not supported.

types was 0.10 ± 0.02 , whereas the P-distance with other Geoplanid species was higher (0.16 ± 0.03) and comparable to what we found among Geoplanidae taxa (0.17 ± 0.03). The 18S rDNA type I sequences from the Menorcan specimens formed a strongly supported clade with *C. coerulea* AF033040 (from the UK) (mean P-distance: 0.008 ± 0.002), whereas those of 18S rDNA type II formed a strongly supported clade with *Caenoplana* sp.1 AF048765 (unknown origin) and *Caenoplana* sp. 'Armidale' AJ270156 (from Australia) (mean P-distance: 0.003 ± 0.001). The mean P-distance between the Menorcan type I and type II sequences and sequences from the other geoplanid species was substantially higher, viz. 0.019 ± 0.003 and 0.058 ± 0.005 , respectively.

Caenoplana coerulea is native to eastern Australia but, as a result of human activities, it has been introduced to New Zealand, the United States, the United Kingdom, Norfolk Island (Australia), and France (Ogren 1989; Winsor 1998; Jones 1998, 2005), and more recently in Argentina (Luis-Negrete et al. 2011) and NE Spain (Mateos et al. 2012). After introduction, the species may expand its range rapidly. For example, since its accidental introduction into the USA prior to 1943, it has spread rapidly over a large part of the country (California: 1943, Florida: 1961, Georgia: 1972, Texas: 1978, Iowa: 1999, North Carolina: 2001) (Ogren 2001). Whether this fast expansion is due to its high intrinsic dispersal capacity or due to repeated, independent introductions, is unknown.

In the Iberian Peninsula and Balearic Islands, at present ten autochthonous species of the family Geoplanidae have been reported (Mateos et al. 1998, 2009; Vila-Farré et al. 2008, 2011). In addition, two introduced species, *Bipalium kewense* Moseley, 1878 (Bipaliidae; recorded from Barcelona) (Filella-Subirá 1983) and *Platydemus* sp. (Geoplanidae; recorded from Benamargosa, Málaga) (Vila-Farré et al. 2011), have been reported from the Iberian Peninsula but not from the Balearic Islands where only *Microplana terrestris* (O.F. Müller, 1774) (Geoplanidae) has been found (Minelli 1977). Hence, the present record of two specimens of *C. coerulea* implies the first introduced species of Geoplanidae in the Balearic Islands. Very recently, the species was also found on the Iberian Peninsula (La Garrotxa, Girona province) (Mateos et al. 2012). Also, pictures of the species that were taken in Spain (Boadilla del Monte, October 2010 and Girona, 22 December 2011) can be found at <http://www.flickr.com/photos/51708886@N03/6351086047/> and <http://www.biodiversidadvirtual.org/insectarium/Caenoplana-coerulea-img293381.html>, respectively. In Europe, the species is further only known from a hothouse in Liverpool (Jones 1998, 2005) and one locality in France (Ogren 1989; Winsor 1998; Winsor et al. 2004).

We do not know when exactly this exotic species arrived in the Balearic Islands. The first specimens of *C. coerulea* were found in an orchard in April 2009. In 2011 the species had spread to a nearby garden, where it was found at shaded places. As is the case in other land planarians, its spread and distribution in newly colonized areas is probably mainly determined by moisture (Fraser and Boag 1998). Even in its native region (Australia), the distribution of *C. coerulea* is restricted to areas with a high humidity (Luis-Negrete et al. 2011). Even though the impact of *C. coerulea* on earthworm and terrestrial gastropod populations is not known, the species is at least reported to

feed on isopods, diplopods, earwigs, and snails (Olewine 1972; Barnwell 1978; Terrace and Baker 1994; Jones 2005). Its broad food spectrum might facilitate the establishment and possible spread of the species in Spain and, eventually, elsewhere in Europe.

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Appendix

List of samples used in this study with GenBank accession numbers and sampling locality (if known). The classification follows Sluys et al. (2009).

Species	18S rDNA		COI	Sampling locality
	Type I	Type II		
Maricola				
Family Bdellouridae				
Subfamily Bdellourinae				
<i>Bdelloura candida</i>	Z99947		AJ405983	
Continenticola				
Family Planariidae				
<i>Polycelis tenuis</i>	Z99949		AF178321	Spain
Family Dendrocoelidae				
<i>Dendrocoelum lacteum</i>	AJ312271		AF178312	France
Family Dugesiidae				
<i>Cura pinguis</i>	AF033043		AF178309	New Zealand
<i>Dugesia etrusca</i>			AF178310	Italy
<i>Dugesia gonocephala</i>		DQ666002	DQ666033	The Netherlands
<i>Dugesia japonica</i>	AF013153	D83382	DQ666034	Japan
	D49916			
<i>Dugesia ryukyuensis</i>		AF050433	AF178311	Japan
<i>Dugesia sicula</i>			DQ666035	Spain
<i>Dugesia subtentaculata</i>		AF013155	DQ666036	Spain
<i>Girardia anderlani</i>		DQ666013	DQ666038	Brasil
<i>Girardia dorotocephala</i>			AF178314	USA
<i>Girardia schubarti</i>		DQ666015	DQ666041	Brasil
<i>Girardia tigrina</i>	AF013157	AF013156	DQ666042	France
<i>Neppia montana</i>	AF050432		AF178319	
<i>Romankenkius libidinosus</i>		Z99951		
<i>Schmidtea mediterranea</i>	U31084	U31085	AF178322	Spain
<i>Schmidtea lugubris</i>			AF290022	
<i>Schmidtea nova</i>			AF290023	
<i>Schmidtea polychroa</i>	AF013152	AF0131154	AF178323	Spain
	AF287133			
<i>Spathula alba</i>		DQ666006		New Zealand
<i>Spathula sp.</i>		DQ666007		New Zealand
Family Geoplanidae				
Subfamily Bipaliinae				
<i>Bipalium adventitium</i>		DQ666000	AF178306	USA
			HM346597	
<i>Bipalium kewense</i>	AF033039			
		EU589209		Japan
<i>Bipalium multilineatum</i>			HM346600	Japan / South Korea

Species	18S rDNA		COI	Sampling locality
	Type I	Type II		
<i>Bipalium nobile</i>	DQ666001			Japan
	HM346598			
<i>Bipalium</i> sp. ‘Kawakatsu’		X91402	AF178307	Japan
<i>Novibipalium venosum</i>			DQ666048	Japan
			HM346599	South Korea
Subfamily Microplaninae				
<i>Microplana kwiskea</i>			EU334576	Spain
			AF178318	
<i>Microplana nana</i>	AF033042		AF178317	Spain
			FJ969972	Spain
<i>Microplana scharffi</i>		AF050435	EU334579	UK
			EU334584	
<i>Microplana terrestris</i>			FJ969960	Spain
			FJ969979	Spain
<i>Microplana</i> sp.			DQ666045	Spain
<i>Microplana</i> sp. clade 3			FJ969961	Spain
<i>Microplana</i> sp. clade 4			FJ969967	Spain
<i>Microplana</i> sp. clade 5			FJ969968	Spain
<i>Microplana</i> sp. clade 6			FJ969971	Spain
<i>Microplana</i> sp. clade 7			FJ969978	Spain
<i>Microplana</i> sp. clade 8			FJ969957	Spain
Subfamily Rhynchodeminae				
<i>Arthurdendyus lucasi</i>			DQ465371	
<i>Arthurdendyus testacea</i>			AF178305	Australia
<i>Arthurdendyus</i> sp.			AF178325	Australia
<i>Arthurdendyus triangulatus</i>	AF033038	AF033044 Z99945	AJ405984	
<i>Australoplana sanguinea</i>	AF033041			Australia
<i>Australoplana</i> sp.		AF050434	DQ666028	Australia
<i>Caenoplana coerulea</i>	AF033040		DQ666030	UK
‘Victoria’			DQ465372	Australia
haplotype A			DQ227619	Australia
haplotype B			DQ227620	Australia
haplotype C			DQ227621	Australia
haplotype D			DQ227622	
haplotype E			DQ227623	Australia
haplotype F			DQ227624	Australia
haplotype G			DQ227625	Australia
haplotype H			DQ227626	Australia
haplotype I			DQ227627	
haplotype J			DQ227628	Australia
haplotype K			DQ227629	Australia
haplotype L			DQ227630	Australia
haplotype M			DQ227631	Australia

Species	18S rDNA		COI	Sampling locality
	Type I	Type II		
haplotype N			DQ227632	Australia
haplotype O			DQ227633	Australia
haplotype P			DQ227634	Australia
haplotype Q			DQ227635	Australia
1957			JQ514564	Spain (Menorca)
1958			JQ514564	Spain (Menorca)
1957clone1	JQ639215			Spain (Menorca)
1957clone4	JQ639216			Spain (Menorca)
1957clone11	JQ639217			Spain (Menorca)
1957clone15	JQ639218			Spain (Menorca)
1957clone3-16	JQ639219			Spain (Menorca)
1957clone2		JQ639220		Spain (Menorca)
1957clone5-7-8		JQ639221		Spain (Menorca)
1957clone6		JQ639222		Spain (Menorca)
1957clone9		JQ639223		Spain (Menorca)
1957clone10		JQ639224		Spain (Menorca)
1957clone12		JQ639225		Spain (Menorca)
1957clone13		JQ639226		Spain (Menorca)
1958clone1		JQ639227		Spain (Menorca)
<i>Caenoplana</i> sp.'Armidale'		AJ270156		Australia
<i>Caenoplana</i> sp. 1		AF048765	DQ666031	
<i>Caenoplana</i> sp. 4			DQ666032	
<i>Dolichoplana</i> sp.		DQ666003	DQ666037	
<i>Newzealandia</i> sp.		AF050431		
<i>Platydemus manokwari</i>		AF048766	AF178320	Australia
<i>Rhynchodemus</i> sp.			FJ969946	
Subfamily Geoplaninae				
<i>Cephaloflexa bergi</i>			HQ026440	
<i>Choeradoplana iheringi</i>			HQ026428	Brasil
<i>Enterosyringia pseudorhynchodemus</i>		HQ026399		
<i>Geoplana burmeisteri</i>		DQ666004	DQ666039	Brasil
<i>Geoplana goetschi</i>			HQ026418	
<i>Geoplana ladislavii</i>			AF178315	Brasil
			HQ542890	
<i>Geoplana quagga</i>			DQ666040	Brasil
<i>Geoplana</i> sp.			DQ666043	Uruguay
<i>Notogynaphallia guaiana</i>			HQ542896	
<i>Notogynaphallia</i> sp.			DQ666047	Brasil

