RESEARCH ARTICLE



Three new species of the subgenus Otocepheus (Acrotocepheus) (Acari, Oribatida, Otocepheidae) from China

Li-Hao Zheng^{1,2,3}, Jun Chen^{1,2}

 Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beijing 100080, China 2 College of Life Sciences, University of Chinese Academy of Sciences, Beijing, 100049, China 3 Guang'an Vocational and Technical College, Guang'an, 638000, China

Corresponding author: Jun Chen (chenj@ioz.ac.cn)

Academic e	ditor: V. Pesic		Received 4 January 2020	I	Accepted 27 1	March	2020		Published 19 May	2020
		hti	tp://zoobank.org/84A89C53-9	39.	E-41FE-A0E6-3,	7390F	E7B7B	5		

Citation: Zheng L-H, Chen J (2020) Three new species of the subgenus *Otocepheus (Acortocepheus)* (Acari, Oribatida, Otocepheidae) from China. ZooKeys 934: 1–23. https://doi.org/10.3897/zookeys.934.49862

Abstract

Three new species of subgenus *Otocepheus* (*Acrotocepheus*): *O. (A.) digitatus* **sp. nov.**, *O. (A.) multigranulatus* **sp. nov.**, and *O. (A.) occultatus* **sp. nov.** are proposed and described based on adult material collected from China, and *O. (A.) duplicornutus* Aoki, 1965 is reported in China for the first time. A key to Chinese species of the subgenus *Acrotocepheus* is provided.

Keywords

oribatid mites, new species, new record, taxonomy, key

Introduction

The oribatid mite genus *Otocepheus* was first proposed by Berlese (1905) as a subgenus of *Carobodes* with two new species from Java, *Carabodes* (*Otocepheus*) *longior* and *C*. (*O.*) *crinitus*. Later, Berlese (1913) described another new species, *Otocepheus damoeoides*, and a variety, *O. longior* var. *minor*, both from Java, which suggested that the subgenus was promoted to the generic rank. Trägårdh (1931) recognized the generic status of the genus *Otocepheus* and selected *Carabodes* (*Otocepheus*) *longior* Berlese,

Copyright Li-Hao Zheng, Jun Chen. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1905 as the type species for the genus. At present, *Otocepheus* has three subgenera, *Otocepheus* (*Otocepheus*) Berlese, 1905, *Otocepheus* (*Aceotocepheus*) Aoki, 1965, and *Otocepheus* (*Hexatocepheus*) Wen, 1993, and comprises 53 species (Subías 2004, 2020).

The subgenus *Otocepheus* (*Acrotocepheus*) was proposed by Aoki (1965), with *O*. (*A*.) *quateorum* Aoki, 1965 as type. The subgeneric characters of *Otocepheus* (*Acrotocepheus*) were summarized by Aoki (1965), and identification keys to species from some regions and countries were presented by Aoki (1965) and Corpuz-Raros (2007).

Chen et al. (1992) recorded O. (A.) gracilis (Aoki, 1973) from Anhui, China, which was the first report of genus Otocepheus in China. The following year, Wen (1993) proposed the subgenus Otocepheus (Hexatocepheus) with O. (Hexatocepheus) emeiensis from Sichuan, China as type. Until now, only two subgenera and two species of Otocepheus were recorded in China (Chen et al. 2010). During studies of oribatid mites from China, we discovered three new species of subgenus Otocepheus (Acrotocepheus)–O. (A.) digitatus sp. nov., O. (A.) multigranulatus sp. nov., and O. (A.) occultatus sp. nov.–and the first record in China of O. (A.) duplicornutus Aoki, 1965. All four of these species are described, and an identification key for all known species of this subgenus in China is provided.

Materials and methods

The collection locality and habitat for each new species are given in the "Material examined".

Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration, except one specimen of *O. (A.) digitatus* sp. nov., which was mounted on a permanent slide with Hoyer's medium. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter-femur-genu-tibia-tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu-tibia-tarsus.

General terminology used in this paper follows that of Grandjean (1934), Aoki (1965, 1967), Norton (1977), and Norton and Behan-Pelletier (2009).

Abbreviations and notations

Prodorsum: *ro*, *le*, *in*, *bs*, *ex* – rostral, lamellar, interlamellar, bothridial, and exobothridial setae, respectively; *cos* – costula; *tu* – tutorium; *spa.l* – lamelliform expansion; *tbd*, *tbv* – dorsal and ventral bothridial plate, respectively; *cpm*, *cpl* – medial and lateral prodorsal condyles, respectively; *cex* – extral condyles.

Notogaster: c, la, lm, lp, h-row, p-row – notogastral setae; cnm, cnl – medial and lateral notogastral condyles, respectively; vm – vitta marginalis; ia, im, ip – anterior,

middle, posterior lyrifissures, respectively; *ih*, *ips* – same, associated with setal rows *h* and *p*, respectively; gla – opisthonotal gland opening.

Coxisternum and lateral podosoma: 1a, 1b, 1c, 2a, 3a, 3b, 3c, 4a, 4b, 4c – setae of epimeres I–IV; *met* – mentotectum; *cst* – carina sterinalis; *ap1* – apodeme I; *bo1* – epimeral border I; *Pd I, Pd II* – pedotectum I, II respectively; *spd* – sub pedotectum; *fep* – epimeral foramen; *dis* – discidium; *opp* – postpodosomal ornamentation.

Anogenital region: *g*, *ag*, *an*, *ad* – genital, aggenital, anal and adanal setae, respectively; *vr* – ventral ridge; *iag*, *iad* – aggenital, adanal lyrifissure respectively.

Gnathosoma: *lir* – lower lip ridge of mentum; *a*, *m* – anterior, middle seta of gena; *h* – hypostomal seta of mentum; *v*, *l*, *d*, *cm*, *acm*, *ul*, *su*, *vt*, *lt*, *sup*, *inf* – palp setae; ω – palp tarsal solenidion; *ep* – postpalpal seta; *cha*, *chb* – cheliceral setae; *cht* – tooth on dorsal chelicerae; *rbr* – rutellar brush; *ru* – rutellum; *Tg* – Trägårdh's organ.

Legs: σ , φ , ω – solenidia of genu, tibia and tarsus, respectively; ε – famulus of tarsus I; d, l, v – dorsal, lateral, ventral setae, respectively; ev, bv – basal trochanteral setae; ft, tc, it, p, u, a, s, pv – tarsal setae; Tr, Fe, Ge, Ti, Ta – trochanter, femur, genu, tibia, tarsus of legs, respectively.

Descriptions

Otocepheus (Acrotocepheus) digitatus sp. nov.

http://zoobank.org/BA165CB6-E780-4F37-942E-F7A36B42F2AE Figs 1–7

Diagnosis. Body size: 1020×330 . Body surface densely foveolate. Bothridial setae with a long fusiform head and a strongly curved peduncle. Lateral notogastral condyles finger-shaped, with wide base. Notogastral setae different in length, setae *lm*, *lp*, *h*₁, *h*₂, *p*₂ flagelliform and distinctly longer than the others. Genital plates each with two longitudinal, slant furrows.

Description. *Measurements* (holotype: male). Body length: 1020, notogaster width: 330. Setae length and mutual distance: *bs* 100, *in* 140, *le*180, *ro* 160, *ex* 25; *c*, *la*, h_3 , p_1 , p_3 range 100–160; *lm*, *lp*, h_1 , h_2 , p_2 range 300–450; *c*–*c* 120, *la*–*la* 160, *lm*–*lm* 190, *lp*–*lp* 240, h_2 – h_2 160, h_1 – h_1 170.

Integument. Body color light yellow-brownish. Body surface densely foveolate.

Prodorsum. Rostrum broadly rounded. Rostral seta moderately curved inward, densely barbed outside. Lamellar seta inserted behind tip of costula, curved inward, roughened externally. Interlamellar seta barbed, blunt at tip. Bothridial seta with a long fusiform head and a strongly curved peduncle. Exobothridial seta short. Bothridium opening laterally, dorsal bothridial plate straight or curved outward slightly, ventral bothridial plate broadly triangular in dorsal view. Tutorium well developed. Two pairs of prodorsal condyles present, lateral prodorsal condyles broadly rounded, median prodorsal condyles large and rounded, well separated from each other. Mutual distance



Figures 1–4. *Otocepheus (Acrotocepheus) digitatus* sp. nov., adult **I** bothridial setae **2** ventral view (legs not shown) **3** dorsal view **4** genital plate. Scale bars: 100 μm (**1**, **4**), 200 μm (**2**, **3**).

between ventral bothridial plates nearly equal with that between lateral prodorsal condyles. Subpedotectum well developed.

Notogaster. L/W of notogaster about 1.8. Surface of notogaster densely punctate. Anterior margin of notogater strait. Lateral notogastral condyles finger-shaped, with wide base. Median notogastral condyles absent. Ten pairs of notogastral setae glabrous, setae c, la, h_3 , p_1 , p_3 setiform and relatively short in length, while the rest notogastral setae lm, lp, h_1 , h_2 , p_2 flagelliform and longer in length. Setae c, la, lm nearly located on the same line. All lyrifissures well visible, ip located between setae p_2 and p_3 , ips between setae h_3 and p_3 . Opisthonotal gland opening located anterior and very close to lyrifissure im. Vitta marginalis distinct.

Epimeral and lateral podosomal regions. Apodemes I, II and sejugal well developed, apodeme III invisible. Carina sterinalis well developed. Epimeral setal formula 3-1-3-3. Seta 4a inserted between 4b and 4c, and closer to 4c. Epimeral setae 1b, 1c, 3b, 3c, 4a distinctly longer than the rest. Postpodosomal ornamentation invisible.

Anogenital region. Genital plates each with 2 longitudinal, slant furrows. Four pairs of genital setae (mutual distances $g_1-g_1 \approx g_2-g_2 \approx g_4-g_4 < g_3-g_3$). Aggenital lyrifissure located close and anterolateral to genital aperture. One pair of aggenital, two pairs of anal (mutual distances $an_1-an_1 < an_2-an_2$) and three pairs of adamal setae similar in length. Setae ad_3-ad_3 below level of anterior margin of anal opening. Adamal lyrifissure located in diagonal position and close to anal aperture, below level of anterior margin of anal opening.

Legs. Monodactylous. Claw of each leg strong and smooth. Formulae of leg setation and solenidia: I (1-4-3-4-16) [1-2-2], II (1-4-3-3-15) [1-1-2], III (2-3-1-2-15) [1-1-0], IV (1-2-2-2-12) [0-1-0]. Leg seta u setiform (L-type) on tarsi I, thorn-like (S-type) on tarsi II–IV. Homology of setae and solenidia indicated in Table 1.

Material examined. Holotype (male, LD-07-117): China, Hainan Province, Qiongzhong City, Limu Mountain, 19°6'18"N, 109°26'42"E, 616 m a.s.l., in soil and debris under reeds, 20 July 2007, collected by Dong Liu.

Type deposition. The holotype is deposited in the collection of the Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing (IZAS) (Zhang 2018).

Table 1. Leg setation and solenidia of adult *Otocepheus (Acrotocepheus) digitatus* sp. nov., *Otocepheus (Acrotocepheus) multigranulatus* sp. nov., *Otocepheus (Acrotocepheus) occultatus* sp. nov., and *Otocepheus (Acrotocepheus) duplicornutus* Aoki, 1965.

Leg	Tr	Fe	Ge	Ti	Ta
Ι	v'	d, (l), bv"	(<i>l</i>), <i>v</i> ', σ	$(l), (v), \varphi_1, \varphi_2$	(ft), (tc), (it), (p), (u), (a), s, (pv), ε , ω_1 , ω_2
II	v'	d, (l), bv"	(<i>l</i>), <i>v</i> ', σ	l', (ν), φ	$(ft), (tc), (it), (p), (u), (a), s, (pv), \omega_1, \omega_2$
III	v', l'	d, l', ev'	ľ, σ	(ν), φ	(ft), (tc), (it), (p), (u), (a), s, (pv)
IV	ν'	<i>d</i> , <i>ev</i> '	d, l'	(v), φ	ft'', (tc), (p), (u), (a), s, (pv)

Note: Roman letters refer to normal setae, Greek letters to solenidia (except ε = famulus). Single prime (') marks setae on the anterior and double prime (') setae on the posterior side of a given leg segment. Parentheses refer to a pair of setae.



Figures 5, 6. *Otocepheus (Acrotocepheus) digitatus* sp. nov., adult, microscope images **5** dorsal view **6** prodorsal and notogastral condyles, interlamellar and bothridial setae, notogastral setae *c*. Scale bar: 200 μm (**5**).



Figure 7. *Otocepheus (Acrotocepheus) digitatus* sp. nov., adult, microscope image, ventral view. Scale bar: 200 µm.

Etymology. The specific name "*digitatus*" is from Latin for "finger-like" refers to the finger-shaped lateral notogastral condyles.

Remarks. The new species is similar to *O*. (*A*.) *duplicornutus discrepans* (Balogh & Mahunka, 1967) from Vietnam and *O*. (*A*.) *bajau* Mahunka, 2000 from Malaysia in having similar shape of lateral notogastral condyles. However, it differs from *O*. (*A*.) *duplicornutus discrepans* by the flagelliform setae lm, lp, h_1 , h_2 , p_2 (versus blunt at tips), different length in notogastral setae (versus nearly same length), postpodosomal ornamentation invisible (versus markedly developed), bothridial setae with a long fusiform head (versus flattened distally); it differs from *O*. (*A*.) *bajau* by the flagelliform setae lm, lp, h_1 , h_2 , p_2 (versus setiform), setae c, la, h_3 , p_1 , p_3 shorter than the other notogastral setae (versus length increasing toward the posterior part of notogaster), lyrifissure *ips* located between h_3 and p_3 (versus between p_3 and p_2), surface of notogaster densely foveolate (versus granulate).

Otocepheus (Acrotocepheus) multigranulatus sp. nov.

http://zoobank.org/72F9B5C4-CEBC-49DC-9EFD-2D0D053C6CFA Figs 8–22

Diagnosis. Body size (n = 3): 1150–1240 × 530–609. Bothridial setae with a fusiform head. Lateral notogastral condyles wide, like staircase with two to three layers mainly. An extra pair of condyles (*cex*) located posterior to lateral prodorsal condyles, covered by lateral notogastral condyles. Bothridial seta with a fusiform head. Body surface densely granulate.

Description. *Measurements.* Body length: 1240 (holotype: female), 1150–1230 (two paratypes: all males); notogaster width: 609 (holotype), 530–600 (paratypes). Setae length and mutual distance (holotype): *bs* 160, *in* 200, *le* 210, *ro* 160, *ex* 35; *c*, *la*, *lm*, *lp*, h_1 , h_2 , h_3 , p_1 , p_2 , p_3 range 170–200; *c*–*c* 199, *la*–*la* 290, *lm*–*lm* 240, *lp*–*lp* 390, h_2 – h_2 260, h_1 – h_1 240.

Integument. Body color light yellow-brownish. Body surface densely granulate.

Prodorsum. Rostrum rounded. Rostral seta moderately curved inward, densely barbed outside. Lamellar seta inserted behind tip of costula, curved inward, roughened outside. Interlamellar seta barbed, setiform. Bothridial seta with a fusiform head. Exobothridial seta short. Bothridium opening laterally, dorsal bothridial plate straight, ventral bothridial plate broadly rounded in dorsal view. Tutorium well developed. Two pairs of prodorsal condyles present, lateral prodorsal condyles earlobe-shaped, median prodorsal condyles rounded, well separated from each other. An extra pair of condyles located posterior to lateral prodorsal condyles, covered by lateral notogastral condyles. Mutual distance between ventral bothridial plates larger than that between lateral prodorsal condyles. Subpedotectum well developed.

Notogaster. L/W of notogaster about 1.2. Surface of notogaster densely and obviously granulate. Anterior margin of notogaster straight. The largest width of notogaster medially, near level of seta *lp*. Lateral notogastral condyles wide, like a lateral view of



Figures 8–12. Otocepheus (Acrotocepheus) multigranulatus sp. nov., adult **8** seta ro **9** seta le **10** ventral view (legs not shown) **11** dorsal view **12** bothridial seta. Scale bars: 100 µm (**8, 9, 12**), 200 µm (**10, 11**).



Figures 13–15. *Otocepheus (Acrotocepheus) multigranulatus* sp. nov., adult, microscope images **13** dorsal view **14** ventral view **15** lateral view. Scale bars: 200 µm.



Figures 16–18. *Otocepheus (Acrotocepheus) multigranulatus* sp. nov., adult **16** subcapitulum, ventral view **17** right palp (without trochanter), abaxial view **18** right chelicera, adaxial view. Scale bars: 50 µm.

staircase with two to three steps mainly. Median notogastral condyles absent. Ten pairs of notogastral setae nearly same in length, barbed. A faint, short ridge present lateral to insertion of seta *c*. Mutual distance between setae p_1 lager than that between p_1 and p_2 . Seta *lm* and lyriffissure *im* nearly on same line. Five pairs of lyrifissures visible, *ip* located between setae p_2 and p_3 , *ips* between setae h_3 and p_3 . Opisthonotal gland opening located anterior to lyriffissure *im*. Vitta marginalis well developed, fainted anteriorly.

Epimeral and lateral podosomal regions. Apodemes I, II and sejugal well developed, apodeme III invisible. Carina sterinalis well developed. Epimeral setal formula 3-1-3-3. Seta *4a* inserted between *4b* and *4c*, and closer to *4c*. Postpodosomal ornamentation invisible.

Anogenital region. A pair of longitudinal ridges posterior to epimeral seta 4a. Genital plates smooth. Four pairs of genital setae (mutual distances $g_1-g_1\approx g_2-g_2 < g_4-g_4 < g_3-g_3$). Aggenital lyrifissure located close and anterolateral to genital aperture. One pair of aggenital, two pairs of anal (mutual distances $an_1-an_1 < an_2-an_2$) and three pairs of adanal setae. Anal and adanal setae barbed like notogastral setae. Setae ad_3-ad_3 below level of anterior margin of anal opening. Adanal lyrifissure situated anterior to level of seta ad_3 .

Gnathosoma. Subcapitular setae fistulous, barbed. Adoral setae and their alveoli absent. Rutellum pantelobasic, with typical dentition and rutellar brush. Chelicera chelatedentate; with a minute denticle proximal to seta *cha*; *cha* longer than *chb*, both of them setiform, barbed; Trägårdh's organ narrowly triangular. Palp with usual setal formula: 0-2-1-3-8 (+ ω); setae of *femur* to tibia barbed. Tarsus with four short, blunt distal eupathidia–*acm*, *su*, (*ul*); other tarsal setae smooth or with sparse, inconspicuous barbs; solenidion ω connected with seta *ul*', seta *ul*' medioanteriorly. Postpalpal seta erect, smooth.



Figures 19–22. Otocepheus (Acrotocepheus) multigranulatus sp. nov., adult: leg I–IV, right, antiaxial view. Scale bars: 100 μm (**19–22**).

Legs. Monodactylous. Claw of each leg strong and smooth. Formulae of leg setation and solenidia: I (1-4-3-4-16) [1-2-2], II (1-4-3-3-15) [1-1-2], III (2-3-1-2-15) [1-1-0], IV (1-2-2-2-12) [0-1-0]. Leg seta *u* setiform (L-type) on tarsi I, thorn-like (S-type) on tarsi II–IV. Homology of setae and solenidia indicated in Table 1.

Material examined. Holotype (female, LD-08-10): China, Hunan Province, Yanling County, Taoyuan Dong, 26°17'42"N, 114°1'15"E, 1065 m a.s.l., in soil and debris under trees, 6 July 2008, collected by Dong Liu. Two paratypes (males, LD-08-49): China, Hunan Province, Guidong County, Xinlong Village, 26°4'29"N, 113°46'53"E, 1525 m a.s.l., in soil and debris under trees, 12 July 2008, collected by Dong Liu.

Type deposition. All type specimens are deposited in the collection of IZAS.

Etymology. The specific name "*multigranulatus*" is from Latin for "granulate" and is in reference to the uneven, granular body surface.

Remarks. The new species is similar to *O*. (*A*.) *lienhardorum* Mahunka, 2000 from Malaysia, *O*. (*A*.) *macrodentatus* Hammer, 1981 from Java, and *O*. (*A*.) *holtmanni* Aoki, 1965 from New Guinea in having similar shaped lateral notogastral condyles. However, it differs from *O*. (*A*.) *lienhardorum* by the granulate ventral plate (versus foveolate), notogastral setae nearly same in length (versus setae p_1-p_3 and h_3 long), bothridial seta with a fusiform head (versus markedly developed), and seta *Ia* well visible (versus minute or absent). It differs from *O*. (*A*.) *macrodentatus* by the epimeral setal formula 3-1-3-3 (versus 3-1-2-3), normal seta h_3 (versus much smaller and thinner than the other notogasral setae), surface of notogaster densely, and obviously granulate (versus minutely and densely punctured), lyrifissure *ips* located between setae h_3 and p_3 (versus anterior to seta h_3), the largest width of notogaster medially, near level of seta *lp* (versus the largest width rather anteriorly, near level of seta *lm*), vitta marginalis well developed, faint anteriorly (versus vitta marginalis visible only on anterior half of notogaster).

Otocepheus (Acrotocepheus) occultatus sp. nov.

http://zoobank.org/16C79F8A-145D-40B4-9204-E2D6DC7124A0 Figs 23–29

Diagnosis. Body size (n = 4): 1240–1410 × 560–670. Bothridial seta with a long fusiform head and a short peduncle. Lateral prodorsal condyles on prodorsum small, rounded, lateral prodorsal condyles markedly anterior to medial prodorsal condyles. An extra pair of condyles located posterior to lateral prodorsal condyles, covered by lateral notogastral condyles. Lateral notogastral condyles large, width nearly equal with their mutual distance, tips markedly anterior to medial prodorsal condyles. Anterior median part of mentum with a lower lip ridge.

Description. *Measurements*. Body length: 1280 (holotype: female), 1240–1410 (three paratypes: one female and two males); notogaster width: 530 (holotype), 560–670 (paratypes). Setae length and mutual distance (holotype): *bs* 85, *in* 220, *le* 235, *ro*

175, ex 19; c, la, lm, lp, h₁, h₂, h₃, p₁, p₂, p₃ range 150–300; *c*-*c* 200, *la*-*la* 300, *lm*-*lm* 230, *lp*-*lp* 350, h₂-h₂ 225, h₁-h₁ 230.

Integument. Body color light yellow-brownish. Body surface densely foveolate.

Prodorsum. Rostrum rounded. Rostral seta curved inward, densely barbed outside. Lamellar seta inserted behind tip of costula, moderately curved inward, roughened outside. Interlamellar seta barbed, setiform. Bothridial seta with a long fusiform head and a short peduncle. Exobothridial seta short. Costula straight, nearly paralleled. Bothridium opening laterally, dorsal bothridial plate straight, ventral bothridial plate broadly rounded in dorsal view. Lamelliform expansion pointing to bottom of seta *ro*. Two pairs of prodorsal condyles present. Lateral prodorsal condyles small, rounded, markedly anterior to medial prodorsal condyle. Median prodorsal condyles small, rounded, well separated from each other. An extra pair of condyles located posterior to lateral prodorsal condyles, covered by lateral notogastral condyles. Mutual distance between ventral bothridial plates larger than that between lateral prodorsal condyles. Subpedotectum well developed.

Notogaster. L/W of notogaster about 1.3. Surface of notogaster densely punctate. Lateral notogastral condyles large, triangular and rounded distally, inner part with a narrow base, anteromedial margins distinctly excavated, width nearly equal with their mutual distance, tips markedly anterior to medial prodorsal condyles. Medial notogastral condyles absent. Ten pairs of notogastral setae, slightly barbed, setae located posteriorly tend whip-like at tips. All lyrifissures well visible, *ip* located between setae p_2 and p_3 , *ips* between setae h_3 and p_3 . Opisthonotal gland opening located posterior to lyrifissure *im*. Vitta marginalis distinct.

Epimeral and lateral podosomal regions. Surface punctured. Apodemes II and sejugal well developed, apodeme III invisible. Carina sterinalis short. Epimeral setal formula 3-1-3-3. Seta 4a inserted between 4b and 4c, and closer to 4c. Postpodosomal ornamentation invisible.

Anogenital region. A pair of longitudinal ridges posterior to epimeral setae 4a. Genital plates with two or three longitudinal ridges on both sides. Four pairs of genital setae smooth (mutual distances $g_1-g_1\approx g_2-g_2\approx g_4-g_4 < g_3-g_3$). Aggenital lyrifissure located close and anterolateral to genital aperture. One pair of aggenital, two pairs of anal (mutual distances $an_1-an_1 < an_2-an_2$), and three pairs of adanal setae. Anal setae barbed and blunt at tips, adanal setae barbed and whip-like at tips. Seta an_2 well separated from outer margin of anal plate. Location of adanal setae normal, inside external margin of ventral plate. Setae ad_3-ad_3 below level of anterior margin of anal opening. Adanal lyrifissure located in diagonal position and close to anal aperture.

Gnathosoma. Anterior median part of mentum with a lower lip ridge. Subcapitular setae relatively smooth. Adoral setae and their alveoli absent. Rutellum pantelobasic, with typical dentition and rutellar brush. Chelicera chelate-dentate; with a minute denticle proximal to seta *cha*; *cha* longer than *chb*, both of them setiform, barbed; Trägårdh's organ narrowly triangular. Palp with usual setal formula: 0-2-1-3-8 (+ ω); setae of femur to tibia barbed. Tarsus with four short, blunt distal eupathidia–*acm*, *su*,



Figures 23–26. *Otocepheus (Acrotocepheus) occultatus* sp. nov., adult 23 bothridial seta 24 ventral view (legs not shown) 25 dorsal view 26 lateral lamelliform expansion. Scale bars: 100 μ m (23, 26), 200 μ m (24, 25).



Figure 27. *Otocepheus (Acrotocepheus) occultatus* sp. nov., adult: lateral view (legs not shown). Scale bar: 200 µm.

(*ul*); other tarsal setae smooth or with sparse, inconspicuous barbs; solenidion ω connected with seta *ul*, seta *ul*, medioanteriorly. Postpalpal seta erect, smooth.

Legs. Monodactylous. Claw of each leg strong and smooth. Formulae of leg setation and solenidia: I (1-4-3-4-16) [1-2-2], II (1-4-3-3-15) [1-1-2], III (2-3-1-2-14) [1-1-0], IV (1-2-2-2-12) [0-1-0]. Leg seta u setiform (L-type) on tarsi I, thorn-like (S-type) on tarsi II–IV. Homology of setae and solenidia indicated in Table 1.

Material examined. Holotype (male, ZLH-12-34): China, Guangxi Province, Wuming County, Daming Mountain, 23°29'42"N, 108°26'17"E, 1223 m a.s.l., in soil and debris under bush, 17 July 2012, collected by Lihao Zheng. Three paratypes (one female and two males, ZLH-12-37): same locality as holotype, 23°28'51"N, 108°27'18"E, 1410 m a.s.l., in soil and debris under tree, 20 July 2012, collected by Lihao Zheng.

Type deposition. All type specimens are deposited in the collection of IZAS.

Etymology. The specific name "*occultatus*" is from Latin for "hiding", in reference to the extra condyles which are covered by the large lateral notogastral condyles.

Remarks. The new species is most similar to O. (A.) bajau Mahunka, 2000 from Malaysia and O. (A.) consimilis (Balogh, 1970) from Ceylon in having large lateral prodorsal condyles. However, it differs from O. (A.) bajau by the extra condyles on prodorsum covered by lateral notogastral condyles (versus none), bothridial seta with a long fusiform head (versus with a lanceolate head), tarsus I normal (versus with triangular teeth), and it differs from O. (A.) consimilis by the lateral prodorsal condyles nearly in same line with median prodorsal condyles), seta an_2 well separated from outer margin of anal plate (versus very close to outer margin of anal plate), notogastral setae located posteriorly tend whip-like at tips (versus not), normal location of adanal setae,



Figures 28–30. *Otocepheus (Acrotocepheus) occultatus* sp. nov., adult. **28** subcapitulum, ventral view **29** right palp, abaxial view **30** right chelicera, adaxial view. Scale bars: 50 μm.

and inside external margin of ventral plate (versus arising on and parallel with external margin of ventral plate).

Otocepheus (Acrotocepheus) duplicornutus Aoki, 1965: new record in China Figs 31–39

Otocepheus (Acrotocepheus) duplicornutus Aoki 1965: 303. Otocepheus (Acrotocepheus) duplicornutus discrepans (A.): Balogh & Mahunka 1967: 49.

Diagnosis. Body size (n = 4): 1150–1400 × 480–600. Body ratio (length/width): 2.3–2.4. Lateral notogastral condyles appears to be double-structured, the outer portion of lateral notogastral condyles triangular anteriorly. Medial notogastral condyles absent. Postpodosomal ornamentation well developed. A pair of longitudinal ridges posterior to epimeral setae 4a present.

Description. *Measurements.* Body length: 1150–1400 (four males), notogaster width: 480–600 (four males). Setae length and mutual distance (one male, ZLH-12-73): *bs* 150, *in* 215, *le* 190, *ro* 150, *ex* 35; *c*, *la*, *lm*, *lp*, h_1 , h_2 , h_3 , p_1 , p_2 , p_3 range 250–300; *c*–*c* 110, *la–la* 190, *lm–lm* 160, *lp–lp* 260, h_2 – h_2 180, h_1 – h_1 190.

Integument. Body color light brown, but genital plates and legs dark brown. Body surface densely foveolate.

Prodorsum. Rostrum rounded. Seta *ro* moderately curved inward, densely barbed outside. Seta *le* removed backward from tip of costula, curved inward, roughened externally. Setae *le* and *in* slightly barbed, with blunt tips. Bothridium opening laterally, dorsal bothridial plate nearly straight, ventral bothridial plate broadly triangular in dorsal view. Bothridial seta with lanceolate head, slightly roughened. Seta *ex* short, setiform. Tutorium developed. Lamelliform expansion pointing to bottom of seta *ro*. Costula well developed. Prodorsal condyles broadly rounded, well separated from each other. Subpedotectum well developed. Extra condyles posterior to lateral prodorsal condyles invisible.

Notogaster. Anterior margin of notogater weakly concaved. Lateral notogastral condyles appears to be double-structured, the outer portion of lateral notogastral condyles triangular anteriorly. Medial notogastral condyles absent. Notogaster with ten pairs of setae, setiform, slightly barbed. Lyrifissures distinct, *ip* between setae p_2 and p_3 , *ips* between setae h_3 and p_3 , *ih* anterior to seta h_3 , *im* interiorly to opisthonotal gland opening.

Epimeral and lateral podosomal regions. Apodemes II and sejugal well-developed, apodeme III invisible, epimeral foramen small and rounded. Epimeral setal formula: 3-1-3-3. Setae setiform, *4a* inserted between *4b* and *4c*, and closer to *4c*. Postpodosomal ornamentation well developed.

Anogenital region. Aggenital lyrifissure located close and anterolateral to genital aperture. A pair of longitudinal ridges posterior to epimeral seta 4a present. Genital plates smooth. Four pairs of genital setae (mutual distances $g_1-g_1 \approx g_2-g_2 \approx g_4-g_4 < g_3-g_3$) and one pair of aggenital setae present, setiform and slightly barbed. Three pairs of adanal and two pairs of anal setae (mutual distance $an_1-an_1 < an_2-an_2$) slightly barbed. Setae ad_3-ad_3 below level of anterior margin of anal opening. Adanal lyrifissure located in diagonal position and close to anal aperture (in some specimens one of the adanal lyrifissures aligned transversely while the other one aligned diagonally), below level of anterior margin of anal opening.

Gnathosoma. Subcapitular setae fistulous, barbed. Adoral setae and their alveoli absent. Rutellum pantelobasic, with typical dentition and rutellar brush. Chelicera chelate-dentate; with a minute denticle proximal to seta *cha*; *cha* longer than *chb*, both of them setiform, barbed; Trägårdh's organ narrowly triangular. Palp with usual setal formula: 0-2-1-3-8 (+ ω); setae of femur to tibia barbed. Tarsus with four short, blunt distal eupathidia – *acm*, *su*, (*ul*); other tarsal setae smooth or with sparse, inconspicuous barbs; solenidion ω connected with seta *ul*', seta *ul*'' medioanteriorly. Postpalpal seta erect, smooth.

Legs. Claw of each leg strong and smooth. Formulae of leg setation and solenidia: I (1-4-3-4-16) [1-2-2], II (1-4-3-3-15) [1-1-2], III (2-3-1-2-15) [1-1-0], IV (1-2-2-2-12) [0-1-0]. Leg seta *u* setiform (L-type) on tarsi I, thorn-like (S-type) on tarsi II–IV. Homology of setae and solenidia indicated in Table 1.

Material examined. One male (ZLH-12-72): China, Guangxi Province, Longzhou County, 22°25'19"N, 106°58'12"E, 149 m a.s.l., in soil and debris beside deadwood, 3 August 2012; one male (ZLH-12-73): same locality as ZLH-12-72, 22°25'11"N,



Figures 31–33. *Otocepheus (Acrotocepheus) duplicornutus* Aoki, 1965, adult **31** Dorsal view **32** bothridial seta **33** ventral view (legs not shown). Scale bars: 200 μm (**31, 33**), 100 μm (**32**).



Figures 34–36. *Otocepheus (Acrotocepheus) duplicornutus* Aoki, 1965, adult, microscope images **34** dorsal view **35** ventral view **36** lateral view. Scale bars: 200 μm.



Figures 37–39. *Otocepheus (Acrotocepheus) duplicornutus* Aoki, 1965, adult **37** subcapitulum, ventral view **38** right palp, abaxial view **39** left chelicera, adaxial view. Scale bars: 50 μm.

106°58'6"E, 154 m a.s.l., in soil and debris beside deadwood, 3 August 2012; one male (ZLH-12-74): same locality as ZLH-12-72, 22°25'7"N, 106°58'2"E, 166 m a.s.l., in soil and debris under liana, 3 August 2012; one male (ZLH-12-77): China, Guangxi Province, Fusui County, 22°27'36"N, 107°53'24"E, 100 m a.s.l., in soil and debris under leaf wood, 8 August 2012. All specimens were collected by Lihao Zheng.

Specimen deposition. Specimens are deposited in the collection of IZAS.

Remarks. The morphological characters of specimens checked in this study are almost coincident with the original description of this species by Aoki (1965), which was based on material collected from Sara Buri, Thailand, except for the following delicate differences: arc degrees of prodorsal condyles (broadly rounded versus semicircular) and alignment of adanal lyrrifissure (located in diagonal position versus generally aligned transversely). Though these characters are relatively constant in our limited specimens, the shape of prodorsal or notogastral condyles, as well as the alignment of adanal lyrrifissure, sometimes vary. So, we temporarily treat these minor differences as normal individual variation.

Key to known species of Otocepheus (Acrotocepheus) from China

1	Notogastral setae not longer than distance from nearest one
_	Notogastral setae distinctly longer than distance from nearest one2

2 Surface of notogaster with densely small convex granules, lateral notogastral condyles wide, like a lateral view of staircase with two to three steps mainly ... Surface of notogaster densely foveolate, lateral notogastral condyles not as 3 Lateral notogastral condyles finger-shaped with wide base, notogastral setae c_{i} la, b_3, p_1, p_3 setiform and relatively short in length, while the rest flagelliform and distinctly longer in length O. (A.) digitatus sp. nov. Lateral notogastral condyles portion triangulate, notogastral setae nearly equal in length......4 4 A pair of extra condyles covered by lateral notogastral condyles, anterior median part of mentum with a lower lip ridge, notogastral setae located pos-No extra condyles under lateral notogastral condyles present, anterior median part of mentum relatively flat, all notogastral setae setiform, without whiplike tipes O. (A.) duplicornutus Aoki, 1965

Acknowledgements

We cordially thank all the collectors of the specimens that we studied for this paper. Many thanks go to the anonymous reviewers and the subject editor, Dr Vladimir Pešić, for their thorough reviews of this manuscript and their many valuable suggestions. This work was supported by the National Natural Science Foundation of China (no. 31372155), the Ministry of Science and Technology of the People's Republic of China (MOST grant no. 2016YFE0203100, 2005DKA21402), and the Second Tibetan Plateau Scientific Expedition and Research (STEP) program (grant no. 2019QZKK0501).

References

- Aoki J (1965) A preliminary revision of the family Otocepheidae (Acari, Cryptostigmata). I. Subfamily Otocepheinae. Bulletin of the National Science Museum 8 (3): 258–341.
- Aoki J (1967) A preliminary revision of the family Otocepheidae (Acari, Cryptostigmata). II. Subfamily Tetracondylinae. Bulletin of the National Science Museum 10 (3): 297–359.
- Aoki J (1973) Oribatid mites from Iriomote-jima, the southernmost island of Japan (I). Memoirs of the National Science Museum 6: 85–101.
- Balogh J (1970) New oribatids (Acari) from Ceylon. The scientific results of the Hungarian soil zoological expeditions. Opuscula Zoologica 10(1): 33–67.
- Balogh J, Mahunka S (1967) New oribatids (Acari) from Vietnam. Acta Zoologica Academiae Scientiarum Hungaricae 13 (1–2): 39–74.
- Berlese A (1905) Acari nuovi. Manipulus IV (Acari di Giava). Redia 2: 154–176.
- Berlese A (1913) Acari nuovi. Redia 9: 77-111.

- Chen J, Liu D, Wang HF (2010) Oribatid mites of China: a review of progress, with a checklist. Zoosymposia 4: 186–224. https://doi.org/10.11646/zoosymposia.4.1.14
- Corpuz-Raros LA (2007) Otopentacepheus new genus, seven new species and one new record of Otocepheinae (Acari: Oribatida: Otocepheidae) from the Philippines. Philippine Entomologist 21(1): 76–99.
- Grandjean F (1934) Les poils des épimères chez les oribates (acariens). Bulletin du Museum 6(6): 504–512.
- Hammer M (1981) On some oribatid mites from Java. I. Acarologia, 22(1): 81-99.
- Mahunka S (2000) Oribatids from Sabah (East Malaysia) VIII (Acari: Oribatida: Dampfiellidae and Otocepheidae). (Acarologica Genavensia LXXXVI). Revue Suisse de Zoologie 107(4): 675–720. https://doi.org/10.5962/bhl.part.80144
- Norton RA (1977) A review of F. Grandjean's system of leg chaetotaxy in the Oribatei (Acari) and its application to the family Damaeidae. In: Dindal DL (Ed.), Biology of Oribatid Mites. SUNY College of Environmental Science and Forestry, Syracuse, 33–61.
- Norton RA, Behan-Pelletier VM (2009) Oribatida. In: Krantz GW, Walter DE (Eds) A Manual of Acarology. Texas Tech University Press, Lubbock, 430–564.
- Subías LS (2004) Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes: Oribatida) del mundo (excepto fósiles). Graellsia 60 (número extraordinario): 3–305. https://doi.org/10.3989/graellsia.2004.v60.iExtra.218
- Subías LS (2020) Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes: Oribatida) del mundo (excepto fósiles). [Version 15, updated January 2020]. http://bba.bioucm.es/cont/docs/RO_1.pdf [Accessed on: 2020-4-1]
- Trägårdh I (1931) Acarina from the Jun Fernandez Islands. The Natural History of Juan Fernandez and Easter Island 3: 553–628.
- Zhang ZQ (2018) Repositories for mite and tick specimens: acronyms and their nomenclature. Systematic & Applied Acarology 23(12): 2432–2446. https://doi.org/10.11158/ saa.23.12.12

RESEARCH ARTICLE



Review of the genus Chasmogenus Sharp, 1882 of northeastern South America with an emphasis on Venezuela, Suriname, and Guyana (Coleoptera, Hydrophilidae, Acidocerinae)

Rachel R. Smith¹, Andrew Edward Z. Short¹

l Department of Ecology & Evolutionary Biology, and Division of Entomology, Biodiversity Institute, University of Kansas, Lawrence, KS 66045, USA

Corresponding author: Rachel R. Smith (rr.smith816@ku.edu); Andrew Edward Z. Short (aezshort@ku.edu)

Academic editor: M. Michat Received 12 December 2019 Accepted 5 March 2020	Published 19 May 2020
- http://zoobank.org/B9F2C8D8-C031-4191-B6F5-1E78D4D6881E	

Citation: Smith RR, Short AEZ (2020) Review of the genus *Chasmogenus* Sharp, 1882 of northeastern South America with an emphasis on Venezuela, Suriname, and Guyana (Coleoptera, Hydrophilidae, Acidocerinae). ZooKeys 934: 25–79. https://doi.org/10.3897/zookeys.934.49359

Abstract

The water scavenger beetle genus *Chasmogenus* Sharp, 1882 is reviewed in northeastern South America using an integrative approach that combines adult morphology and molecular data from the gene cy-tochrome c oxidase I (COI). Eighteen new species are described: *Chasmogenus acuminatus* **sp. nov**. (Brazil, French Guiana, Guyana, Suriname), *C. amplius* **sp. nov**. (Venezuela), *C. berbicensis* **sp. nov**. (Guyana), *C. brownsbergensis* **sp. nov**. (Suriname), *C. castaneus* **sp. nov**. (Venezuela), *C. clavijoi* **sp. nov**. (Venezuela), *C. clavijoi* **sp. nov**. (Venezuela), *C. gato* **sp. nov**. (Venezuela), *C. guianensis* **sp. nov**. (Venezuela), *C. ignotus* **sp. nov**. (Venezuela), *C. gato* **sp. nov**. (Suriname), *C. ignotus* **sp. nov**. (Brazil), *C. ligulatus* **sp. nov**. (Suriname), *C. lineatus* **sp. nov**. (Venezuela), *C. pandus* **sp. nov**. (Brazil, French Guiana, Suriname), *C. schmits* **sp. nov**. (Suriname), *C. sinnamarensis* **sp. nov**. (French Guiana), *C. tafelbergensis* **sp. nov**. (Suriname), and *C. undulatus* **sp. nov**. (Guyana). We found genetic support for an additional new species in Guyana which is currently only known from females that we refer to as *Chasmogenus* **sp.** C. We examined the holotypes of the four species previously known from the region, and found that *C. occidentalis* García syn. nov. and *C. yukparum* García syn. nov. are conspecific with *C. bariorum* García, 2000 and are synonymized with that species, which is here redescribed. We redescribe *C. australis* García and expand the range of this species to include northern Brazil, Guyana, and French Guiana. All species are aquatic, with most being associated with forested

Copyright R.R. Smith, A.E.Z. Short. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

streams and forest pools. Of the 21 species, more than half (11) are only known from a single locality indicating the genus may have many more micro-endemic species yet to be discovered in the region. Characters of the male genitalia are essential for confirming the identity of some species, consequently it is not always possible to make positive identifications of unassociated female specimens based on morphology alone. Habitus images are provided as well as a revised key to the genus for northeastern South America.

Keywords

South America, aquatic beetles, new species, new synonymy, taxonomy

Introduction

The water scavenger beetle genus *Chasmogenus* Sharp (Hydrophilidae: Acidocerinae) is a widespread lineage that occurs in all regions except the Nearctic. Although the genus contains more than 45 described species worldwide, the Neotropical region has been poorly studied and contains only 15 described species (Clarkson and Ferreira-Jr 2014, Short 2005). Fieldwork over the last decade has generated thousands of new specimens of the genus from northern South America, particularly Venezuela, Suriname, and Guyana. Recent studies by García (2000; Venezuela) and Clarkson and Ferreira-Jr (2014; southeastern Brazil) have begun to elucidate the diversity of this genus in South America; however, it still remains largely unknown on the continent. This is partly due to the low degree of morphological variation between species, making identification and even routine morphospecies sorting a substantial challenge. Here, we take an integrative approach utilizing both adult morphology and molecular data from the mitochondrial gene cytochrome c oxidase I (COI) to review the genus for northeastern South America.

Materials and methods

Morphological methods

Morphological terminology largely follows Hansen (1991) except for the use of mesoand metaventrite instead of meso- and metasternum. All specimens were examined with an Olympus SZX7 (to 56× magnification) microscope. Measurements were taken with an ocular micrometer. Habitus photographs were taken with a Visionary Digital imaging system. All final images were created by stacking multiple individual photographs from different focal planes using the software Zerene Stacker. Males chosen for dissection were relaxed in 70% ethanol for at least eight hours and genitalia were cleared in warm 10% KOH solution in a water bath for approximately one hour. Cleared genitalia were placed and stored on slides in glycerin. Between 7–25 photos of genitalia were taken using an Olympus SZX16 (to 110×) and an Olympus BX51 (to 200×) and compiled via the focus stacking software CombineZP. We used Simplemappr (Shorthouse 2010) to create the distribution maps.

Molecular methods

Total genomic DNA extractions were performed on whole beetles using a DNeasy tissue kit (Qiagen, Alameda, CA). Vouchers (Table 1) are deposited at the University of Kansas (Lawrence, KS, USA) unless otherwise indicated in the material examined section. We sequenced multiple populations of species that were widely distributed. We amplified the mitochondrial gene COI using the primers and protocols given in Short and Fikáček (2013). Amplification was successful for all species except for *C. castaneus* (for which an attempt to extract and amplify DNA from a pinned specimen failed) and *C. tafelbergensis* (which was a fresh specimen). We assembled and edited the resulting DNA sequences in Geneious 8.0.5 (Biomatters, http://www.geneious.com). We also used Geneious to calculate raw pairwise distances between sequences. All newly generated sequences are deposited in GenBank (Table 1). We used the IQ-Tree webserver (Nguyen et al. 2015) to conduct a maximum likelihood analysis on the COI data. The optimal model of substitution was selected using the Auto function in IQ-TREE. To assess nodal support, we performed 1000 ultrafast bootstrap replicates (Minh et al. 2013). We included the Central American species *Chasmogenus ruidus* Short, 2005 to root the tree (GenBank accession KC935240).

Depositories of examined material

CBDG	Center for Biological Diversity, University of Guyana, Georgetown
INPA	Instituto Nacional de Pesquisas da Amazônia, Colecão Sistemática da
	Entomologia, Manaus, Brazil (N. Hamada)
MALUZ	Museo de Artrópodos de la Universidad del Zulia, Maracaibo, Ven-
	ezuela (J. Camacho, M. García)
MIZA	Museo del Instituto de Zoología Agrícola, Maracay, Venezuela (L. Joly)
NZCS	National Zoological Collection of Suriname, Paramaribo (A. Ganga-
	din, V. Kadosoe)
SEMC	Snow Entomological Collection, University of Kansas, Lawrence, KS
	(A. Short)
USNM	U.S. National Museum of Natural History, Smithsonian Institution,
	Washington, DC (C. Micheli).

Results

The results of the Maximum Likelihood analysis (Fig. 1) found all morphological species recognized here to be reciprocally monophyletic. The smallest interspecific raw divergence between any species pair was 7.1% (between *C. pandus* and *C. ligulatus*) followed by 7.2% (between *C. amplius* and *C. clavijoi*). The sequence divergence between all other species was greater than 8.0%. The maximum intraspecific raw sequence divergence was 2.1% (most were below 1.0%) with one exception: the distance between individuals of *C. acuminatus* was as high as 6.0%, which we discuss further below. A table showing the pairwise genetic distances between all individuals is shown in Suppl. material 1: Table S1.

Taxon	Voucher	Country: State/Site: Coordinates	Accession number
C. acuminatus	SLE445	Suriname: Kwamala: 2.175350, -56.787399	MT052762
	SLE516	French Guiana: Petit-Saut: 5.070, -53.029	MT052775
	SLE1081	Suriname: Raleighvallen: 4.681833, -56.185635	MT052770
	SLE1086	Guvana: Parabara: 2.108200, -59.227551	MT052760
	SLE1619	Suriname: Sipaliwini: 2.005700, -55.969151	MT052766
	SLE1623	Brazil: Para: -1.49292, -54,51566	MT052761
	SLE1804	Suriname: Kabalebo: 4.42313, -57,19198	MT052772
	SLE1805	Suriname: Kabalebo: 4.42313, -57,19198	MT052773
	SLE1820	Suriname: Kwamala: 2,182883, -56,787251	MT052765
	SLE1822	Suriname: Werehpai: 2.362933, -56.697681	MT052763
	SLE1823	Suriname: Werehpai: 2.362933, -56.697681	MT052764
	SLE1830	Suriname: Kappel: 3.791317, -56.149467	MT052767
	SLE1838	Suriname: Voltzberg: 4.673867, -56,184650	MT052769
	SLE1839	Suriname: Voltzberg: 4.673867, -56,184650	MT052768
	SLE1840	French Guiana: Petit-Saut: 5.09794, -53.06402	MT052776
	SLE1849	Suriname: Raleighvallen: 4,708000, -56,219318	MT052774
	SLE1850	Brazil: Amapá: 3.65822, -51.76958	MT052771
C. amplius	SLE1201	Venezuela: Amazonas: 4,980750, -67,739082	MT052788
C. australis	SLE1080	Venezuela: Barinas: 8.282567, -70.397781	MT052781
	SLE1082	Venezuela: Zulia: 10.043017, -71.007133	MT052782
	SLE1615	Guvana: Zilda Wao: 2.828733, -59.809101	MT052783
	SLE1621	Venezuela: Monagas: 9.096633, -62.726967	MT052780
	SLE1624	Brazil: Roraima: 0.730611, -60.432806	MT052784
	SLE1629	Brazil: Roraima: 3.305800, -60.857633	MT052779
	SLE1774	Brazil: Roraima: 1.58485, -61.001967	MT052778
	SLE1856	French Guiana: Yiyi: 5.419, -53.050	MT052777
C. bariorum	SLE078	Venezuela: Aragua: 10.373190, -67.742500	MT052749
	SLE530	Venezuela: Aragua: 10.373190, -67.742500	MT052747
	SLE531	Venezuela: Aragua: 10.373190, -67.742500	MT052748
	SLE534	Venezuela: Zulia: 9.841500, -72.821831	MT052745
	SLE1613	Venezuela: Guárico: 9.772017, -67.353348	MT052746
C. berbicensis	SLE1864	Guyana: Berbice: 4.146817, -58.237202	MT052787
C. brownsbergensis	SLE1828	Suriname: Brownsberg: 4.947850, -55.181850	MT052790
Ū	SLE1861	Suriname: Brownsberg: 4.948900, -55.180416	MT052791
C. clavijoi	SLE1198	Venezuela: Guarico: 8.138267, -66.407654	MT052789
C. cuspifer	SLE532	Venezuela: Zulia: 10.373190, -67.742500	MT052750
	SLE533	Venezuela: Zulia: 9.841500, -72.821831	MT052751
C. flavomarginatus	SLE1083	Venezuela: Barinas: 8.807067, -70.518982	MT052740
	SLE1084	Venezuela: Tachira: 7.58396, -72.17233	MT052742
	SLE1235	Venezuela: Barinas: 8.807067, -70.518982	MT052741
C. gato	SLE1202	Venezuela: Amazonas: 4.980750, -67.739082	MT052785
C. guianensis	SLE1616	Guyana: Berbice: 4.154817, -58.178616	MT052792
	SLE1821	Suriname: Sipaliwini: 2.182883, -56.787251	MT052798
	SLE1826	Suriname: Palumeu: 2.477000, -55.629410	MT052800
	SLE1827	Suriname: Palumeu: 2.477000, -55.629410	MT052797
	SLE1834	Guyana: Berbice: 4.154817, -58.178616	MT052796
	SLE1835	Guyana: Berbice: 4.154817, -58.178616	MT052799
	SLE1836	Guyana: Berbice: 4.154817, -58.178616	MT052795
	SLE1862	Guyana: Berbice: 4.154817, -58.178616	MT052793
	SLE1863	Suriname: Palumeu: 2.477000, -55.629410	MT052794
C. ignotus	SLE1844	Brazil: Amazonas: -2.93079, -59.97514	MT052753

Table 1. List specimens and GenBank accession numbers used in this study.

Taxon	Voucher	Country: State/Site: Coordinates	Accession number
C. ligulatus	SLE474	Suriname: Sipaliwini: 2.977310, -55.384998	MT052759
C. lineatus	SLE1061	Venezuela: Lara: 10.1543, -69.9576	MT052743
	SLE1614	Venezuela: Guárico: 9.772017, -67.353348	MT052744
	SLE1772	Venezuela: Bum Bum: 8.300550, -70.753349	MT052742
C. pandus	SLE1858	Brazil: Amapa: 3.85039, -51.81683	MT052801
C. schmits	SLE1824	Suriname: Kutari: 2.175350, -56.787399	MT052786
C. sinnamarensis	SLE077	French Guiana: Petit-Saut: 5.070, -53.029	KC935241
	SLE517	French Guiana: Petit-Saut: 5.070, -53.029	MT052752
C. undulatus	SLE1618	Guyana: Region 8: 5.304350, -59.837616	MT052756
	SLE1831	Guyana: Region 8: 5.304350, -59.837616	MT052755
	SLE1832	Guyana: Region 8: 5.304350, -59.837616	MT052754
	SLE1833	Guyana: Region 8: 5.304350, -59.837616	MT052757
<i>C.</i> sp. C	SLE1783	Guyana: Region 6: 4.146817, -58.237202	MT052758

List of species

1. Chasmogenus acuminatus sp. nov.	Brazil (Amapá, Pará), French Guiana, Guyana, Suriname
2. Chasmogenus amplius sp. nov.	Venezuela
3. Chasmogenus australis García, 2000	Venezuela, French Guiana, Guy- ana, Brazil (Roraima)
4. Chasmogenus bariorum García, 2000	Venezuela
Chasmogenus occidentalis García, 2000 syn. nov.	
Chasmogenus yukparum García, 2000 syn. nov.	
5. Chasmogenus berbicensis sp. nov.	Guyana
6. Chasmogenus brownsbergensis sp. nov.	Suriname
7. Chasmogenus castaneus sp. nov.	Venezuela
8. Chasmogenus clavijoi sp. nov.	Venezuela
9. Chasmogenus cuspifer sp. nov.	Venezuela
10. Chasmogenus flavomarginatus sp. nov.	Venezuela
11. Chasmogenus gato sp. nov.	Venezuela
12. Chasmogenus guianensis sp. nov.	Suriname, Guyana
13. Chasmogenus ignotus sp. nov.	Brazil (Amazonas)
14. Chasmogenus ligulatus sp. nov.	Suriname
15. Chasmogenus lineatus sp. nov.	Venezuela
16. Chasmogenus pandus sp. nov.	Brazil (Amapá), French Guiana,
	Suriname
17. Chasmogenus schmits sp. nov.	Suriname
18. Chasmogenus sinnamarensis sp. nov.	French Guiana
19. Chasmogenus tafelbergensis sp. nov.	Suriname
20. Chasmogenus undulatus sp. nov.	Guyana
21. Chasmogenus sp. C	Guyana



Figure 1. Maximum likelihood phylogeny of *Chasmogenus* spp. based on COI sequences. Ultra Fast Bootstrap (UFBS) values are indicated at nodes.

Characters of taxonomic importance

Species of New World *Chasmogenus* are generally quite similar morphologically. There are several characters that easily separate species into rough species-groups, such as the condition of the labro-clypeal emargination, the elevation of the mesoventrite, and

general size. However, within each of these groups, the aedeagus is often the only diagnostic feature. For a number of species, especially in the Amazon region, unassociated females cannot be identified with confidence using morphology alone. Here we review some characters that show inter- and/or intraspecific variation.

Dorsal coloration. The dorsal coloration of most species ranges from shades of brown to dark red-brown (Figs 2A–C, 3A–I, 4A–F, 5A–F), but in a few cases (e.g., *C. australis*, Fig. 4D–F) may be much paler and appear almost yellow. Care should be taken not to confuse pale teneral specimens with true pale coloration. The coloration of the dorsum of the head is useful in diagnosing a few species, as some have uniformly colored heads (e.g., *C. lineatus*, Fig. 8F) and others may be bicolored (e.g., *C. australis* and *C. amplius*, Figs 8B, 9A), or appearing translucent (e.g., *C. pandus* Fig. 10D). Distinct pale preocular patches may be found on only one species (e.g., *C. flavomarginatus*, Fig. 8E). Most species for which long series are available exhibit some intraspecific dorsal color variation and this character should not be used alone for definitive identification.

Labro-clypeal margin. The anterior margin of the clypeus is a key feature for separating groups of species. In most species, the clypeus emarginates anteroposteriorly exposing a gap between the clypeus and labrum, however in the absence of this gap in which the clypeus and labrum are contiguous, it is diagnostic of some species (e.g., *C. flavomarginatus*, and *C. lineatus*, Fig. 8E, F). The shape of the gap and the degree to which the clypeus emarginates is generally uniform within species, and is helpful in determining species identification, but is not a unique diagnostic feature of any species.

Mentum. In all species, the anterior half to two-thirds of the mentum is depressed to a varying degree with a medial notch of variable shape, usually either triangular or rounded. The depression of the mentum may or may not be interrupted with a low curved ridge situated just posterior to the medial notch, a feature that is found in several species (e.g., *C. lineatus, C. cuspifer*, and *C. sinnamarensis*) and may serve to distinguish these from other closely related taxa.

Mesoventrite. The condition of the mesoventrite is markedly variable in elevation; though always forming a longitudinal carina, it varies from a very low, faint carina to a distinctly raised acute tooth. When it is raised into a tooth, it is diagnostic of either *C. bariorum* or *C. cuspifer*; form of the tooth is slightly variable, sometimes rounded on the posterior slope to linear on the anterior and posterior slope in an acute triangular form (e.g., Fig. 7A, B). In many other species, it is indistinct and very weakly elevated, in others with a mild elevation, it may be convex along the outer margins.

Aedeagus. The aedeagus is the primary and sometimes only definitive diagnostic feature for a number of the species included here. Additionally, we found substantially more variation in form of the genitalia than had previously been reported for the genus. Most species have a rather "normal" trilobed form with the relative length and shape of the parameres and median lobe being the most helpful in separating species. One group of species (e.g., *C. acuminatus, C. undulatus, C. ligulatus, C. pandus,* Fig. 15A–E, G–I) possess a large and often asymmetrical sclerite associated with the median lobe, the presence and shape of this sclerite is important to separating species. Two species exhibit a strikingly modified and asymmetrical aedeagus (*C. ignotus* and *C. tafelbergensis*, Fig. 16). In these two species the parameres are greatly enlarged, with one

wider than the other, and the median lobe is reduced to a narrow strip. In addition, the aedeagus is very deep and three dimensional.

Taxonomic treatment

Chasmogenus Sharp, 1882

Chasmogenus Sharp, 1882: 73.

Differential diagnosis. Moderately sized beetles, elongate oval in dorsal view, moderately dorsoventrally compressed, 2.5-6.2 mm in total length. Dorsal coloration from light tan-yellow to very dark brown. Ground punctation of the head fine to moderately coarse, labrum with slightly finer ground punctation and almost indistinguishably small systematic punctures that bear long golden setae along the distoanterior margin. Anterior margin of labrum slightly concave medially. Systematic punctures present on the clypeus, pronotum, and elytra. Elytra with very fine to coarse ground punctation and five loosely organized longitudinal rows of sparsely setose systematic punctures, sometimes only distinguishable by presence of setae; with sharply impressed sutural striae. Antennae with eight (Neotropical species) or nine antennomeres (Old World species). Maxillary palps half as long to longer than width of head posterior to eyes. Anterior half of mentum depressed with anteromedial notch, notch variable from shallowly rounded to triangular. Prosternum pubescent, form variable from evenly smooth to moderately tectiform. Mesoventrite either weakly elevated into medial longitudinal carina, or strongly elevated into posteroapical tooth. Metaventrite with median ovoid glabrous region, extending ca. half to slightly more than half the length of the metaventrite and ca. twice as long as it is wide. Metafemora densely and uniformly pubescent basally with a distal glabrous region of variable proportion. Abdomen densely and uniformly pubescent with golden to light yellow setae. Fifth abdominal ventrite with rounded posteromedial emargination lined with short, bristle-like setae. Size and form of aedeagus variable.

Chasmogenus acuminatus sp. nov.

http://zoobank.org/CBA0DEFA-D4FD-4066-80A4-E4187B8B41D2 Figures 5A–C, 9B, 15H–I, 18, 21E, 22C, D

Chasmogenus sp. X Short, 2013: 87 (in part); Short & Kadosoe, 2011: 87 (in part), Short, Salisbury, & La Cruz 2018: 193 (in part).

Type material. Holotype (male): "SURINAME: Sipaliwini District/2°21.776'N, 56°41.861'W, 237 m/ Camp 3 Wehepai; leg. Short &/ Kadosoe; sandy forest creek/4–6.ix.2010; SR10-0904-01A/ CI-RAP Survey", "DNA VOUCHER/ Extraction #/ SLE-1822", "HOLOTYPE/ CHASMOGENUS/ acuminatus sp. n./ des. Smith & Short." (NZCS). Paratypes (321): BRAZIL: Amapa: Oiapoque (c. 22 km

S) on BR-156, leg. Short, forested detrital pools, BR18-0720-01B (1 ex., SEMC, DNA voucher SLE1850). Para: Vale do Paraíso, ca. 55 km N. Alenguer, -1.49292, -54.51566, leg. Short, detrital pool, BR18-0203-01B (1 ex., SEMC, DNA voucher SLE1623). FRENCH GUIANA: Petit-Saut, 5.070, -53.029 (2 exs., SEMC, DNA Vouchers SLE516 and SLE1840). GUYANA: Region 9: along road to Parabara, 2°09.557'N, 59°17.569'W, 268 m, 1.xi.2013, leg. Short, Isaacs and Salisbury, forest pools near Mushai Wao, GY13-1101-02A (4 exs., SEMC); Parabara, trail to mines, 2°05.095'N, 59°14.174'W, 250 m, 2.xi.2013, leg. Short, Isaacs and Salisbury, detrital pools in forest, GY13-1102-01A (2 exs., SEMC); North of Parabara, Bototo Wau Creek, 2°10.908'N, 59°20.306'W, 289 m, 31.x.2013, leg. Short, Isaacs and Salisbury, stream margins, GY13-1031-01A (3 exs., SEMC); Parabara north side of river, 2°06.492'N, 59°13.653'W, 274 m, 3.xi.2013, detritus margins and leaf packs, GY13-1103-02A (2 exs., SEMC, including DNA Voucher SLE1086). Region 6: Upper Berbice circa 1 km south of Basecamp 1, 4°09.241'N, 58°10.627'W, 109 m, 25.ix.2014, leg. Short and La Cruz, margins of creek with leaf packs and mud, GY14-0925-01B (2 exs., SEMC); Upper Berbice Basecamp 1, 4°09.289'N, 58°10.717'W, 96 m, 21.ix.2014, leg, Short, Salisbury and La Cruz, muddy detrital pools in drying creekbed near camp, GY14-0921-02A (5 exs., SEMC, CBDG); same data as previous except: 24.ix.2014, margins of basecamp creek, GY14-0924-01A (1 ex., SEMC); Upper Berbice circa 1 km west of Basecamp 1, 4°09.143'N, 58°11.207'W, 105 m, 22.iv.2014, leg, Short, Salisbury and La Cruz, margins of creek, GY14-0921-03H (2 exs., SEMC); same data as previous except: 21.ix.2014, leg. A. Short, sandy stream, GY14-0921-03A (1 ex. SEMC); Upper Berbice Basecamp 2, 4°45.301'N, 58°00.404'W, 49 m, 26.ix.2014, leg. Short, Salisbury and La Cruz, shallow detrital pool in forest draining into creek, GY14-0926-01A (2 exs. SEMC). Region 8: Konawaruk River, Basecamp 2 (NARIL basecamp), 5°07.539'N, 59°06.732'W, 80 m, 15.ix.2014, leg. Salisbury and La Cruz, unnamed clear water creek, slow flowing and shallow, GY14-0915-02 (7 exs., SEMC); Upper Potaro Camp (circa 7 km northwest of Chenapau), 5°0.660'N, 59°38.283'W, 484 m, 11.iii.2014, leg. Short, Baca, Salisbury and La Cruz, Potaro margin trail with wet detritus in sandy area, GY14-0311-04A (1 ex., SEMC). Region 10: Upper Berbice logging road KM 1, 5°03.892'N, 58°03.303'W, 71 m, 29.ix.2014, leg. Short, Salisbury and La Cruz, marsh and creek, GY14-0929-01B (1 ex., SEMC). SURINAME: Sipaliwini District: Camp 3, Werehpai, 2°21.776'N, 56°41.861'W, 237 m, 3-7. ix.2010, leg. Short and Kadosoe, detrital pools forest, 2010 CI-RAP Survey, SR10-0903-02A (4 exs., SEMC); same data as previous except: 3.ix.2010, pooled up detrital creek, 2010 CI-RAP Survey, SR10-0903-01A (54 exs., NZCS, SEMC, INPA); same data as previous except: 4-6.ix.2010, sandy forest creek, SR10-0904-01A (26 exs., SEMC, including DNA vouchers SLE1822 and SLE1823); Camp 2 on Sipaliwini River 2°10.973'N, 56°47.235'W; 210 m, 28.viii.2010, Short and Kadosoe, small detrital stream, CI-RAP Survey, SR10-0828-03A (27 exs., SEMC); same data as previous except: 30.viii.2010, forest creek, SR10-0831-01A (24 exs., SEMC); same data as previous except: 31.viii.2010, sandy forest creek with detritus, SR10-0831-01B (38 exs., SEMC); same data as previous except: 28-29.viii.2010, large forest stream,

SR10-0828-02A (16 exs., SEMC, including DNA voucher SLE1820); Camp 1 on Kutari River, 2°10.521'N, 56°47.244'W, 228 m, 20.viii.2010, leg. Short and Kadosoe, forest stream, CI-RAP Survey, SR10-0820-01A (7 exs., SEMC); same data as previous except: 19.viii.2010, SR10-0819-02A (1 ex., SEMC); same data as previous except: 19.viii.2010, forested swamp, SR10-0819-01A (39 exs., SEMC); same data as previous except: 19-24.viii.2010, leg. Short, Kadosoe, and Larsen, FIT, SR10-0819-TN1 (1 ex., SEMC); rapids on Kutari River, 2°19.280'N, 56°52.595'W, 224 m, 18.viii.2010, leg. A. E. Z. Short, forest stream, 2010 CI-RAP Survey, SR10-0818-01A (1 ex., SEMC); Camp 2 on Sipaliwini River, 2°10.973'N, 56°47.235'W, 210 m, 29-30.viii.2010, leg. Short and Kadosoe, inselberg, 2010 CI-RAP Survey, SR10-0829-01A (1 ex. SEMC); Camp 1 on Kutari River, 2°10.521'N, 56°47.244'W, 228 m, 22.viii.2010, Short and Kadosoe, forest swamp, CI-RAP Survey, SR10-0822-02A (7 exs., SEMC including DNA Voucher SLE 445); Camp 1 Upper Palumeu, 2.47700N, 55.62941W, 275 m, 10-16.iii.2012, leg. A. Short, 2012 CI-RAP Survey, Flight Intercept Trap, SR12-0310-TN1 (1 ex. SEMC); Raleighvallen Nature Reserve, base of Voltzberg, 4°40.432'N, 56°11.079'W, 86 m, 16.iii.2016, leg. Short et al., pooled up stream, SR16-0316-01B (10 exs., SEMC, including DNA vouchers SLE1838 and SLE1839); Raleighvallen Nature Reserve Lolopaise area, 4°42.48'N, 56°13.15908'W, 24 m, 18.iii.2016, leg. Short et al., intermittent stream margins and flotation, SR16-0318-01D (3 exs., SEMC, including DNA voucher SLE1849); Raleighvallen Nature Reserve, trail from plateau to Voltzberg, 17.iii.2016, leg. J. Girón, stream with roots and mud, SR16-0317-04A (3 exs., SEMC); Raleighvallen Nature Reserve, Fungu Island, 4°43.459'N, 56°12.658'W, 30 m, 14.iii.2016, leg. A. Short, isolated river margin pools with rocky bottom, SR16-0314-01E (1 ex., SEMC); Raleighvallen Nature Reserve Voltzberg Station, 04°40.910'N, 56°11.138'W, 78 m, 29.vii.2012, leg. A. Short and C. McIntosh, detrital side pool, SR12-0729-02B (2 exs., SEMC); same data as previous except: 29.vii.2012, leg. Short, Maier, McIntosh, and Kadosoe, stream margins, SR12-0729-02A (3 exs., SEMC); Raleighvallen Nature Reserve, trail to Raleighvallen, 04°42.480'N, 56°13.159'W, 24 m, 27.vii.2012, leg. C. McIntosh, detrital pools near creek in forest, SR12-0727-03D (5 exs., SEMC); Raleighvallen Nature Reserve Voltzberg trail, 04°40.910'N, 56°11.138'W, 78 m, 30.vii.2012, leg. A. Short and C. McIntosh, detrital pools along stream, SR12-0730-01B (6 exs., SEMC, including DNA Voucher SLE1081); CSNR Tafelberg Summit near Augustus Creek Camp, 3°55.600'N, 56°11.300'W, 600 m, 16.viii.2013, leg. Short and Bloom, pond on trail into Arrowhead basin, SR13-0816-02A (1 ex., SEMC); same data as previous except: 22.viii.2013, detrital creek, SR13-0822-01A (1 ex., SEMC); Sipaliwini Savanna Nature Reserve, Four Brothers Mountain, 2°00'20.5"N, 55°58'08.9"W, 337 m, 31.iii.2017, leg. A. Short, detrital pools, SR17-0331-01D (1 ex., SEMC DNA Voucher SLE1619); Kabalebo Nature Resort, Moi Moi Creek, leg. Short, detrital pool, SR19-0310-01G (2 exs., SEMC, DNA vouchers SLE1804 and SLE1805).

Differential diagnosis. Among species that have a broad clypeal emargination and the apex of the median lobe extending past the apex of the parameres, *C. acuminatus* may be distinguished by the straight outer margin (Fig. 15H, I) of the parameres, (dis-

tinctly sinuated in the similar and regionally co-occurring *C. undulatus*, *C. ligulatus*, and *C. pandus*). Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. Size and color. Total body length 3.4-3.9 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head brown to dark brown, clypeus distinctly paler brown (Fig. 9B). Pronotum and elytra uniformly dark orange-brown (Fig. 5A). Venter dark orange centrally, dark red-brown distally (Fig. 5C). Head. Ground punctation on head coarse. Clypeus with anteromedial emargination, which exposes a broadly rounded to angulate gap between the clypeus and labrum (Fig. 9B). Mentum strongly depressed in anterior half with a triangular to subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thoras. Ground punctation on pronotum moderately coarse (Fig. 5A). Prosternum tectiform. Mesoventrite with weak elevation forming a thin posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths (Fig. 5C). Aedeagus. Aedeagus (Fig. 15H, I) with median lobe subtriangular in shape, widest at base and gradually tapering along entire length; apex acute, distinctly extending beyond the apex of the parameres. Sclerite of the median lobe expanded, but very narrow and weakly developed, apex not reaching the apex of the parameres. Gonopore situated ca. one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins very slightly inwardly curved a long length; width of each paramere gradually narrowed to a blunt (Fig. 15H) to slightly acute (Fig. 15I) apex. Basal piece short, ca. one-third the length of the parameres.

Etymology. The species name is derived from the Latin *acuminatus*, meaning "pointed", after the condition of the aedeagus, in which the apex of the median lobe is extended and forms an acute point.

Distribution. Known from a broad range in the eastern Guiana Shield region of South America, from Guyana east to the state of Amapá, Brazil and south to the Amazon River (Fig. 18).

Biology. This species is relatively widespread and one of the most commonly encountered *Chasmogenus* in the eastern Guiana Shield. It is found in forested habitats, typically associated with detrital pools, the margins of streams and creeks, and forested swamps (Figs 21E, 22C, D). Some specimens have been collected in flight intercept traps (FITs).

Remarks. There is a high level of genetic diversity in the species (Fig. 1), with observed COI divergence as high as 6% between some individuals. However, we did not identify any substantial corresponding morphological variation and believe it is best to consider this intraspecific genetic variation for the time being.

Chasmogenus amplius sp. nov.

http://zoobank.org/C5534EEE-91ED-4EE6-94AA-4BC0C181826E Figures 2A–C, 9A, 14A, 17, 20A

Type material. Holotype (male): "VENEZUELA: Amazonas State/ 4°58.838'N, 67°44.341'W; 95m/ Communidad Caño Gato, on Rio/ Sipapo; 16.i.2009; leg.



Figure 2. Habitus of *Chasmogenus amplius*: A dorsal view B lateral view C ventral view. Scale bar: 2 mm.

Short/ Miller, Camacho, Joly, & García/ VZ09-0116-01X: along stream", "[barcode]/ SM0843452/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ amplius sp. n./ des. Smith & Short" (MIZA). **Paratypes (57): VENEZUELA: Amazonas:** Same data as holotype (53 exs., MIZA, SEMC, including DNA voucher SLE1201); stream along Rio Sipapo, 4°55.849'N, 67°44.645'W, 87 m, 16.i.2009, leg. Short, García, Camacho, Miller and Joly, stream habitats, VZ09-0116-02X (2 exs., SEMC); Communidad Caño Gato, 4°58.845'N, 67°44.345'W, 100 m, 7.i.2006, leg. A.E.Z. Short, stream margin/detritus, AS-06-016 (2 exs., SEMC).
Differential diagnosis. The large size (ca. 5.0 mm) and broad body form (Fig. 2A–C) of this species serve to differentiate *C. amplius* from most other congeners, and no other sympatric species may be confused with it. It is approximately the same size as and is morphologically similar to *C. berbicensis* from eastern Guyana, but may be distinguished by its paler dorsal coloration.

Description. Size and color. Total body length 4.5-5.0 mm. Body form elongate oval with broad, slightly curved lateral margins. Dorsum of head bicolored, frons dark brown, clypeus and labrum distinctly paler (Fig. 9A). Pronotum and elytra dark orange-brown to dark brown (Fig. 2A). Venter dark red-brown centrally, dark brown marginally (Fig. 2C). Abdominal ventrites orange-brown. Head. Ground punctation on head fine. Clypeus with anteromedial emargination, which exposes a rounded to angulate gap between clypeus and labrum (Fig. 9A). Mentum strongly depressed on anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum weakly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths (Fig. 2C). Aedeagus. Aedeagus (Fig. 14A) with median lobe widest at base and very slightly tapering until the apical quarter, then narrowing abruptly to form an acute triangular apex which is even with or slightly extends beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. three-quarters the length of the parameres.

Variation. There is a fair amount of variation in dorsal coloration; most specimens examined are medium-orange brown, whereas some are slightly paler.

Etymology. The species name is derived from the Latin *amplius*, meaning "larger", after the large body size of this species, the largest known species of the genus in northern South America.

Distribution. Known from a few closely situated localities along the Orinoco River in southern Venezuela (Amazonas) (Fig. 17).

Biology. This species has been collected in series along the margins of a small sandy stream that flowed into the Rio Sipapo (Fig. 20A). Specimens were found by agitating marginal areas where leaf detritus and sand had accumulated.

Chasmogenus australis García, 2000

Figures 4D-F, 6, 8B, 13A-D, 18, 20C-F

Chasmogenus australis García, 2000: 52.

Type material examined. Holotype (Male): "VENEZUELA, Apure/ Mcipo. Achaguas, / parroquia Saman de/ Apure, 25–26/VIII/1997", "Colectores:/ M. García", "[Barcode]/

MALUZ10146/ LUZ-Venezuela", "Holotipo [male symbol]/ Chasmogenus/ australis/ Dcrip. M. García, 1999" (MALUZ). The label data of the holotype (Fig. 6) differs slightly from that given in the original description. The locality is identical as listed in García (2000), but the date and collector data differ (given as 13 August 1998 and M. García & E. Gomez). The type is an undissected male, the aedeagus is visibly protruding from the abdomen. We also examined a permanent genitalia slide that is labeled as this species (Fig. 13A).

Additional material examined. BRAZIL: Roraima: Circa 30 km southeast of Caracarai on BR-174, 1°35.091'N, 61°00.118'W, 80 m, 16.i.2018, leg. Short, Benetti, and Santana, marsh, BR18-0116-05A (37 exs., INPA, SEMC, including DNA Voucher SLE1774); Murupu River at BR-174 north of Boa Vista, 3°01.276'N, 60°46.565'W, 75 m, 13.i.2018, leg. A. E. Z. Short, muddy backwaters of stream, BR18-0113-01A (3 exs., SEMC); Vicinal 30, 00°43'50.2"N, 060°25'58"W, 77 m, 10.i.2018, leg. Short and Benetti, large roadside ditch with dense vegetation, BR18-0110-03A (24 exs., INPA, SEMC, including DNA voucher SLE1624); ca. 16 km west of Amajari on BR-203, 3°36.874'N, 61°33.470'W, 125 m, 13.i.2018, leg. Short, Benetti, and Santana, marsh, BR18-0113-04A (9 exs., SEMC); Circa 26 km south of Cantá, 2°22.547'N, 60°33.538'W, 93 m, 11.i.2018, leg. Short, marsh with lots of emergent vegetation, BR18-0111-02A (1 ex., SEMC); Circa 7 km south of Iracema on BR-174, 2°6.277'N, 61°4.922'W, 59 m, 16.i.2018, leg. Short, Benetti, and Santana, marsh and palm swamp, BR18-0116-01A (1 ex., SEMC); Jundia on BR-174, 00°12'20.3"S, 060°41'35.1"W, 57 m, 10.i.2018, leg. Short and Benetti, marsh with lots of emergent vegetation, BR18-0110-01A (1 ex.., SEMC); Sitio Bem Querer ca. 3 km west, 1°56.131'N, 61°01.737'W, 80 m, 16.i.2018, leg. Short, Benetti, and Santana, BR18-0116-04A (2 exs., SEMC); near Boa Vista, 2°44.558'N, 60°47.179'W, 105 m, 15.i.2018, leg. Short, Benetti, and Santana, UV light by drying marsh, BR18-0115-03A, (1 ex., SEMC); BR-174, c. 50 km NW Boa Vista, 3 18.348'N, 60 51.458'W, 100 m, 13.i.2018, leg. Short, marsh, BR18-0113-02A (1 ex., SEMC, DNA Voucher 1629). FRENCH GUIANA: Yiyi, 5.419, -53.050 (1 ex., SEMC, DNA Voucher SLE1856). GUYANA: Region 9: near Kusad Mountains, 2°52.204'N, 59°55.003'W, 124 m, 27.x.2013, leg. Short, Isaacs, and Salisbury, marshy area, GY13-1027-01A (2 exs., SEMC); Ziida Wao Creek near Kusad Mountains, 2°49.724'N, 59°48.546'W, 121 m, 25.x.2013, leg. Short, Isaacs, and Salisbury, stagnant vegetated creek, GY13-1025-02A (3 exs., CBDG, SEMC, including DNA Voucher SLE1615); VENEZUELA: Barinas: ca. 13 km southeast of Ciudad Bolivia, 8°19.394'N, 70°28.238'W, 173 m, 25.i.2012, leg. Short, Arias, and Gustafson, marsh, VZ12-0125-02A (6 exs., SEMC, including DNA voucher SLE1080). Cojedes: Rio Caiman Grande at San Brano, 9°39.246'N, 68°11.860'W, 137m, 20.i.2012, leg. Short, Arias, and Gustafson, river margin, VZ12-0120-03A (2 exs., SEMC). Monagas: South of Maturin, 9°16.398'N, 62°56.246'W, 22 m, 2.ii.2010, leg. Short, García, and Joly, morichal margin, VZ10-0202-02A (6 exs., SEMC); between Morichal Largo and Tembledor, 9°05.798'N, 62°43.618'W, 29 m, 2.ii.2010, leg. Short, García, and Joly, margins of vegetated pond, VZ10-0202-03A (11 exs., MIZA, SEMC; including DNA voucher SLE1621). Zulia: Sabana de Machango, 10.043017, -71.007133, 35 m, 29.i.2012, leg. Short, Arias and Gustafson, margin of artificial pond, VZ12-0129-03A (1 ex., SEMC, DNA Voucher SLE1082).

Differential diagnosis. The small size (<3.5 mm) and very pale dorsal coloration (Fig. 4D–F) serves to separate *C. australis* from most other small-bodied regional congeners, as well as its distinctive aedeagus. It also almost exclusively occurs in open marsh habitats, whereas most all other congeners are typically found in other types of habitat.

Description. Size and color. Total body length 3.0-3.4 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored; frons dark brown, clypeus and labrum light tan-brown (Fig. 8B). Pronotum and elytra light tan-orange, light golden yellow marginally (Fig. 4D). Venter almost entirely light golden-brown, venter of head and lateral margins of metaventrite light brown (Fig. 4F). Tibiae orangebrown. *Head*. Ground punctation on head fine, labrum with slightly finer punctation. Clypeus with anteromedial emargination, which exposes a wide trapezoidal-shaped gap between clypeus and labrum (Fig. 8B). Mentum weakly to moderately depressed on anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation of pronotum moderate. Prosternum tectiform. Mesoventrite with weak elevation forming a thin posteromedial longitudinal carina. Metafemora densely pubescent with long golden setae in basal six-sevenths (Fig.4F). Aedeagus. Aedeagus (Fig. 13A-D) with outer margins of median lobe strongly situate, such that it appears constricted in the middle; above constriction, margins tapering to form a weakly pointed apex, which slightly extends beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres with outer margins weakly and evenly curved (Fig. 13A) to slightly sinuate near the apex (Fig. 14B-D), with outer apex bluntly rounded and inner apex appear as a right angle. Basal piece long, subequal to slightly shorter than the length of the parameres.

Distribution. This species has a very broad range, occurring from northwestern Venezuela to the coast of French Guiana (Fig. 18). It was originally described from the central region of the Venezuelan Llanos. We have collected it across a very broad range in Venezuela, including the Maracaibo Basin, across the Llanos region, as well as in the Rupununi/Roraima savannah complex in northern Brazil and Guyana. We also report it from the coastal savannahs of French Guiana.

Biology. Unlike most *Chasmogenus*, *C. australis* is almost exclusively associated with lentic or open marsh habitats (Fig. 20C–F). A few specimens have been taken along the muddy and vegetated margins of large, slow-flowing rivers (morichales).

Remarks. Despite its broad range, sequenced populations of *C. australis* displayed virtually no genetic variation in COI, with less than 1% divergence between all sampled individuals spanning more than 2000 km from western Venezuela to French Guiana, south to the state of Roraima, Brazil. We also note the strong similarities in aedeagal morphology and habitat to *C. sapucay* Fernández, which was originally described from Argentina and Paraguay but whose range was recently extended into Brazil (Fernandez 1986, Clarkson & Ferreira-Jr 2014). Although we suspect *C. australis* may be a junior subjective synonym of *C. sapucay*, we are refraining from making any nomenclatural changes until the two taxa can be compared in more detail.

Chasmogenus bariorum García, 2000

Figures 3D-F, 6, 7A, 8C, 11A-H, 17, 19A-C, 19E, F

Chasmogenus bariorum García, 2000: 49.

Synonyms. *Chasmogenus occidentalis* García, 2000, syn. nov. Type material examined: Holotype (male): "VENEZUELA, Zulia/Mcpio. Machique de/ Perija, El Tokuku,/300 msnm 03/V/1998", "Colectores:/M. García", "[Barcode]/ MALUZ10150/ LUZ-Venezuela", "Holotipo ['male symbol'/ Chasmogenus/ occidentalis/ Dcrip. M. García, 1999" (MALUZ). The date on the label of the holotype (Fig. 6) differs slightly from that given in the original description, which was listed as 2 May 1995 instead of 3 May 1998. The type is an undissected male, the aedeagus is visibly protruding from the abdomen. We also examined a permanent genitalia slide that had been presumed to be the holotype and is labeled as this species (Fig. 11B).

Chasmogenus yukparum García, 2000, syn. nov. Type material examined: Holotype (male): "VENEZUELA, Zulia/Mcpio. Machique de/ Perija, El Tokuku,/300 msnm 03/V/1998", "Colectores:/M. García", "[Barcode]/ MALUZ10149/ LUZ-Venezuela", "Holotipo ['male symbol'/ Chasmogenus/ yukparum/ Dcrip. M. García, 1998" (MALUZ). The date on the label of the holotype (Fig. 6) differs slightly from that given in the original description, which was listed as 5 May 1995 instead of 3 May 1998. The dorsal portion of the abdomen is missing and may be the result of dissection. We also examined a permanent genitalia slide which is labeled as this species and had been presumed to be the holotype (Fig. 11C). The description of this species was based on a single male so we assume the genitalia on the slide is the holotype.

Type material examined. Holotype (male): "VENEZUELA, Zulia/Mcpio. Machique de/ Perija, El Tokuku,/300 msnm 03/V/1998", "Colectores:/M. García", "[Barcode]/MALUZ10148/ LUZ-Venezuela", "Holotipo ['male symbol'/ Chasmogenus/ bariorum/ Dcrip. M. García, 1998" (MALUZ). The date on the label of the holotype (Fig. 6) differs slightly from that given in the original description, which was listed as 2 May 1995 instead of 3 May 1998. The type is an undissected male, the aedeagus is visibly protruding from the abdomen. We also examined a permanent genitalia slide that had been presumed to be the holotype and is labeled as this species (Fig. 11A).

Additional material examined (198). VENEZUELA: Aragua: Henri Pittier National Park, Río La Trilla, 10.37319°N, 67.74250°W, 295 m, 4.i.2009, Short, Miller, Camacho, & Garíca [sic], pools, VZ09-0104-01A (25 exs., MIZA, SEMC, including DNA Vouchers SLE078 and SLE531); Henri Pittier National Park, Río Cumboto, 10.39376N, 67.79597W, 130m, 4.i.2009, leg. Short, García, & Miller, riverside pools, VZ09-0104-02B (7 exs., SEMC); Henri Pittier National Park, 10°21.017'N, 67°40.883'W, 5.i.2009, leg. Miller, Camacho, and García, small stream, VZ09-0105-01A (1 ex., SEMC). Guárico: Río San Antonio, north of Dos Caminos, 9°46.320'N, 67°21.177'W, 280 m, 8.i.2009, leg. Short, Miller and García, river margins, VZ09-0108-02A (7 exs., SEMC); same as previous except: leg. Miller & Short, side stream, VZ09-0108-02B (8 exs., SEMC, including DNA Voucher SLE1613); same as previ-



Figure 3. Habitus of *Chasmogenus* spp. **A–C** *C. flavomarginatus*: **A** dorsal view **B** lateral view **C** ventral view. **D–F** *C. bariorum*: **D** dorsal view **E** lateral view **F** ventral view. **G–I** *C. castaneus* **G** dorsal view **H** lateral view **I** ventral view. Scale bar: 2 mm.

ous except: leg. K. B. Miller, micro habitats, VZ09-0108-02C (2 exs., SEMC); Stream at road crossing, north of Palenque, 9°6.794'N, 66°59.595'W, 152m, 8.i.2009, leg. Short, García, Miller, Camacho and Joly, stream, VZ09-0108-03X (3 exs, SEMC); Río Guárico, N. San Juan, 9.95788N, 67.37773W, 435 m, 8.i.2009, leg. K. Miller & L. Joly, along river, VZ09-0108-01X (5 exs., SEMC); ~15 km south of San Juan, 9°46.321'N, 67°21.201'W, 255 m, 3.i.2006, leg. A. E. Z. Short, stream margin and rock pools, AS-06-005 (1 ex., SEMC); ~20 km north of Dos Caminos, 9°44.034'N, 67°19.003'W, 225 m, leg. A. E. Z. Short, gravelly margin of river, AS-06-020 (24 exs., SEMC). Falcón: Rio Ricoa near Dos Bocas, 11°17.424'N, 69°26.061'W, 170 m, 9.vii.2009, leg. Short, Sites, Gustafson, García, Camacho, and Inciarte, along river margins, VZ09-0709-02A/L-1063 (4 exs., SEMC). Lara: Río Salado west of Arenales, 10°9.260'N, 69°57.458'W, 490 m, 22.i.2009, leg. Short, García, and Camacho, gravel stream, VZ09-0122-01X (5 exs., SEMC). Trujillo: Rio Jirajara near Sabana Grande, 9°42.307'N, 70°32.570'W, 199 m, 29.i.2012, leg. Short, Arias, and Gustafson, muddy pool in floodplain, VZ12-0129-02A (4 exs., SEMC). Zulia: Perija National Park Tukuko, Río Manantial, 9°50.490'N, 72°49.310'W, 270 m, 29.i.2009, leg. Short, García, and Camacho, gravel margin, VZ09-0129-01A (13 exs., SEMC, including DNA Voucher SLE534); same data as previous except: 22.ix.2007, leg. A. E. Z. Short, rock pools/margins, AS-07-020b (27 exs., SEMC); same data as previous except: 16.vii.2008, leg A. Short, margins and pools, AS-08-027 (14 exs., SEMC); Perija National Park, Rio Tukuko, 09°50.515'N, 72°48.334'W, 15.vii.2008, leg. A. E. Z. Short, upstream of Tukuko, AS-08-029 (1 ex., SEMC); Perija National Park, Toromo, 10°03.058'N, 72°42.974'W, 435 m, 31.xii.2005, leg. A. E. Z. Short, small stream and seep, AS-06-001 (5 exs., SEMC); same data as previous except: 28.i.2009, leg. A. Short, detrital pool, VZ09-0128-01A (3 exs., SEMC); c. 15 km southwest of El Dibujo, 10.79307N, 72.32331W, 155 m, 30.xii.2008, leg. Short, García, and Camacho, muddy puddle, VZ08-1230-03B (1 ex, SEMC); same data as previous except: in stream, VZ08-1230-03X (2 exs., SEMC); Marshy pond, 10.85498N, 72.30837W, 81 m, 30.xii.2008, leg. Short, García, and Camacho, pond margin, VZ08-1230-02X (1 ex., SEMC); 15 km west of Machiques, 10°02.962'N, 72°42.615'W, 432 m, 31.xii.2005, leg. A. E. Z. Short, isolated rock pool, AS-06-002 (1 ex., SEMC); Quebrada Riencito, 10.86041N, 72.32210W, 95 m, 30.xii.2008, leg. A. Short and M. García, along margin, VZ08-1230-01B (34 exs., MIZA, SEMC).

Differential diagnosis. This species may be easily distinguished from others in the region by mesoventrite raised into an acute tooth (Fig. 7A), shared only with the sympatric *C. cuspifer. Chasmogenus bariorum* can be separated from *C. cuspifer* by its larger size (\geq 3.5 mm) and narrower apex of the median lobe (11A–H).

Description. *Size and color.* Total body length 3.5–3.7 mm. Body form elongate oval with slightly subparallel lateral margins. Dorsum of head very dark brown to black, anterior margin of labrum slightly paler in color (Fig.8C). Pronotum dark brown, distinctly paler at anterior and lateral margins; elytra dark brown, slightly paler at posterior margins (Fig. 3D). Prosternum and abdominal ventrites dark brown; meso- and metaventrites dark red-brown, trochanters and glabrous portion of femora



Figure 4. Habitus of *Chasmogenus* spp. **A–C** *C. lineatus*: **A** dorsal view **B** lateral view **C** ventral view. **D–F** *C. australis*: **D** dorsal view **E** lateral view **F** ventral view. Scale bar: 2 mm.

red-orange (Fig. 3F). *Head.* Ground punctation on head fine. Clypeus with anteromedial emargination, which exposes a trapezoidal-shaped gap between clypeus and labrum (Fig. 8C). Mentum weakly depressed in anterior half with shallowly rounded anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation of pronotum fine. Prosternum moderately tectiform. Mesoventrite with median longitudinal carina, which is elevated into an acute tooth medially (Fig. 7A). Metafemora densely pubescent with long golden setae in basal four-fifths (Fig. 3F). *Aedeagus.* Aedeagus (Fig. 11A–H) with outer margins of median lobe straight and parallel sided, with apex in the form of an acutely pointed triangle, which distinctly extends beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width



Figure 5. Habitus of *Chasmogenus* spp. A-C *C. acuminatus*: A dorsal view B lateral view C ventral view.D-F *C. pandus*: D dorsal view E lateral view F ventral view. Scale bar: 2 mm.

below the apex of the median lobe. Parameres symmetrical, with outer margins slightly curved along entire length, appearing weakly convex; apex bifid, with outer and inner lobes subequal in height but with inner lobe usually narrower. Basal piece long, subequal to the length of the parameres.

Distribution. Venezuela (Aragua, Falcón, Guárico, Lara, Trujillo, Zulia) (Fig. 17).

Biology. Nearly all specimens are associated with the margins or side pools of streams and small rivers in the foothills of various Andean regions of Venezuela up to elevations of ca. 500 m. (Fig. 19A–C, 19E, F)

Remarks. García (2000) described three species from the Rio Manantial, a small forested stream near Tokuko in the Serranía de Perijá in northwestern Venezuela. We compared the holotypes of *C. bariorum*, *C. occidentalis*, and *C. yukparum* and deter-



Figure 6. Holotype labels of the four Venezuelan species of Chasmogenus described by García (2000).



Figure 7. Lateral view of mesoventrite. A C. bariorum B C. cuspifer. Scale bar: 0.10 mm.

mined they are conspecific. Because all three were described in the same publication, we here select *C. bariorum* as the valid name based on the principal of first reviser.

The shape of the mesoventral tooth was used as a primary character to separate these three species but after examining specimens from a variety of localities we found this character to be variable. The presence of only a single species despite the variability of this feature is also supported by genetic data (Fig. 1). In his species descriptions, García (2000) further differentiates *C. yukparum* from *C. bariorum* and *C. occidentalis* by indicating that the former has asymmetrical mandibles, while the latter two exhibit symmetrical mandibles; however, in the identification key this character is reversed, with the mandibles of *C. occidentalis* being described as asymmetrical while those of *C. yukparum* are symmetrical. Regardless, we examined the mandibles in the three holotypes and found no substantial difference in mandibular symmetry; all three types have bifid mandibles with minor variation in the size of the teeth, as with many of the other specimens we examined.

There appears to be some confusion with regard to the genitalia slides associated with the holotypes. In García (2000), the caption of fig. 3 indicates all illustrated geni-



Figure 8. Dorsal view of heads of *Chasmogenus* spp. **A** *C. castaneus* **B** *C. australis* **C** *C. bariorum* **D** *C. cuspifer* **E** *C. flavomarginatus* **F** *C. lineatus.*

talia are of the holotypes. However, this is not possible as some of the labeled holotypes are undissected males. Because *C. yukparum* was described from a single male and its abdomen is partially missing, we presume the genitalia slide associated with the holotype is in fact the holotype. However, we are uncertain of which exact specimens should be associated with the "type" genitalia slides of *C. bariorum* and *C. occidentalis*. Regardless, this uncertain association does not impact any of our conclusions regarding

their synonymy: it is clear that all three genitalia slides represent a single species (*C. bariorum*) and that all three male holotype specimens represent the same conspecific species as those on the slides.

Chasmogenus berbicensis sp. nov.

http://zoobank.org/58124959-D58E-4CF6-9815-D6ED103DDF7B Figures 9C, 14D, 17, 22A

Chasmogenus sp. B Short, Salisbury, & La Cruz 2018: 193.

Type material. Holotype (male): "GUYANA: Region 6/ 4°08.809'N, 58°14.232'W, 108/ Upper Berbice, Basecamp 1/ margin of berbice river/ leg. Short, Salisbury, La Cruz/ 22.ix.2014; GY14-0922-02A"/ "[barcode] SEMC1357824/ KUNHM-ENT", "HOLO-TYPE/ CHASMOGENUS/ berbicensis sp. n./ des. Smith & Short" (CBDG). **Paratypes (6): GUYANA: Region 6:** same data as holotype (3 exs., SEMC including DNA Voucher SLE1864); Upper Berbice Basecamp 1m 4°09.289'N, 58°10.717'W, 96 m, 24.ix.2014, leg. Short, Salisbury, and La Cruz, margins of basecamp creek, GY14-0924-01A (2 exs., SEMC); same data as previous except, 21.ix.2014, leg. Short Salisbury and La Cruz, muddy detrital pools in drying creek bed near camp, GY14-0921-02A (1 ex., SEMC).

Differential diagnosis. See differential diagnosis for C. amplius.

Description. Size and color. Total body length 4.5–4.9 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head multi-colored, frons dark brown, clypeus dark orange-brown, labrum pale yellow-orange (Fig. 9C). Pronotum red-orange, elytra pale orange-brown with serial dark brown spots. Head. Ground punctation on head fine. Clypeus with anteroposterior emargination that exposes a wide trapezoidal shaped gap between clypeus and labrum (Fig.9C). Mentum moderately depressed in anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum mildly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14D) with median lobe widest at base, and very slightly tapering until the apical quarter, then narrowing abruptly to form an acute triangular apex which is even with or appears very slightly extended beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. four-fifths the length of the parameres.

Etymology. The species is named after the Berbice River in Guyana from where was collected. To be treated as a noun in apposition.

Distribution. Known only from the type locality along the upper Berbice River in Guyana (Fig. 17).

Biology. This species was collected in detrital leaf packs along the margin of the upper Berbice River (Fig. 22A).



Figure 9. Dorsal view of heads of *Chasmogenus* spp. A *C. amplius* B *C. acuminatus* C *C. berbicensis* D *C. clavijoi* E *C. undulatus* F *C. gato.*

Chasmogenus brownsbergensis sp. nov.

http://zoobank.org/91D796FA-D130-4970-BF69-524AEB0050C7 Figures 10A, 14E, 17, 21A

Type material. Holotype (male): "SURINAME: Brokopondo District/ 04°56.871'N, 55°10.911'W, 462 m/ Brownsberg Nature Park, forested/ stream with lots of detritus; leg./



Figure 10. Dorsal view of heads of *Chasmogenus* spp. from Suriname and Guyana A *C. brownsbergensis* B *C. ligulatus* C *C. guianensis* D *C. pandus.*

Short, Maier, McIntosh; 4.viii.2012/ SR12-0804-01A", "[barcode]/SEMC1114121/ KUNHM-ENT" "HOLOTYPE/ CHASMOGENUS/ brownsbergensis sp. n./ des. Smith & Short" (NZCS). **Paratypes (46): SURINAME : Brokopondo District:** same data as holotype except: 4.viii.2012, pools in road, SR12-0804-03A (20 exs., SEMC, including DNA Voucher SLE1828); Brownsberg Nature Park, trail between Park HQ and Mazaroni Val, 4°56.934'N, 55°10.825'W, 467 m, 20.iii.2017, leg. Short et al., pools in dirt road, SR17-0320-02A (18 exs., SEMC, NZCS); same data as previous except: 22.iii.2017, SR17-0322-01A (8 exs., SEMC, including DNA Voucher SLE1861).

Differential diagnosis. Among smaller species with a broadly rounded clypeal emargination, this species is similar in size, morphology, and general form of the aedeagus as *C. guianensis*, but can be distinguished by the coloration of the head which has mesal dark patches on the clypeus and labrum (Fig. 10A) in contrast to the typical bicolored or uniform coloration of the head. In addition, the apex of the median lobe of the aedeagus is ca. the same level as the apex of the parameres. In *C. guianensis*, the apex of the median lobe is shorter than the apex of the parameres.

Description. *Size and color.* Total body length 3.7–3.8 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons very dark

brown, labrum and clypeus dark orange-brown (Fig. 10A). Darker patches on mesal portions of clypeus and labrum (Fig. 10A). Elytra uniformly dark brown. Venter dark orange-brown centrally, dark brown marginally. Head. Ground punctation on head moderately coarse. Clypeus with anteromedial emargination, which exposes a wide smoothly rounded gap between labrum and clypeus (Fig.10A). Mentum strongly depressed in anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum moderately coarse. Prosternum even, not tectiform. Mesoventrite with very weak elevation forming a thin posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14E) with median lobe widest at base and very slightly tapering until the apical fifth, then narrowing to form an acute triangular apex which is even with the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated ca. half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex inwardly curved, tapered, and bluntly rounded. Basal piece of medium length, ca. two-thirds the length of the parameres.

Etymology. The species is named after Brownsberg Nature Park, the only locality where it is currently known. To be treated as a noun in apposition.

Distribution. This species is only known from Brownsberg Nature Park in Suriname (Fig. 17).

Biology. Long series of this species were collected from pools in dirt roads in Brownsberg Nature Park. The pools are large, and often contain detritus as they are through forested areas (Fig. 21A). One specimen was collected in a forested stream with lots of detritus.

Chasmogenus castaneus sp. nov.

http://zoobank.org/8664C494-2BBD-455F-AB19-72431B581C13 Figures 3G–I, 8A, 12A, 17, 19A, B

Type material. Holotype (male): "VENEZUELA: Zulia State/ 09°50.490'N, 72°49.310'W; 270m/ Perija National Park, Tukuko,/ Rio Manantial: margins and pools/ 16.vii.2008/ leg. A. Short; AS-08-027", "[barcode]/ SEMC0929744/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ castaneus sp. n./ des. Smith & Short" (MIZA). **Paratypes (3): VEN-**EZUELA: Zulia: Same data as holotype (3 exs., SEMC, including DNA voucher SLE1779).

Differential diagnosis. From other Andean species with a triangular clypeal emargination, *C. castaneus* can be differentiated by its larger size (> 4.5 mm) and its distinct chestnut dorsal coloration (Fig. 3G–I). The overall body form with parallel sides is similar to *C. lineatus*, but that species is much smaller and entirely dark brown to black in coloration. In addition, the apex of the parameres are not sinuated.

Description. *Size and color.* Total body length 4.0 mm. Body form elongate oval with slightly subparallel lateral margins. Dorsum of head bicolored, frons dark brown to mottled orange-brown (Fig. 8A), anterior margin of labrum and clypeus



Figure 11. Aedeagi (dorsal view) **A** *C. bariorum* holotype (Venezuela: Zulia) **B** *C. occidentalis* holotype **C** *C. yukparum* holotype **D–H** *C. bariorum* **D** specimen from Zulia **E** specimen from Aragua **F** specimen from Falcón **G** specimen from Guárico **H** specimen from Trujillo. Scale bars: 0.25 mm.

slightly paler in color. Pronotum mottled dark orange and dark brown, paler on lateral anterior margin (Fig. 3G). Elytra orange-brown, lateral margins very dark brown (Fig. 3G). Venter of head dark brown to dark red-brown. Maxillary palps and tarsi exhibit proximodistal gradation from light brown to light tannish yellow. Venter dark red-brown (Fig. 3I). *Head.* Ground punctation on head fine. Clypeus with anteromedial emargination which exposes a wide rounded to subtriangular gap between labrum and



Figure 12. Aedeagi (dorsal view) of *Chasmogenus* spp. A *C. castaneus* B *C. flavomarginatus* C *C. flavomarginatus* C *C. flavomarginatus* D *C. cuspifer* E–I *C. lineatus*. Scale bar: 0.25 mm.

clypeus (Fig. 8A). Mentum strongly depressed in anterior half with rounded anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum moderately coarse. Prosternum tectiform. Mesoventrite with broad elevation posteromedially, forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal six-sevenths (Fig. 3I). *Aedeagus.* Aedeagus (Fig. 12A) with median lobe very wide at base, wider than the width of one paramere, tapering abruptly in apical quarter to form a narrow triangular projection which is even with to slightly extending beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated ca. half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins slightly curved along entire length, appearing weakly convex; apex weakly angled inward. Basal piece long, slightly shorter than the length of the parameres. **Etymology.** The species name is derived from the Latin *castaneus*, meaning "of the color of chestnuts", a reference to the distinctive reddish brown dorsal coloration of this species.

Distribution. Only known from the type locality in northwestern Venezuela (Fig. 17).

Biology. All specimens of *C. castaneus* were collected in marginal pools by a stream (Fig. 19A, B).

Chasmogenus clavijoi sp. nov.

http://zoobank.org/02C1D58C-E5EC-493D-A4E4-182972AD729B Figures 9D, 14B, 17, 20B

Material examined. Holotype (male): "VENEZUELA: Guárico State/ 8°8.296'N, 66°24.459'W/ San Nicolasito Field Station/ 10.i.2009; leg. Short & Miller/ VZ09-0110-02X; morichal"/ "[barcode]/ SEMC0855289/ KUNHM-ENT", "HOLO-TYPE/ CHASMOGENUS/ clavijoi sp. n./ des. Smith & Short" (MIZA). Paratypes (5): same data as holotype (5 exs. SEMC, including DNA voucher SLE1198).

Differential diagnosis. Though *C. clavijoi* shares a smaller body size and similar morphology as *C. gato*, it may be differentiated by the paler dorsal coloration.

Description. Size and color. Total body length 3.8-4.5 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons dark brown, clypeus and labrum orange-brown (Fig. 9D). Pronotum dark orange brown, slightly paler marginally. Elytra yellow-orange with serial dark brown spots. Head. Ground punctation on head fine. Clypeus with anteroposterior emargination which exposes a broadly rounded gap between clypeus and labrum (Fig. 9D). Mentum moderately depressed in anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum slightly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14B) with median lobe widest at base, appearing weakly constricted medially, slightly tapering until the apical quarter, then narrowing abruptly to form an acute triangular apex which is even with the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. four-fifths the length of the parameres.

Etymology. Named in honor of Venezuelan entomologist José (Pepe) Clavijo, retired director of MIZA, for all his contributions to Neotropical entomology. To be treated as a noun in apposition.

Distribution. Known only from the San Nicolasito Research Station in the Llanos of Venezuela (Fig. 17).

Biology. This species was collected along the margins of a morichal, a riparian habitat of slow-moving water through a savannah (Fig. 20B).



Figure 13. Aedeagi (dorsal view) of *C. australis* **A** holotype (Venezuela: Apure) **B** specimen from Guyana (Region 9) **C** specimen from Venezuela (Monagas) **D** specimen from Brazil (Roraima). Scale bar: 0.25 mm.

Chasmogenus cuspifer sp. nov.

http://zoobank.org/7CB1B53B-4F0F-47A3-8DEA-527F2B6054BA Figures 7B, 8D, 12D, 17, 19A–C

Type material. Holotype (male): "VENEZUELA: Zulia State/ 9°50.490'N, 72°49.310'W, 270 m/ Perija N.P. Tukuko: Río Manantial/ 29.i.2009; Short, García, Camacho/VZ09-0129-01A: gravel margin"/ "[barcode]/SEMC0857741/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ cuspifer sp. n./ des. Smith & Short" (MIZA). **Paratypes (19): VENEZUELA: Aragua State:** Henri Pittier National Park, Rio La Trilla, 10.37319N, 67.74250W, 295 m, 4.i.2009, leg. Short, Miller, Camacho and García, pools, VZ09-0104-01A (1 ex., SEMC, DNA Voucher SLE532). **Zulia State:** Perija National Park, Tukuko: Rio Manantial, 9°50.490'N, 72°49.310'W, 270 m, 29.i.2009, leg. Short, García and Camacho, gravel margin, VZ09-0129-01A (11 exs., MIZA, SEMC, including DNA Voucher SLE533); same data as previous except: 16.vii.2008, leg. A. Short, margins and pools, AS-08-027 (2 exs., SEMC); same data as previous except: 22.ix.2007, rock pools/margin, leg. A. E. Z. Short, AS-07-020b (3 exs., SEMC); Perija National Park Toromo, 10°03.058'N, 72°42.974'W, 435 m, 31.xii.2005, leg. A. E. Z. Short, small stream and seep, AS-06-001 (1 ex., SEMC), same data as previous except: 28.i.2009, leg. A. Short, detrital pool, VZ09-0128-01A (1 ex., SEMC).

Differential diagnosis. See differential diagnosis for Chasmogenus bariorum.

Description. Size and color. Total body length 3.0-3.2 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head very dark brown to black, anterior margin of labrum slightly paler in color (Fig. 8D). Pronotum dark brown, distinctly paler at lateral margins; elytra dark brown. Venter dark red-brown mesally, dark brown marginally. Head. Ground punctation on head fine. Clypeus with anteromedial emargination, which exposes a small angulate gap between clypeus and labrum (Fig. 8D). Mentum very weakly depressed in anterior half with widely rounded anteromedial notch followed by rounded elevated ridge just posterior of the notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation of pronotum fine. Prosternum tectiform. Mesoventrite with strong elevation forming an acute tooth posteromedially (Fig. 7B). Metafemora densely pubescent in basal four-fifths. Aedeagus. Aedeagus (Fig. 12D) with median lobe subtriangular in shape, widest at base and gradually tapering along entire length; apex acute, which extends to the same level as the inner cusp of the parameres. Sclerite of the median lobe not expanded. Gonopore situated slightly less than one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins slightly curved along entire length, appearing weakly convex; apex bifid, with outer lobe slightly more elevated than inner lobe; inner lobe much narrower than outer lobe. Basal piece very long, distinctly longer than the length of the parameres.

Etymology. The species name is derived from the Latin *cuspis*, meaning "pointed", after the toothed mesoventral carina.

Distribution. This species is known from stream habitats in the Perijá and the Coastal Mountains of Venezuela (Fig. 17).

Biology. All specimens were collected in the margins of forested stream habitats, typically with gravel margins (Fig. 19C).

Chasmogenus flavomarginatus sp. nov.

http://zoobank.org/F6737BA7-61CB-453B-BF28-B7FA1830F4F0 Figures 3A–C, 8E, 12B, C, 17, 19D

Type material. Holotype (male): "VENEZUELA: Barinas State/ 8°48.424'N, 70°31.139'W, 992m/ ca. 13km NW Baranitas, 24.i.2012/ leg. Short, Arias, & Gustafson/ Small stream pool: VZ12-0124-02B", "[barcode]/ SEMC1030004/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ flavomarginatus sp. n./ des. Smith & Short" (MIZA). Paratypes (88): VENEZUELA: Barinas: Same data as holotype (85 exs., MIZA, SEMC, including DNA voucher SLE1235); same data as holotype except: seepage by road, VZ12-0124-02A (2 exs., SEMC, including DNA voucher SLE1083). Táchira: near El Tama, 26.i.2012, leg. Short, VZ12-0126-04A (1 ex., SEMC, DNA voucher SLE1084).

Differential diagnosis. The lack of a clypeal emargination (Fig. 8E) easily separates *C. flavomarginatus* from most other congeners. It shares this characteristic with *C. lineatus*

but can be separated by the overall paler dorsal coloration and the distinct yellow margins (Fig. 3A, B) of the pronotum (dorsum entirely dark brown to black in *C. lineatus*).

Description. Size and color. Total body length 3.2-3.5 mm. Body form elongate oval with slightly subparallel lateral margins. Dorsum of head very dark brown to black with slightly paler preocular patches (Fig. 8E). Anterior margin of labrum and lateral margins of clypeus sometimes slightly paler. Pronotum dark brown to black centrally, distinctly bright yellow at anterior and lateral margins (Fig. 3A-B). Elytra dark redbrown to dark brown, slightly paler or bright yellow marginally (Fig. 3A). Venter dark red brown, abdominal ventrites dark brown. Head. Ground punctation on head fine. Clypeus and labrum contiguous (Fig. 8E). Mentum weakly depressed in anterior half with shallowly rounded anteromedial notch. Maxillary palps short, just slightly shorter than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum moderately tectiform. Mesoventrite with elevation forming a posteromedial longitudinal carina with convex distolateral margins. Metafemora densely pubescent in basal four-fifths (Fig. 3C). Aedeagus. Aedeagus (Fig. 12B, C) with outer margins of median lobe straight and parallel sided, with apex in the form of an acutely pointed triangle, which slightly extends beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins slightly curved along basal four fifths, appearing weakly convex, then curved slightly outward at apex; apex very weakly bifid, with outer lobe more elevated than inner lobe; inner lobe minute, almost appearing absent. Basal piece long, ca. four-fifths the length of the parameres.

Variation. In material examined, there was some variation in dorsal coloration, ranging from dark brown to black. There is also variation in the coloration of the dorsum of the head, where some specimens had paler margins on the anterior portion of the labrum and the lateral margins of the clypeus, most were uniformly black.

Etymology. The species name is derived from the Latin *flavus*, meaning "yellow", after the distinct yellow margins of the pronotum and elytra.

Distribution. Known from the Andean States of Táchira and Barinas (Fig. 17).

Biology. A long series of this species was collected in a small pool that was formed by a road-cut in the Andes (Fig. 19D). It was being fed by a small stream/seepage, in which two additional specimens were collected. The specimen from Táchira was found in a small pool along a dirt road.

Chasmogenus gato sp. nov.

http://zoobank.org/E80A3658-638D-40CA-A2D5-D01BA0382CE2 Figures 9F, 14C, 17, 20A

Type material. Holotype (male): "VENEZUELA: Amazonas State/ 4°58.838'N, 67°44.341'W; 95m/ Communidad Caño Gato on Rio/ Sipapo; 16.i.2009; leg. Short/ Miller, Camacho, Joly, & García/ VZ09-0116-01X: along stream", "[barcode]/



Figure 14. Aedeagi of (dorsal view) of *Chasmogenus* spp. **A** *C. amplius* **B** *C. clavijoi* **C** *C. gato* **D** *C. berbicensis* **E** *C. brownsbergensis* **F** *C. schmits* **G**, **H** *C. guianensis* **G** specimen from Suriname **H** specimen from Guyana. Scale bar: 0.25 mm.

SM0843374/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ gato sp. n./ des. Smith & Short" (MIZA). **Paratypes (19): VENEZUELA: Amazonas:** same data as holotype (14 exs., MIZA, SEMC, including DNA voucher SLE1202); River near Orinoco/ Sipapo confluence, 5°03.707'N, 67°46.768'W, 92 m, 15.i.2009; leg K. Miller, detrital pools, VZ09-0115-01B (3 exs., SEMC); S. Communidad Porvenir, 5°20.514'N, 67°45.315'W, 87 m, 15.i.2009, leg. Short & García, pool in culvert, VZ09-0115-03A (1 ex., SEMC); ca. 15 km E. Puerto Ayacucho, 5°34.408'N, 67°30.283'W, 66 m, 6.i.2006, leg. A. E. Z. Short, stream at road crossing, AS-06-015 (1 ex., SEMC). **Differential diagnosis.** Of smaller species with a broadly rounded clypeal emargination, this species is similar in size, morphology, and general form of the aedeagus to *C. clavijoi* but can be differentiated by the slightly darker dorsal coloration, which is very dark brown.

Description. Size and color. Total body length 3.3-3.8 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons and clypeus pale to dark brown, labrum pale yellow-brown (Fig. 9F). Pronotum and elytra dark orange-brown to dark brown. Head. Ground punctation on head fine, slightly finer on labrum. Clypeus with anteromedial emargination, which exposes a rounded to angulate gap between the labrum and clypeus (Fig. 9F). Mentum moderately depressed in anterior half with subtriangular notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum very weakly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14C) with median lobe widest at base and very slightly tapering until apical fifth, then narrowing to form an acute triangular apex which is even with the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. four-fifths the length of the parameres.

Etymology. The species is named after the community of Caño Gato, from where the species was collected. To be treated as a noun in apposition.

Distribution. Known from several closely situated localities in southern Venezuela (Amazonas) (Fig. 17).

Biology. This species has been collected in stream margins and associated stream habitats such as nearby detrital pools (Fig. 20A).

Chasmogenus guianensis sp. nov.

http://zoobank.org/F43EBB30-B396-4945-9AF0-31563B4F3087 Figures 10C, 14G, H, 17, 21F, 22C

Chasmogenus sp. X Short, 2013: 87 (in part); Short & Kadosoe, 2011: 87 (in part).

Type material. Holotype (male): "SURINAME: Sipaliwini District/ 2.47700N, 55.62941W, 275 m/ Camp 1, Upper Palumeu/ leg. A. Short; large sandy creek/ 14.iii.2012; SR12-0314-01A/2012 CI-RAP Survey", "[barcode]/SEMC1088252/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ guianensis sp. n./ des. Smith & Short." (NZCS). **Paratypes (235): SURINAME: Para District:** near Overbridge River Resort, 05°31.8'N, 055°03.5'W, 15-18-FEB-2010, Flight Intercept Trap, leg. P. Skelley, W. Warner, and C. Gillett (1 ex., SEMC). **Sipaliwini District:** same data as holotype (55 exs., NZCS, SEMC, including DNA Voucher SLE1826), same data as holotype except: 10.iii.2012, small forest pool, SR12-0310-02A (27 exs., SEMC); same data as

holotype except: 10–12.iii.2012, large detrital pools, SR12-0310-01A (8 exs., SEMC); same data as holotype except: 11.iii.2012, large pool by trail, SR12-0311-01A (73 exs., SEMC, including DNA Vouchers SLE1827 and SLE1863); same data as holotype except: water held in dead palm leaf, SR12-0311-02A (1 ex., SEMC); same data as holotype except: 10–16.iii.2012, Flight Intercept Trap, SR12-0310-TN1 (44 exs., SEMC); Rapids on Kutari River, 2°19.280'N, 56°52.595'W, 224 m, 18.viii.2010, leg. A. E. Z. Short, 2010 CI-RAP Survey, forest stream, SR10-0818-01A (1 ex., SEMC); Camp 2 on Sipaliwini River 2°10.973'N, 56°47.235'W; 210 m, 28–29.viii.2010, leg. Short and Kadosoe 2010 CI-RAP Survey, large forest stream, SR10-0828-02A (1 ex., SEMC, DNA Voucher SLE1821); same data as previous except: 28.viii.2010, small detrital stream, SR10-0828-03A (1 ex., SEMC). GUYANA: Region 6: Upper Berbice Basecamp 1, 4°09.289'N, 58°10.717'W, 96 m, 24.xi.2014, leg. Short, Salisbury, and La Cruz, margins of basecamp creek, GY14-0924-01A (15 exs., CBDG, SEMC, including DNA Vouchers SLE1616, SLE1836, and SLE1862); same data as previous except: 21.xi.2014, muddy detrital pools in drying creek bed near camp, GY14-0921-02A (5 exs., SEMC, including DNA Vouchers SLE1834 and SLE1835); Upper Berbice ca. 1 km south of Basecamp 1, 4°09.241'N, 58°10.627'W, 109 m, 25.ix.2014, leg. Short, Salisbury, and La Cruz, detritus pools in dry creek bed, GY14-0925-01D (3 exs., SEMC).

Differential diagnosis. Among species that have a broad, rounded clypeal emargination, this species belongs to a group that have an aedeagal form with relatively broad, straight parameres and a wide median lobe which is slightly shorter to slightly longer than the apex of the parameres. It is distinctly smaller than *C. amplius, C. berbicencis*, and *C. clavijoi*. It is most similar to the comparably-sized *C. brownsbergensis* but the parameres are slightly wider and sublinear along the outer margins (Fig. 14G, H). Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. Size and color. Total body length 3.6-4.0 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons dark orangebrown, clypeus and labrum dark orange to dark yellow-orange (Fig. 10C). Pronotum and elytra dark orange-brown. Venter dark red-brown mesally, dark brown marginally. Head. Ground punctation on head moderately coarse. Clypeus with anteroposterior emargination, which exposes a rounded to angulate gap between clypeus and labrum (Fig. 10C). Mentum moderately depressed in anterior half with rounded notch on anteromedial margin. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum moderately coarse. Prosternum even, not tectiform. Mesoventrite with very weak elevation forming a thin posteromedial longitudinal carina. Metafemora densely pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14G, H) with median lobe widest at base and very slightly tapering along entire length, terminating in a bluntly triangular apex which is distinctly shorter than the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated nearly one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. three-quarters the length of the parameres.

Etymology. This species is named after the Guiana Shield, the region of South America from which it is known. To be treated as a noun in apposition.

Distribution. This species has been found at several localities in Guyana and Suriname (Fig. 17).

Biology. This species was found in a variety of habitats including a forested swamp, ephemeral detrital pools, general creek margins and a large sandy creek (Fig. 21F). It was also collected passively via a flight intercept trap. A single specimen was collected from water in a dead palm leaf on the ground.

Chasmogenus ignotus sp. nov.

http://zoobank.org/8DCFAD4B-4C3E-45C6-AAB9-1D92CD9488EC Figures 16E–H, 17

Type material. Holotype (male): "BRAZIL: Amazonas: Manaus/ -2.93079, -59.97514, 75 m/ Ducke Reserve, near Station/ 5–10.vi.2018; leg. Short & Team/ Flight Intercept Trap/ BR18-0607-FIT", "HOLOTYPE/ CHASMOGENUS/ ignotus sp. n./ des. Smith & Short" (INPA). **Paratypes (6): BRAZIL: Amazonas:** Same data as holotype (5 exs., INPA, SEMC); same locality but trail to Igarape Barro Branco, 6.vi.2018, leg. Short & Team, isolated forest pools, BR18-0606-02A (1 ex., SEMC DNA voucher SLE-1844).

Differential diagnosis. The strongly asymmetrical parameres, highly reduced basal piece, and extraordinary depth of the aedeagus (Fig. 16E–H) will easily separate this species from all others except *C. tafelbergensis*, from which it may be separated by its wider aedeagal profile. Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. Size and color. Total body length 3.5 mm. Dorsum of head, pronotum and elytra uniformly dark brown. Venter slightly lighter brown. Head. Ground punctation on head fine. Clypeus with anteroposterior emargination which exposes a very narrow, broad gap between clypeus and labrum. Mentum strongly depressed in anterior two-thirds with triangular anteromedial notch. Maxillary palps long, as long as width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum moderately coarse. Surface of prosternum even, not tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely and uniformly pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 16E-H) with median lobe highly modified, appearing as a narrow subparallel-sided strap and partly rotated laterally, with apex extending to the apex of the parametes to slightly beyond. Sclerite of the median lobe extremely well developed and appearing as a thin curved strut that extends the full length of the genitalia. Gonopore oriented laterally (Fig. 16F); situated more than twice gonopore width below the apex of the median lobe. Parameres asymmetrical, with left paramere wider than right paramere; outer margins of parameres strongly sclerotized, with the sclerotized region on the right paramere thicker than the left. Aedeagus, especially the parameres, thickened, such that it takes on a three-dimensional appearance (Fig. 16F, G); in lateral view widest at base with

dorsal surface flat with ventral surface graduating tapering to the apex. Basal piece short, less than half the length of the parameres; partly obscured by the strongly sclerotized and enlarged base of the median lobe and parameres.

Etymology. The species name is derived from the Latin *ignotus*, meaning "strange", after the bizarre form of the aedeagus.

Distribution. Only known from the Adolpho Ducke Forest Reserve in Manaus, Brazil.

Biology. One specimen was collected in an isolated forest detrital pool near Igarape Barro Branco, while another series of specimens came from a flight intercept trap in the forest.

Chasmogenus ligulatus sp. nov.

http://zoobank.org/F863DFA5-50EB-43C5-86DD-0F05DDD797C8 Figures 10B, 15E, 17, 21B

Chasmogenus sp. X Short, 2013: 87 (in part).

Type material. Holotype (male): "SURINAME: Sipaliwini District/ 2.97731N, 55.38500W, 200 m/ Camp 4 (low), Kasikasima; sandy/ creek, trail to Kasikasima; leg. A. Short/ 22.iii.2012; SR12-0322-02A/ flotation; 2012 CI-RAP Survey", "[barcode]/ SEMC1086819/ KUNHM-ENT". "HOLOTYPE/ CHASMOGENUS/ ligulatus sp. n./ des. Smith & Short" (NZCS). Paratypes (5): SURINAME: Sipaliwini: same data as holotype except: 20.iii.2012, sandy stream on trail to METS camp, SR12-0320-02A (4 exs., SEMC, including DNA Voucher SLE474); same data as holotype except: 20–25.iii.2012, detrital pools along trail to METS camp, SR12-0320-03A (1 ex., SEMC).

Differential diagnosis. The very thin gap between the clypeus and labrum (Fig. 10B) distinguish this species from all other congeners except for *C. sinnamarensis*, both of which are similar in size and morphology, but *C. sinnamarensis* is translucent dark red in dorsal coloration, and *C. ligulatus* is opaque and dark brown dorsally.

Description. *Size and color.* Total body length 3.2–3.5 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head multi-colored, frons dark brown, clypeus slightly paler, labrum distinctly paler (Fig. 10C). Pronotum dark orange-brown, slightly paler marginally. Elytra uniformly dark orange-brown to dark brown. Venter orange-brown mesally, dark brown marginally. *Head.* Ground punctation on head fine to moderately dense. Clypeus with anteromedial emargination which exposes a shallowly rounded gap between the labrum and the clypeus (Fig. 10C). Mentum strongly depressed in anterior two-thirds with triangular notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum fine. Prosternum very weakly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely and uniformly pubescent in basal nine-tenths. *Aedeagus.* Aedeagus (Fig. 15E) with median lobe nearly parallel-sided but curved slightly to the left; apex bluntly



Figure 15. Aedeagi of *Chasmogenus* spp. A–D *C. pandus* A dorsal view (Suriname) B side view (Suriname) C specimen from French Guiana D specimen from Brazil E *C. ligulatus* F *C. sinnamarensis* G *C. undulatus* H, I *C. acuminatus* H specimen from Suriname I specimen from Guyana. Scale bars: 0.25 mm.



Figure 16. Aedeagi of *Chasmogenus* spp. A–D *C. tafelbergensis* A dorsal view B side view C side view D ventral view E–H *C. ignotus* E dorsal view F side view G side view H ventral view. Scale bar: 0.25 mm.

rounded, distinctly extending beyond the apex of the parameres. Sclerite of the median lobe expanded and developed into a long, narrow crescent. Gonopore situated near the base of the median lobe. Parameres symmetrical, with outer margins strongly sinuate; the basal half of the parameres parallel sided with apical half appearing greatly expanded, then tapering to a blunt apex. Basal piece short, ca. one-third the length of the parameres.

Etymology. The species name is derived from the Latin *ligula*, meaning "tongue" after the broad and extended tongue-like form of the median lobe of the aedeagus.

Distribution. Known from lowland rainforest near the base of Mt. Kasikasima in southern Suriname (Fig. 17).



Figure 17. Distribution of Chasmogenus spp.

Biology. Two of the three collecting events for this species were from small sandy streams in dense rainforest (Fig. 21B). A single specimen was also collected from a very large nearby detrital pool that was draining into a stream.

Chasmogenus lineatus sp. nov.

http://zoobank.org/78AFBB94-2494-4733-A4F8-B0CFBA090C98 Figures 4A–C, 8F, 12E–I, 17, 19E, F

Type material. Holotype (male): "VENEZUELA: Guárico State/ 9°46.320'N, 67°21.177'W, 280m/ Río San Antonio, N. Dos Caminos/ 8.i.2009; leg. Short, Miller & García/ VZ09-0108-02A: river margins", "[barcode]/ SEMC0864029/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ lineatus sp. n./ des. Smith & Short" (MIZA). Paratypes (247): VENEZUELA: Barinas: River near Bum Bum, 8°18.033'N,



Figure 18. Distribution of *Chasmogenus* spp. Localities marked with stars/triangles indicate populations that were sampled for DNA in Fig. 1.

70°45.201'W, 216 m, 15.vii.2009, leg. A. Short et al., river margins, VZ09-0715-02A (48 exs., MIZA, SEMC, including DNA voucher SLE 1772). Guárico: Same data as holotype (35 exs., SEMC); same data as holotype except: leg. Miller & Short, side stream, VZ09-0108-02B (3 exs., SEMC, including DNA voucher SLE1614); Río Guárico, north of San Juan, 9.95788N, 67.37773W, 435 m, 8.i.2009, leg, K. Miller and L. Joly, along river, VZ09-0108-01X (11 exs, SEMC); ~20 km north of Dos Caminos, 9°44.034'N, 67°19.00'W, 225 m, leg. A. E. Z. Short, gravelly margin of river, AS-06-020 (54 exs, SEMC); ~15 km south of San Juan, 9°46.321'N, 67°21.201'W, 255 m, 3.i.2006, leg. A. E. Z. Short, stream margin & rock pools, AS-06-005 (17 exs., SEMC). Lara: Rio Salado, west of Arenales, 10°9.260'N, 69°57.458'W, 490 m, 22.i.2009, leg. Short, García, and Camacho, gravel stream, VZ09-0122-01X (66 exs., MIZA, SEMC, including DNA voucher SLE1061). Portuguesa: Tributary of Rio Guanare, south of Biscucuy, 9°14.457'N, 69°55.994'W, 370 m, 19.i.2009, leg. Short, García, and Camacho, gravel stream, VZ09-0119-03X (8 exs., SEMC); Rio Guanare, north of Guanare, 8°25.773'N, 69°35.202'W, 185 m, 19.i.2009, leg. Short, García, and Camacho, main river, VZ09-0119-02A (4 exs., SEMC); Rio Are at Aparicion, 9°22.900'N, 69°23.153'W, 220 m, 22.i.2012, leg. Short & Arias, river margins, VZ12-0122-02A (1 ex., SEMC).

Differential diagnosis. The lack of a clypeal emargination serves to distinguish *C. lineatus* from all other congeners except *C. flavomarginatus*, from which it may be separated by the almost completely black dorsal coloration of the head (Fig. 8F) and the absence of pale preocular patches (pale margins and preocular patches present in *C. flavomarginatus*).

Description. *Size and color.* Total body length 2.9–3.3 mm. Body form very elongate oval with straight, subparallel lateral margins. Dorsum of head very dark brown to black (Fig.8F). Pronotum and elytra uniformly dark brown. Prosternum dark orange to dark brown. Mesoventrite uniformly dark orange to dark brown. Metaventrite dark brown, slightly paler on posterior margin. Trochanters and glabrous portion of femora red-orange. Abdominal ventrites dark brown, slightly paler mesally (Fig. 4C). *Head.* Ground punctation on head fine. Clypeus and labrum contiguous (Fig. 8F). Mentum very weakly depressed in anterior half with triangular notch, followed by a medial elevated curved ridge situated posterior to triangular notch. Maxillary palps long, longer



Figure 19. Habitat of *Chasmogenus* spp in the Andean region of Venezuela. **A**, **B** Type locality and habitat for *C. bariorum*, *C. cuspifer*, and *C. castaneus*, near El Tukuko, Rio Manantial collecting event VZ09-0129-01A) **C** habitat for *C. bariorum* and *C. cuspifer*, Henri Pittier National Park, Rio Cumboto (collecting event VZ09-0104-02B) **D** type locality and habitat for *C. flavomarginatus*, ca. 13 km NW of Baranitas (collecting event VZ12-0124-02B) **E** habitat for *C. bariorum* and *C. lineatus*, between San Juan and Dos Caminos, Rio San Antonio (collecting event VZ09-0108-02A) **F** habitat for *C. bariorum* and *C. lineatus*, near Arenales, Rio Salado (collecting event VZ09-0122-01X).

than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum fine. Prosternum moderately tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina with its distolateral margins slightly convex. Metafemora densely pubescent in basal three-fourths (Fig. 4F). *Aedeagus.* Aedea-



Figure 20. Habitat of *Chasmogenus* spp. A Type locality and habitat for *C. amplius* and *C. gato*, Venezuela: Amazonas, Caño Gato (collecting event VZ09-0116-01X) B type locality and habitat for *C. clavijoi*, Venezuela: Guarico, San Nicolasito Field Station (collecting event VZ09-0110-02X) C-F habitat for *C. australis*: C Venezuela, Barinas, 13 km southeast of Ciudad Bolivia (collecting event VZ12-0125-02A)
D Guyana, near Kusad Mountains (collecting event GY13-1027-01A). E, F Brazil, Roraima, near Caracarai, red circles showing live individuals of *C. australis* floating on the water surface (collecting event BR18-0116-05A).

gus (Fig. 12E–I) with median lobe subtriangular in shape, widest at base and gradually tapering along entire length; apex acute, which extends slightly beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated slightly more than two gonopore widths below the apex of the median lobe. Parameres symmetrical,

with outer margins slightly curved, appearing weakly convex in basal three-quarters, then abruptly angled outwards; apex bifid, appearing "mitten shaped", with outer lobe very large, rounded, and directed outwards, and inner lobe very small and slightly more acuminate. Basal piece long, ca. as long as the length of the parameres.

Variation. In some specimens examined, the abdominal ventrites were somewhat more densely pubescent than described in the taxonomic treatment. The color of the abdominal ventrites is also slightly variable; in some specimens either the anterior or posterior margin of each ventrite is slightly paler.

Etymology. The species name is derived from the Latin *lineatus*, meaning "linear", after the straight parallel-sided body form and also for the linear, unemarginated anterior margin of the clypeus.

Distribution. This species is known from lowland gravel streams in the Andean region of Venezuela (Fig. 17).

Biology. This species can be found in abundance in gravel streams along the foothills of the Merida Andes, especially exposed areas of gravel and sand with algae (Fig. 19E, F).

Chasmogenus pandus sp. nov.

http://zoobank.org/C82E6A49-872D-45A7-A9D9-114A54E677D0 Figures 5D–F, 10D, 15A–D, 17

Type material. Holotype (male): "SURINAME: Para District/ Zanderij, near Guesthouse/ 05°27.5'N, 055°13.0'W/ 9-18-FEB-2010; P.Skelley,/ W.Warner, C.Gillett; FIT", "[barcode]/SEMC1085915/ KUNHM-ENT", "HOLOTYPE/ CHASMOGE-NUS/ pandus sp. n./ des. Smith & Short." (NZCS). **Paratypes (15): BRAZIL: Amapa:** ca. 1 km E Oiapoque, 3.85039°, -51.81683°, 17 m, 18.vii.2018, leg. Short, flotation of detritus on forested seep, BR18-0718-03C (1 ex., INPA, DNA Voucher SLE1858). **FRENCH GUIANA:** Roura, 27.4 km south-southeast, 4°44'20"N, 52°13'25"W, 280 m, 10 JUN 1997, leg. J. Ashe and R. Brooks, Flight Intercept Trap, FG1AB97 177 (2 exs., SEMC); same data as previous except: 23–24 May 1997, FG1AB97 022 (1 ex., SEMC); same data as previous except: 25–29 May 1997, FG1AB97 079 (1 ex., SEMC). **SURINAME: Para District:** same data as holotype (9 exs., SEMC); same data as previous except: 7-9-FEB-2010, lights (1 ex., SEMC).

Differential diagnosis. The very narrow gap between the clypeus and the labrum (Fig. 10D) is a characteristic shared only with *C. ligulatus*, but the two differ in the form of the aedeagus, in which the median lobe of *C. pandus* is very thin and the parameres are parallel-sided along the outer margins (Fig. 15A–D), which contrasts with the very convex parameres of *C. ligulatus*. Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. *Size and color.* Total body length 3.5–3.7 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons dark redbrown, clypeus and labrum slightly paler (Fig. 10D). Pronotum and elytra uniformly dark brown. Venter uniformly dark brown (Fig.5F). *Head.* Ground punctation on head

moderately coarse. Clypeus with medial anteroposterior emargination which exposes a very narrow, wide gap between the clypeus and labrum (Fig. 10D). Mentum strongly depressed in anteromedial two-thirds with subtriangular notch. Maxillary palps long, longer than width of head immediately anterior to the eyes. Thorax. Ground punctation on pronotum fine. Prosternum tectiform. Mesoventrite with elevation forming a posteromedial longitudinal carina, increasing in elevation anteroposteriorly with highest elevation near protrochanters; slightly convex along outer margins. Metafemora densely pubescent in basal six-sevenths (Fig.5F). Aedeagus. Aedeagus (Fig. 15A-D) with median lobe nearly parallel-sided and widest in basal half, then angled slightly to the left and tapering gradually to a weakly acuminate apex, distinctly extending beyond the apex of the parameres. Sclerite of the median lobe expanded and developed into a long, narrow sliver with a sharply acute apex that extends to the apex of the parameres. Gonopore situated in the middle of the median lobe, ca. two gonopore widths below the apex. Parameres symmetrical, with outer margins strongly bisinuated, giving the margins a weakly undulating appearance, apical half not wider than basal half; apex bluntly rounded. Basal piece short, ca. one-third the length of the parameres.

Etymology. The species name is derived from the Latin *pandus*, meaning "bent" after the curved sclerite of the medial lobe of the aedeagus.

Distribution. Known from Brazil (Amapá), Suriname (Para District), and French Guiana (Fig. 17).

Biology. Specimens from French Guiana and Suriname were collected via a Flight Intercept Trap. The single specimen from Brazil was collected by floating detritus in a forested seepage.

Remarks. Most examined specimens appeared to be more translucent than is typical of most species of *Chasmogenus*. It is unknown if this was due to preservation method or an actual diagnostic feature of this species.

Chasmogenus schmits sp. nov.

http://zoobank.org/43FCAE8F-5A93-4E35-99C6-8E937EE27521 Figures 14F, 17, 21D

Chasmogenus sp. X Short & Kadosoe, 2011: 87 (in part).

Type material. Holotype (male): "SURINAME: Sipaliwini District/ 2°10.521'N, 56°47.244'W, 228 m/ on Kutari River; leg. Short/ & Kadosoe; forested swamp/ 19.viii.2010; SR10-0819-01A/ Camp 1; 2010 CI-RAP Survey"/ "[barcode] SEMC0914251/KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ schmits sp. n./ des. Smith & Short", "DNA VOUCHER/ Extraction #/ SLE-1824" (NZCS). **Paratypes (2): SURINAME: Sipaliwini:** same data as holotype (2 exs., SEMC).

Differential diagnosis. This species is similar morphologically to *C. clavijoi*, but the median lobe emarginates laterally to a greater degree and is only as wide as one paramere basally (Fig. 14F), whereas the median lobe is ca. $1.5 \times$ the width

of one paramere basally in *C. clavijoi*. The apices of the parameres are also more squarely blunted rather than roundly curved. Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. Size and color. Total body length 4.3 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head dark brown, labrum distinctly paler. Pronotum and elytra uniformly dark brown. Venter dark orange-brown. Head. Ground punctation on head fine. Clypeus with anteromedial emargination which exposes trapezoidal gap between clypeus and labrum. Mentum moderately depressed in anterior half with triangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. Thorax. Ground punctation on pronotum fine. Prosternum mildly tectiform. Mesoventrite with weak elevation forming a posteromedial longitudinal carina. Metafemora densely and uniformly pubescent in basal nine-tenths. Aedeagus. Aedeagus (Fig. 14F) with median lobe widest at base, appearing weakly constricted medially, then narrowing abruptly in the apical fifth to form an acute triangular apex which is slightly below the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than a third of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex slightly inwardly curved and bluntly rounded. Basal piece long, ca. four-fifths the length of the parameres.

Etymology. Named in honor of Sarah C. Schmits, a longtime member of the Short Lab who has provided invaluable support to advance and disseminate knowledge of aquatic beetles.

Distribution. Known only from the type locality in Suriname (Fig. 17).

Biology. This species was collected from a forested swamp habitat (Fig. 21D).

Chasmogenus sinnamarensis sp. nov.

http://zoobank.org/DF6731D8-AD00-498E-B2B1-083827DACCB0 Figures 15F, 17

Type material. Holotype (male): "FRENCH GUYANA:/ Road Petit Saut,/ Crique Eau Claire/ xii.2002–1.2003./ M. Balke leg.", "DNA VOUCHER/ Extraction #/ SLE-77" (SEMC). **Paratypes (3):** same data as holotype (3 exs., SEMC including DNA Voucher SLE517).

Differential diagnosis. Chasmogenus sinnamarensis is similar in morphology and size to *C. berbicensis*, but can be differentiated from that species by the form of the mentum, which possesses an elevated ridge posterior to the anteromedial notch. This mentum character is also shared with the Andean species *C. bariorum*, *C. cuspifer*, and *C. lineatus*, however these species either have a distinctly toothed mesoventrite (not toothed in *C. sinnamarensis*) or clypeus without an anteromedial emargination (emarginated in *C. sinnamarensis*).

Description. *Size and color.* Total body length 4.9–5.0 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head dark brown. Pronotum dark



Figure 21. Habitat of *Chasmogenus* spp in Suriname. **A** Type locality and habitat for *C. brownsbergensis*, Brownsberg Nature Park (collecting event SR12-0804-03A) **B** type locality and habitat for *C. ligulatus*, near Mt. Kasikasima (collecting event SR12-0320-02A) **C** type locality and habitat for *C. tafelbergensis*, summit of Tafelberg tepui (collecting event SR13-0817-01A) **D** type locality and habitat for *C. schmits*, S of Kwamala along the Kutari River (collecting event SR10-0316-01B) **E** habitat for *C. acuminatus*, Central Suriname Nature Reserve, Raleighvallen (collecting event SR16-0316-01B) **F** habitat for *C. guianensis*, upper Palumeu River, (collecting event SR12-0311-01A).

brown with slightly paler lateral margins, elytra uniformly dark brown. *Head.* Ground punctation on head fine. Clypeus with anteromedial emargination, which exposes broadly rounded shaped gap between clypeus and labrum. Mentum moderately depressed in anterior half with rounded anteromedial notch followed by rounded elevated ridge just

posterior of the notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum fine. Prosternum mildly tectiform. Mesoventrite with very weak elevation forming a posteromedial longitudinal carina. Metafemora densely and uniformly pubescent in basal nine-tenths. *Aedeagus.* Aedeagus (Fig. 15F) with median lobe widest at base, nearly parallel sided in basal three-quarters, then narrowing abruptly to form an acute triangular apex which is even with or slightly extends beyond the apex of the parameres. Sclerite of the median lobe not expanded. Gonopore situated less than half of one gonopore width below the apex of the median lobe. Parameres symmetrical, with outer margins straight, with apex very slightly inwardly curved and bluntly rounded. Basal piece long, ca. as long as the length of the parameres.

Etymology. Named after the Sinnamary River, close to where it was collected. To be treated as a noun in apposition.

Distribution. Only known from the type locality in French Guiana (Fig. 17). **Biology.** This species was collected from a clear water creek.

Chasmogenus tafelbergensis sp. nov.

http://zoobank.org/D3640B54-0826-4469-A091-AF1164BBEA14 Figures 16A–D, 17, 21C

Type material. Holotype (male). "SURINAME: Sipaliwini District/ 3°55.600'N 56°11.300'W, 600m/ CSNR: Tafelberg Summit, nr/ Augustus Creek Camp, pools &/ creeks on trail into Arrowhead/ basin; leg. Short & Bloom. 17.viii.2013; SR13-0817-01A", "HOLOTYPE/ CHASMOGENUS/ tafelbergensis sp. n./ des. Smith & Short", "DNA VOUCHER/ Extraction #/ SLE-1825". (NZCS).

Differential diagnosis. The strongly asymmetrical parameres, highly reduced basal piece, and extraordinary depth of the aedeagus (Fig. 16A–D) will easily separate this species from all others except *C. ignotus*, from which it may be differentiated by its narrower aedeagal profile. Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. *Size and color.* Total body length 3.3 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head bicolored, frons dark red-brown, clypeus and labrum dark orange-brown. Pronotum and elytra uniformly dark brown. *Head.* Ground punctation on head moderately coarse. Clypeus with anteromedial emargination, which exposes angulate gap between clypeus and labrum. Mentum moderately depressed in anterior half with anteromedial subtriangular notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum moderately coarse. Prosternum mildly tectiform. Mesoventrite with very weak elevation forming a posteromedial longitudinal carina. Metafemora densely pubescent in basal six-sevenths. *Aedeagus.* Aedeagus (Fig. 16A–D) with median lobe highly modified, appearing as a narrow subparallel-sided strap and partly rotated laterally, with apex extending to the apex of the parameres. Sclerite of the median lobe extremely well developed and appearing as a thin curved strut that extends the full length of the genitalia. Gonopore oriented laterally (Fig. 15B); situated twice gonopore width below
the apex of the median lobe. Parameres asymmetrical, with left paramere wider than right paramere; outer margins of parameres strongly sclerotized, with the sclerotized region on the right paramere thicker than the left. Aedeagus, especially the parameres, thickened, such that it takes on a highly three-dimensional appearance (Fig. 16B, C); in lateral view widest in basal half, with dorsal surface strongly convex, with ventral surface nearly flat. Basal piece short, less than half the length of the parameres; partly obscured by the strongly sclerotized and enlarged base of the median lobe and parameres.

Etymology. Named after Tafelberg, a low elevation sandstone tepui in central Suriname. To be treated as a noun in apposition.

Distribution. This species only known from the summit of Tafelberg Tepui in Suriname (Fig. 17).

Biology. The single specimen of this species was collected from forested pools which contained extremely dense layers of leaf litter detritus (Fig. 21C).

Chasmogenus undulatus sp. nov.

http://zoobank.org/8D86B749-C001-4FFB-8423-DDC75A7BA12B Figures 9E, 15G, 17, 22B

Chasmogenus sp. A Short, Salisbury, & La Cruz 2018: 193.

Type material. Holotype (male): "GUYANA: Region XIII/ 5°18.261'N, 59°50.257'W; 687 m/ Ayanganna Airstrip, trail from air-/ strip to Ayanganna; forested/ detrital pools; leg. A. Short/ 18.iii.2014/ GY14-0318-01B", "[barcode]/SEMC1313817/ KUNHM-ENT", "HOLOTYPE/ CHASMOGENUS/ undulatus sp. n./ des. Smith & Short" (CBDG). **Paratypes (20):** GUYANA: Region 8: same data as holotype (4 exs., SEMC including DNA Voucher SLE1618); same data as holotype except: 17.iii.2014, forest detrital pools, GY14-0317-01A (14 exs., CBDG, SEMC including DNA Vouchers SLE1832 and SLE1833); same data as holotype except: 19.iii.2014, trail from airstrip to marshy mined area, GY14-0319-02A (1 ex., SEMC); Ayanganna Airstrip, trail from Blackwater Creek Camp to Potaro River, 5°17.823'N, 59°50.000'W, 684 m, 19.iii.2014, leg. A. Short, forest detrital pools, GY14-0319-01A (1 ex., SEMC, DNA Voucher SLE1831).

Differential diagnosis. Among species that have a broad clypeal emargination and the apex of the median lobe extending past the apex of the paramere, *C. undulatus* may be distinguished from the widespread and similar *C. acuminatus* by the distinctly sinuated outer margins of the parameres (Fig. 15G) (straight in *C. acuminatus*). In other species with sinuated outer margins of the parameres (*C. ligulatus* and *C. pandus*), this species may be distinguished by the gradually tapered and blunt apex of the median lobe (more pointed in *C. pandus*, not tapered in *C ligulatus*). Examination of the aedeagus is the only way to definitively identify this species. Unassociated females may not be determined with certainty.

Description. *Size and color.* Total body length 3.8–4.0 mm. Body form elongate oval with slightly curved lateral margins. Dorsum of head dark brown, clypeus slightly paler (Fig. 9E). Pronotum dark orange-brown, distinctly paler marginally. Elytra



Figure 22. Habitat of *Chasmogenus* spp in Guyana. **A** Type locality and habitat for *C. berbicensis*, Guyana, margin/detrital sandbar of the upper Berbice River (collecting event GY14-0922-02A) **B** type locality and habitat for *C. undulatus* Guyana, near Ayanganna airstrip (collecting event GY14-0317-01A) **C** habitat for *C. acuminatus* and *C. guianensis*, Guyana, small tributary of the upper Berbice River (collecting event GY14-0924-01A) **D** habitat for *C. acuminatus* (collecting event GY13-1103-02A).

uniformly dark brown. Venter dark red brown to dark brown. *Head.* Ground punctation on head fine to moderately coarse. Clypeus with anteromedial emargination, which exposes a trapezoidal gap between the clypeus and labrum (Fig. 9E). Mentum strongly depressed in anterior half with subtriangular anteromedial notch. Maxillary palps long, longer than width of head immediately posterior to eyes. *Thorax.* Ground punctation on pronotum moderately coarse. Prosternum tectiform. Mesoventrite with elevation forming a posteromedial longitudinal carina with the lateral margins convex. Metafemora densely pubescent in basal six-sevenths. *Aedeagus.* Aedeagus (Fig. 15G) with median lobe nearly parallel-sided and widest in basal half, then angled slightly to the left and tapering gradually to a weakly acuminate apex, distinctly extending beyond the apex of the parameres. Sclerite of the median lobe expanded and developed into a wide angulate sliver with a sharply acute apex that extends to the apex of the parameres. Gonopore situated ca. 1.5 gonopore widths below the apex of the median lobe. Parameres symmetrical, with outer margins strongly bisinuated, giving the margins a weakly undulating appearance, apical distinctly narrower than basal half; apex bluntly rounded. Basal piece short, ca. one-third the length of the parameres.

Etymology. The species name is derived from the Latin *undulatus*, meaning "wavy", after the curvy and sinuated margins of the parameres.

Distribution. This species is known from several collections near Mount Ayanganna in western Guyana.

Biology. Series of this species were collected in forested detrital pools (Fig. 22B).

Chasmogenus sp. C

Chasmogenus sp. C Short, Salisbury, & La Cruz 2018: 193.

Material examined (4). GUYANA: Region 6: Upper Berbice, Basecamp 2, 4°45.301'N, 58°00.404'W, 49 m, 26.ix.2014, leg. Short, Salisbury and La Cruz, shallow detrital pools in forest draining into creek, GY14-0926-01A (4 females, CBDG, SEMC including DNA Voucher SLE1783).

Remarks. This species is only known from four female specimens. We sequenced one specimen which was genetically distinct from all other described species in the region and likely represents an undescribed species. However, because the aedeagus is critical for identification, we have chosen not to formally describe this species until males can be found. This species is morphologically similar to *C. pandus*, particularly the reddish dorsal coloration and smaller size. It was first recognized as a distinct morphospecies by Short et al. (2018), where it was listed as "*Chasmogenus* sp. C", and we have followed this naming convention for continuity.

Key to species of *Chasmogenus* Sharp of Venezuela, Suriname, Guyana, French Guiana, and Brazil north of the Amazon River

1	Anterior margin of clypeus straight, not emarginated (Figs 8E, F)2
_	Anterior margin of clypeus emarginated, which may be narrow to broad (e.g.,
	Figs 8A–D, 9A–F)
2	Dorsum of head completely black (Fig. 8F). Lateral margins of pronotum not
	distinctly paler than on disc (Fig. 4A) C. lineatus sp. nov.
_	Dorsum of head with pale preocular patches on the lateral margins of the
	clypeus (Fig. 8E). Lateral margins of pronotum distinctly paler than disc (Fig.
	3A) C. flavomarginatus sp. nov.
3	Anterior emargination of the clypeus triangular (e.g., Fig. 8A-D). Andean
	region
_	Anterior emargination of clypeus broad and rounded (e.g. Figs 9A-F, 10A-
	D). Widespread but generally not from the Andean region (except the low-
	land C. australis)

4 Mesoventrite with longitudinal carinae that is strongly elevated into an acute tooth (Fig. 7A, B). Dorsal coloration dark brown to black (e.g. Fig. 3D) 5 Mesoventrite with longitudinal carinae, but never elevated into a tooth. Dor-5 Body length > 3.5 mm; aedeagus with median lobe as wide as one paramere, tapering only at apical fourth (Fig. 11A–H)...... C. bariorum García Body length < 3.5 mm; aedeagus with median lobe narrower than one paramere, tapering gradually and consistently along entire length (Fig. 12D) Body length < 4.5 mm, though typically less than 4.0 mm. Apex of median 6 lobe of aedeagus ca. as long as the apex of the parameres (e.g., Figs 13A-D, 14A–E).....**10** Body length > 4.5 mm. Apex of median lobe of aedeagus of variable length7 7 Basal piece very long, subequal in length as length of parametes (Fig. 15F). Depression of mentum with anteromedial notch and anteroposteriorly curved rounded ridge posterior to notch C. sinnamarensis sp. nov. Basal piece of aedeagus distinctly shorter than length of parametes (e.g. Fig. Dorsal coloration usually dark brown. Venezuela and the Guianas......9 8 Dorsal coloration pale to medium brown (Fig. 2A). Aedeagus as in Fig. 14A. 9 Body length 4.5–4.9 mm. Aedeagus as in Fig. 14D. Guyana (Berbice River) .. Body length 3.8-4.5 mm. Aedeagus as in Fig. 14B. Venezuela (Rio Aguaro corridor) *C. clavijoi* sp. nov. (in part) 10 Body tan to very pale brown dorsal coloration (Fig. 4D). Typically found in Body usually darker in overall coloration. Typically found in forested streams 11 Aedeagus highly asymmetrical, with parameres of unequal size and only partial sclerotization on dorsal surface; median lobe longitudinally divided and extremely narrow, basal piece oblique (Fig. 14B, C, 14F, G)12 Ventral face of aedeagus strongly curved, convex in lateral view (Fig. 16B) ... 12 Ventral face of aedeagus nearly flat to slightly concave in lateral view (Fig. 16F)..... *C. ignotus* sp. nov. Apex of median lobe long, distinctly extending beyond the apex of the para-13 meres; basal piece short, one-third the total length of the parameres or less (e.g. Fig. 15A–E, 15G–I)......14 Apex of median lobe short, not extending beyond the apex of the parameres; basal piece long, up to one-half the length of the entire aedeagus......17

76

Parameres evenly curved along outer margins, not sinuate (Fig. 15H, I)
Parameres slightly to strongly sinuate along outer margins (e.g. Fig. 15A,
С-Е)
Median lobe nearly uniform in width along entire length, with a broadly
rounded apex (Fig. 15E) <i>C. ligulatus</i> sp. nov.
Median lobe gradually narrowing apically, with a narrowly rounded to point-
ed apex (Fig. 15A–D, G)16
Median lobe with apex pointed (e.g., Fig. 15A-D); dorsal coloration dark
reddish brown. Emargination of the clypeus extremely narrow and broad
(Figs 5D–F, 10D)
Median lobe with apex rounded (Fig. 15G); dorsal coloration dark brown.
Emargination of the clypeus rounded to angulate C. undulatus sp. nov.
Apex of median lobe distinctly shorter than length of parameres (Fig. 14F,
H)
Apex of median lobe approximately even with apex of parameres (Fig. 14B,
C, E)
Apex of parameres bluntly rounded inwards, giving the apicomedial angle an
almost toothlike appearance (Fig. 14F)
Apex of parametes smoothly rounded inwards (Fig. 14G, H)
C. guianensis sp. nov.
Apex of parameres inwardly curved and distinctly narrowed along inner mar-
gin (Fig. 14E). Distinct dark patches on mesal portion of clypeus and labrum
(Fig. 10A)
Apex of parameres inwardly curved but not or only slightly narrowed along
inner margin (Fig. 14B, C). Clypeus and labrum without distinct dark
patches
Body length \leq 3.8 mm, dorsal coloration darker, appearing very dark brown
<i>C. gato</i> sp. nov.
Body length \geq 3.8 mm, dorsal coloration paler, appearing orange-brown
<i>C. clavijoi</i> sp. nov. (in part)

Acknowledgments

We are extremely grateful for the assistance and support of many colleagues during fieldwork, including Mauricio García (MALUZ), Jesús Camacho (MALUZ), Luis Joly (MIZA), Neusa Hamada (INPA), Cesar Benetti (INPA), Vanessa Kadosoe (NZCS), and Paul Ouboter (NZCS), as well as the curators of the collections listed above for the loan of valuable specimens. We are particularly thankful to the continued assistance of Charyn Micheli (USNM) for assistance in that collection. This study was supported by US National Science Foundation grants DEB-0816904 and DEB-1453452 to AEZS.

RS was supported by an REU supplement to DEB-1453452. Fieldwork in Suriname and Guyana was partly funded by Conservation International and WWF-Guianas respectively. Fieldwork in Brazil was partly funded by a Fulbright fellowship to AEZS. The expedition to Tafelberg was funded by grant #9286-13 from the National Geographic Society Committee for Research and Exploration to AEZS.

References

- Clarkson B, Ferreira-Jr N (2014) Four new species and first nominal record of *Chasmogenus* Sharp, 1882 (Coleoptera: Hydrophilidae) from Brazil. Zootaxa 3765: 481–494. https:// doi.org/10.11646/zootaxa.3765.5.6
- Fernández LA (1986) Consideraciones sobre el género *Chasmogenus* Sharp y description de *Chasmogenus sapucay* sp. nov. (Coleoptera: Hydrophilidae). Neotropica 32: 189–193.
- García M (2000) Cuatro Nuevas Especies de *Chasmogenus* Sharp, 1982 (Coleoptera: Hydrophilidae: Hydrophilinae) de Venezuela. Boletín del Centro de Investigaciones Biológicas Universidad del Zulia 34: 45–58.
- Hansen M (1991) The hydrophiloid beetles. Phylogeny, classification and a revision of the genera (Coleoptera: Hydrophilidae). Biologiske Skrifter 40: 1–367.
- Hebauer F (1992) The species of the genus Chasmogenus Sharp, 1882 (Coleoptera, Hydrophilidae). Acta Coleopterologica 8(2): 61–92.
- Minh BQ, Nguyen MAT, von Haeseler A (2013) Ultrafast approximation for phylogenetic bootstrap. Molecular Biology and Evolution 30: 1188–1195. https://doi.org/10.1093/ molbev/mst024
- Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ (2015) IQ-tree: a fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. Molecular Biology and Evolution 32: 268–274. https://doi.org/10.1093/molbev/msu300
- Short AEZ (2005) A review of the subtribe Acidocerina of Central America with special reference to Costa Rica (Coleoptera: Hydrophilidae). Koleopterologische Rundschau 75: 191–226.
- Short AEZ (2013) Chapter 4. Aquatic Beetles of the Grensgebergte and Kasikasima Regions, Suriname (Insecta: Coleoptera). In: Alonso LE, Larsen TH (Eds) A Rapid Biological Assessment of the Upper Palumeu River Watershed (Grensgebergte and Kasikasima) of Southeastern Suriname. RAP Bulletin of Biological Assessment, 67. Conservation International, Arlington, VA, 79–89.
- Short AEZ, Fikáček M (2013) Molecular Phylogeny, Evolution, and Classification of the Hydrophilidae (Coleoptera). Systematic Entomology 38: 723–752. https://doi.org/10.1111/ syen.12024
- Short AEZ, Kadosoe V (2011) Chapter 4. Aquatic Beetles of the Kwamalasamutu Region, Suriname (Insecta: Coleoptera). In: O'Shea BJ, Alonso LE, Larsen TH (Eds) A Rapid Biological Assessment of the Kwamalasamutu region, Southwestern Suriname. RAP Bulletin of Biological Assessment, 63. Conservation International, Arlington, VA, 79–90.

- Short AEZ, Salisbury S, La Cruz N (2018) Chapter 7. Aquatic Beetles of the Upper Berbice Region, Guyana. In: Alonso LE, Persaud J, Williams A (Eds) Biodiversity Assessment Survey of the Upper Berbice Region, Guyana. BAT Survey Report No. 3. WWF-Guianas, Guyana Office, Georgetown, Guyana, 128–135.
- Shorthouse DP (2010) SimpleMappr, an online tool to produce publication-quality point maps. http://www.simplemappr.net

Supplementary material I

Table S1. Pairwise uncorrected percentage similarity between *Chasmogenus* COI sequences used in this study

Authors: Rachel R. Smith, Andrew Edward Z. Short

Data type: statistical data

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/zookeys.934.49359.suppl1

RESEARCH ARTICLE



A new genus of spider beetle (Coleoptera, Ptinidae) from western Peru

T. Keith Philips¹, Kyle A. Whorrall¹, Olivia M. Gearner¹, Jean-Bernard Huchet²

l Systematics and Evolution Laboratory, Department of Biology, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-3576, USA **2** Muséum National d'Histoire Naturelle, UMR 7205 ISYEB, Institut de Systématique, Evolution et Biodiversité, 45, rue Buffon, F-75005 Paris, France

Corresponding author: T. Keith Philips (Keith.Philips@wku.edu)

Academic editor: Michael Ivie Received 31 July 2019 Accepted 31 March 2020 P	Published 19 May 2020					
http://zoobank.org/8E894A50-7578-4CEA-BA6C-C995776A2DE9						

Citation: Philips TK, Whorrall KA, Gearner OM, Huchet J-B (2020) A new genus of spider beetle (Coleoptera, Ptinidae) from western Peru. ZooKeys 934: 81–91. https://doi.org/10.3897/zookeys.934.38670

Abstract

A new genus of flightless spider beetle from Peru with two new species is described. It is characterized by unique heart-shaped fused elytra and a broad pronotum with five basal depressions. The characters of this new genus and species are illustrated and discussed and the possible phylogenetic placement of this taxon is also included.

Keywords

Atacama Desert, Bostrichoidea, diversity

Introduction

The spider beetle fauna of South America currently includes ca. 100 described species placed in 11 genera. Little recent work has been done on the group with the exception of publications by Bellés on *Ptinus* Linnaeus (1984, 1986), *Bellesus* Özdikmen (as *Arachnomimus* Bellés 1985 and see Özdikmen 2010), *Prosternoptinus* Bellés (1985), and *Tropicoptinus* Bellés (1998), by Borowski on *Trigonogenius* Solier (2000, 2006) and earlier studies on the myrmecophilous fauna (*Gnostus* Westwood and *Fabrasia* Martinez & Viana) by Lawrence and Reichardt (1966). All other descriptive work occurred before

1939 and mainly by Maurice Pic on *Ptinus* (e.g., Pic 1900, 1936, 1939). The fauna is still largely undocumented and possibly most morphologically diverse in the more xeric regions of this continent, a habitat that often leads to highly modified external morphologies and flightlessness (Philips 2000). In particular, additional hidden diversity exemplified by this new genus may be discovered in the drier areas of the west from southern Ecuador through Peru to Chile and east into Argentina. Part of this region in the southern coastal portion is the hyper-arid Atacama Desert.

The two new species that make up this new genus are known only from Peru. Surprisingly one of the new species discovered was in material from the Ditsong Museum located in Pretoria, South Africa. The second species was collected by one of the authors (JBH) during archaeoentomological investigations on the emblematic site of Huaca de la Luna in 2009. Documenting this genus and concomitant new species increases the known morphological range within spider beetles and will make the name available for unpublished phylogenetic studies.

Taxonomy

Cordielytrum Philips, gen. nov.

http://zoobank.org/2F6CB8B5-F409-4C16-9FB0-BD958A68CB5F Figures 1–4

Type species. Cordielytrum peruvianum Whorrall & Philips.

Diagnosis. This genus can be recognized by the heart-shaped pair of fused elytra and the dense appressed setal scale covering (Figs 1, 2). There are also very elongate erect setae on the lateral edge of the pronotum and humeral area of the elytra that extend laterally and curve slightly posteriorly apically. Near the pronotal base are five depressions; one large median and two smaller ones positioned more laterally on each side. There is also a distinct and relatively large pocket on the head positioned below the eye and extending to the lateral edge of the clypeus. Currently the two species in this genus are known only from Peru.

Description. *Body*: small, length approximately 2 to 2.5 mm, ovoid, convex but slightly flattened dorso-ventrally, dorsally body surface completely obscured with appressed or recumbent setae, scale-like especially on head and elytra.

Head (Fig 4A): Eyes not visible dorsally, small, ovoid, slightly rounded ommatidial surface facing slightly upwards; vertex very slightly convex, antennal fossae generally indistinct, smoothly rounded edges, but more distinct dorsally and laterally absent; a large distinct pocket extending laterally from fossa through to gena between eye and lateral edge of clypeus; antennae short in length, no longer than the maximum width of the pronotum, 11 antennomeres, 4–10 relatively stout, only slightly longer than wide, second antennomere inserted off center of scape near lateral edge; interantennal space between antennal insertions wide, width approximately the same as length of scape, flat with no carina between antennal fossae; clypeus triangular, maximal width



Figure 1. *Cordielytrum peruvianum* sp. nov. **A** Dorsal habitus **B** ventral habitus **C** lateral view **D** frontal view. Scale bars: 1.0 mm (**A**, **B**), 0.5 mm (**D**).

 \approx 4/5 width of head measured adjacent to pronotum, labrum (Fig. 4B) ca. 1/3 width of clypeus, anterior edge very slightly emarginated in middle; mandible apex acutely pointed, medial tooth present (Fig. 4C); maxillary and labial palps with four and three palpomeres respectively (Fig. 4D, E); mentum triangular, with small triangular cavity at middle (Fig. 4F).

Pronotum (Fig. 3B): Strongly transverse with five depressions adjacent to the posterior margin, one large median and two smaller laterally on each side (Figs 1A, 2A); elongate erect setae on lateral edge extending laterally.

Elytra (Fig. 3A): Heart-shaped, convex, fused along suture; longitudinal carinae at least at base and sometimes visible the entire length of each elytron, short suberect setae on carinae; relatively elongate setae on humeral area that extend laterally and curve posteriorly near their apex; 2–3 irregular fine puncture rows between each carina.



Figure 2. *Cordielytrum pulchrum* sp. nov. **A** Dorsal habitus **B** ventral habitus **C** lateral view **D** frontal view. Scale bars: 1.0 mm (**A**, **B**), 0.5 mm (**D**).

Thorax (Fig. 3D): Broader than long; prosternal process narrow anteriorly, widening posteriorly, teardrop- shaped, extending posteriorly to same distance as procoxae do posteriorly, extending slightly into mesoventrite; visible part of mesoventrite heart-shaped with a truncate tip posteriorly, between coxae slightly longer than wide, slightly shorter than length of metaventrite at middle; posterior margin of metaventrite broadly emarginated; mesoventral-mesepisternal and metaventral-metepisternal sutures both visible.

Abdominal ventrites (Fig. 3D): Ventrites broad, ca. 2/3 total width of body measured at/opposite ventrite base, all sutures visible, first three ventrites connate, length at middle compared to laterally slightly shorter except fifth where longest at middle; first and second approximately equal in length, third slightly shorter, fourth distinctly shortest, fifth distinctly longest. A





Figure 3. *Cordielytrum pulchrum* sp. nov. **A** Elytra, dorsal view **B** prothorax, frontal view, **C** aedeagus, dorsal view **D** meso- and metaventrites and abdominal ventrites. Scale bars: 0.5 mm (**A**, **B**, **D**), 0.1 mm (**C**).

Legs (Fig. 3B, D): moderate in length, femora widest near middle; tibia gradually expanded toward apex, pro- and mesotibiae similar in length to their respective femora, metatibiae distinctly longer; tarsomeres 2–4 ca. as wide as long, 1st and 5th ca. equal in length; procoxae and mesocoxae approximately rounded, procoxae slightly smaller in diameter than mesocoxae, metacoxae transverse, fused with metaventrite.

Male genitalia (Fig. 3C): relatively simple; parameres and median lobe relatively stout, parameres lacking setal clumps or other modifications.

Etymology. The generic name is derived from *cordi* = Latin for heart and *elytrum* = Greek for sheath in reference to the fused elytra that figuratively resemble an ideographic image of a heart.

Remarks. Sexual dimorphism externally is not apparent.

Distribution. Members of this genus appear to be denizens of xeric coastal areas in Peru (Fig. 5). Based on the locations of the two known species, there is a separation of over 700 km. Recent fieldwork in Peru has resulted in the collection of additional undescribed species in the south with one ca. 730 km straight line distance from Lima at ca. 17° latitude (Whorrall and Philips, unpublished). The discovery of even more undocumented species with further sampling should be expected.



Figure 4. *Cordielytrum pulchrum* sp. nov. **A** Head, frontal view **B** labrum, dorsal view **C** mandible, ventral view **D** maxilla, ventral view **E** labium, dorsal view **F** mentum, ventral view. Scale bars: 0.5 mm (**A**), 0.1 mm (**B–F**).

Ecology. Currently no information on the ecology is known with the exception of the northernmost species that was collected via traps baited with a local corn beer known as chicha: this fluid may have been attractive as a food and/or moisture source. Based on recent collections and current rearing experiments (Philips and Whorrall, unpublished), larvae feed on cat dung and likely any other type in their vicinity, such as that from other mammals, birds, or lizards.



Figure 5. Distribution of *Cordielytrum peruvianum* (circle) and *C. pulchrum* (triangle). The position of the city of Lima is also indicated (star).

Cordielytrum peruvianum Whorrall & Philips, sp. nov.

http://zoobank.org/551A269D-CDA6-4328-B04F-9BE278A60B8D Figures 1, 5

Type material. *Holotype.* **Peru**: Ica, coastal dunes, Seely, 15.I.1980. Deposited in the Museo de Historia Natural, Lima Peru. *Paratypes* (6): Same data as holotype. Para-

types have been deposited in the Ditsong Museum and the collections of the authors (TKPC, JBHC, KAWC).

Diagnosis. This species is distinguished from its congener by its more rotund shape and the narrow light tan scales covering the elytra. It is known only from the type locality in the Ica Region of Southern Peru.

Description. Body small, compact, subovate, convex; head, pronotum, and elytra tan colored. Length (anterior of pronotum to apex of elytra) 2.16 - 2.76 ($\mu = 2.55 \pm 0.20$) mm (N = 7).

Head: densely covered in light tan, depressed, ovoid scales completely covering surface, less dense laterally, with pronounced superantennal carinae; antennomeres 1–9 densely squamous, ultimate and penultimate antennomeres with simple setae, not obscuring surface, antennomeres 1–3 and 11 slightly longer than wide, others subequal.

Pronotum: setose with scales anteriorly and longer densely matted setae posteriorly; short, erect setae sparsely placed throughout, longer at posterio-lateral edge, arising from cavities formed within matted setae, cavities distinctly larger laterally; medial cavity deep, when viewed from above, extending nearly half total length but border absent at middle, extending as a shallow groove anteriorly; two posterio-lateral cavities on each side, deep and distinct.

Elytra: surface densely covered by narrow scales, giving a finely rugose appearance; lateral edge at anterior ¹/₄ with row of sparsely placed bristly very long setae; four prominent longitudinal carinae extending length of each elytron, including one at suture; indistinct very shallow depressions in ~ two rows between carinae; background cuticle color light reddish brown.

Ventral surface: Pro- and mesoventrites with matted setation similar to pronotum; metaventrite and abdominal ventrites with scales similar to elytra. Femora increasing in width from base to apex, girth reaching maximum around midpoint; tibiae increasing in width from base to apex, girth increasing throughout basal third then remaining equal thereafter; tarsomere 1 ca. twice as long as 2–4, ¹/₃ longer than 5, 2–4 sub-equal in length.

Etymology. The specific name *peruvianum* refers to the country in South America where this species was discovered.

Remarks. This species is from the Ica Region, Peru (Fig. 5). The precise location is unclear as the only additional information on the label is "coastal dunes."

Cordielytrum pulchrum Whorrall & Philips, sp. nov.

http://zoobank.org/DA2130D6-0A9C-4230-BD14-FB2381F2AB3E Figures 2, 5

Type material. *Holotype.* Peru: Trujillo, Huaca de la Luna, Plateforme Uhle, J. B. Huchet lgt.; Piège à "Chicha, (bière de maïs), (J6)13/05/2009). Holotype deposited in the Muséum national d'Histoire naturelle, Paris, France. *Paratypes* (18), same data as the holotype (13); Peru-Trujillo, Huaca de la Luna, 6. V–1.VII. 2009, J.B.

Huchet / A. Chauchat (5). Paratypes have been deposited in the Muséum national d'Histoire naturelle, Museo de Historia Natural, Lima, and the collections of the authors (TKPC, JBHC, KAWC).

Diagnosis. This species is distinguished from *C. peruvianum* by its slightly more elongate shape, the vestiture of broad, ovate tan and dark brown scales on its elytra. Currently this species is only known from the type locality in Northern Peru.

Description. Body small, compact, subovate, convex; head and pronotum tan, elytra mottled tan and dark brown. Length (anterior of pronotum to posterior of elytra) 1.84-2.44 ($\mu = 2.13 \pm 0.22$) mm (N = 15).

Head densely covered in light tan, depressed, ovoid scales completely covering surface, less dense laterally, with subtle superantennal carina; antennomeres 1–9 densely squamous, ultimate and penultimate antennomeres with simple setae; antennomeres 1–3 and 11 ca. twice as long as wide, others subequal.

Pronotum setose with scales anteriorly and longer densely matted setae posteriorly; short, erect setae sparsely placed throughout, longer at posterio-lateral edge, arising from cavities formed within matted setae, cavities distinctly larger laterally; medial cavity with poorly defined border, moderate in depth, when viewed from above, extending nearly one third of total length; two posterio-lateral cavities on each side, somewhat more distinct than medial cavity.

Elytra surface densely covered by broad, ovate scales, giving a coarsely rugose appearance; lateral edge at anterior ¹/₃ of each elytron with row of long densely placed bristly very long setae; four low longitudinal carinae extending length of each elytron, including one at suture; deep depressions in ~2 rows between carinae; background cuticle color dark reddish brown.

Ventral surface: Pro-, meso-, and metaventrites and abdominal ventrites with scales similar to elytra. Femora increasing in width from base to apex, girth reaching maximum around midpoint; tibiae increasing in width from base to apex, girth increasing throughout basal third then remaining equal thereafter; tarsomere 1 ca. twice as long as 2–4, ¹/₃ longer than 5, 2–4 sub-equal in length.

Etymology. The name derives from the attractive variegated pattern of dark and light-colored setae on the elytral surface.

Remarks. Many well-preserved, partial remains of this new species were initially recovered within organic material from pre-Columbian Mochica graves at the emblematic archaeological site of Huacas de Moche, located along the pacific coastal desert, in the vicinity of Trujillo, 550 km north of Lima, Peru. This archaeological complex includes two monumental pyramids built as a series of platforms: Huaca del Sol (Temple of the Sun) and Huaca de la Luna (Temple of the Moon), separated by a vast urban centre (Chauchat et al. 2009) (Fig. 6). The archaeological remains were directly associated with human skeletons or from inside ceramic vessels placed as offerings. In order to collect specimens of this "subfossil" species, pitfall traps were placed on site by one of the authors (JBH) baited with meat, rotten fruits or with a local corn beer called *chicha.* This fluid may have been attractive as a food and/or moisture source since this permitted collection of all specimens of the type-series.



Figure 6. The archaeological site of Huacas de Moche, located along the pacific coastal desert, in the vicinity of Trujillo, 550 km north of Lima, Peru. This is the type locality of *Cordielytrum pulchrum* sp. nov.

Discussion

The most plausible sister lineage is the genus *Trigonogenius*, as both are somewhat comparable morphologically and are found in the same region of South America. To support this hypothesis, an attempt to acquire a sample of DNA from a dried specimen was done but amplification attempts failed. Hence more complete data to support relationships and to truly understand where the ancestry of this taxon lies will have to wait until fresh material is processed and sequenced.

Further collecting efforts in coastal Peru south of Lima has resulted in the discovery of additional undescribed species of this genus. How many more species remain to be found in this poorly surveyed part of South America remains unknown.

Acknowledgements

We are very grateful to Ruth Müller and the late Charles Bellamy for providing us the opportunity to study specimens from the Ditsong National Museum of Natural History (Pretoria, South Africa) and in particular the support from them given while the second author was on a postdoctoral fellowship at the University of Pretoria and two sabbaticals (2008 and 2015) while at Western Kentucky University (WKU). We are indebted to Dr. Claude Chauchat ("Archéologie des Amériques," UMR 8096, Centre National de la Recherche Scientifique), director of the French archeological mission at Huaca de la Luna for permitting JBH to conduct entomological investigations at this site, Dr Louis Deharveng, head of the Entomology department, Muséum national d'Histoire naturelle, Paris, France and Dr. Bruno Maureille (University of Bordeaux) for partially supporting the field research in Trujillo, Peru. We are very grateful to Belkys Gutiérrez, Prof. Segundo Vásquez, and our colleagues in the Department of Biological Sciences (Universidad Nacional de Trujillo, Perú) for field support at Huaca de la Luna and logistics while in Peru. Our sincere thanks to Azadeh Taghavian (Muséum national d'Histoire naturelle, Paris) who took pictures of the type specimen of *Trigonogenius impressicolis* Pic to verify excluding it from *Cordielytrum*. The authors gratefully acknowledge the Center for Biodiversity Studies at WKU and a NSF Biological Surveys and Inventories grant (DEB 0430132) that has helped support studies on spider beetles. Lastly, we thank the reviews from Xavier Bellés and Michael Ivie for their useful comments that improved the manuscript.

References

- Borowski J (2000) New synonymies and remarks on some spider beetles (Coleoptera, Ptinidae). Annals of Warsaw Agricultural University. Forestry and Wood Technology 50: 63–70.
- Borowski J (2006) Review of the species of the genus *Trigonogenius* Solier, 1849 (Coleoptera, Ptinidae). [Annals of Warsaw Agricultural University. Forestry and Wood Technology 60: 7–16.
- Bellés X (1984) Descripción de dos nuevos *Ptinus* (Coleoptera, Ptinidae) de Venezuela. Folia Entomológica Mexicana 62: 39–45.
- Bellés X (1985a) Descripción y posición sistemática de Arachnomimus cristithorax n. gen. n. sp. (Coleoptera, Ptinidae) de Venezuela. Miscellania Zoológica 9: 229–232.
- Bellés X (1985b) Contribution a la connaissance des Ptinidae neotropicales; les genre *Proster-noptinus* nov. (Coleoptera). Entomologische Blätter 81(3): 132–142.
- Bellés X (1986) Descripción del *Ptinus angustithorax* n. sp. de Venezuela y definición del grupo *semiobscurus* de la región neotropical. Eos 62: 23–29
- Bellés X (1998) El género *Tropicoptinus* nov. (Coleoptera: Ptinidae) de la región Neotropical. Elytron 12: 85–96.
- Lawrence JF, Reichardt H (1966) Revision of the genera Gnostus and Fabrasia (Coleoptera: Ptinidae). Psyche 73: 30–45. https://doi.org/10.1155/1966/89786
- Manrique R, Ricotta C, Ferrari C, Pezzi G (2014) Latitudinal pattern in plant composition along the Peruvian and Chilean fog oases. Plant Biosystems 148: 1002–1008. https://doi. org/10.1080/11263504.2014.918059
- Özdikmen H (2010) *Bellesus* nom. nov., a new name for the Neotropical genus *Arachnomimus* Bellés, 1985 (Coleoptera: Ptinidae). Munis Entomology & Zoology 5: 312.
- Pic M (1900) Contribution à l'étude des Ptinidae de l'Amérique central et méridionale. [Annales de la Société Entomologique de Belgique 44: 251–258.
- Pic M (1936) Deux nouveaus coléoptères néotropiques (Coleoptera: Cantharidae et Ptinidae). Arbeiten Morphologische Taxonomische Entomologie Berlin-Dahlem 3: 131.
- Pic M (1939) Mutations et nouveautés diverses. Mélange Exotico-Entomologiques, fasc. 71: 1–36.

CHECKLIST



New faunistic records of the family Mycetophilidae (Insecta, Diptera) from Morocco

Ouarda Banamar¹, Peter J. Chandler², Ouafaa Driauach¹, Boutaïna Belqat¹

I Department of Biology, Faculty of Sciences, University Abdelmalek Essaâdi, BP 2121, Tétouan, Morocco
 2 606B Berryfield Lane, Melksham, Wilts SN12 6EL, UK

Corresponding author: Boutaïna Belqat (belqat@gmail.com)

Academic editor: V. Blagoderov Received 6 December 2019 Accepted 4 March 2020 Published 19 May 2020
http://zoobank.org/B6D4D8BA-B7D0-41B7-8171-6E08759B3933

Citation: Banamar O, Chandler PJ, Driauach O, Belqat B (2020) New faunistic records of the family Mycetophilidae (Insecta, Diptera) from Morocco. ZooKeys 934: 93–110. https://doi.org/10.3897/zooKeys.934.49157

Abstract

A total of 54 species of Mycetophilidae are recorded for the first time in Morocco, of which 38 species are new to North Africa. A first checklist of Moroccan Mycetophilidae is appended, containing 64 species in 25 genera.

Keywords

Beni Snassen, checklist, fungus gnats, Middle Atlas, Mycetophilidae, North Africa, Rif

Introduction

The family Mycetophilidae belongs to the superfamily Sciaroidea and is the most abundant and diverse family of fungus gnats worldwide, comprising more than 4500 species (Pape et al. 2011). Adult fungus gnats are associated with humid areas, especially moist woodlands. They are usually found in shady and moist habitats such as cavities and root systems of fallen trees, overhanging stream banks, and among undergrowth of woods (Søli et al. 2000). As larvae, most mycetophilids develop in fungal fruiting bodies, both terrestrial and saproxylic, or in fungal mycelia in dead wood and soil litter, while a few species develop in myxomycetes, and others in rotten wood, bryophytes, bird's nests, or caves (Hutson et al. 1980; Yakovlev 1994).

Copyright Ouarda Banamar et al. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

The fungus gnat fauna of Morocco is practically unknown. The first information on Moroccan Mycetophilidae dates back to Séguy (1941) who described a new species *Rymosia exornata* based on a female collected in the High Atlas and which was placed later in synonymy with *Exechia fulva* Santos Abreu, 1920 by Chandler and Ribeiro (1995).

Five species, without given localities, were recorded by Chandler (1994): *Leia bimaculata* (Meigen, 1804), *Mycetophila sordida* van der Wulp, 1874, *Phronia biarcuata* (Becker, 1908), *Rymosia beaucournui* Matile, 1963, and *Rymosia pseudocretensis* Burghele-Balacesco, 1966. The localities on which these records were based are given here.

Three other species were reported by Chandler and Ribeiro (1995) without specifying localities: *Cordyla crassicornis* Meigen, 1818, *Mycetophila britannica* Laštovka & Kidd, 1975, and *Mycetophila pictula* Meigen, 1830. The localities on which the records of *C. crassicornis* and *M. pictula* were based are also given here.

Recent records were added by Chandler and Blasco-Zumeta (2001) who described *Sciophila iberolutea* Chandler & Blasco-Zumeta, 2001 from Spain and also recorded specimens of the species in Morocco (Oued y Kern, locality). Thus, prior to the present study, there were 10 species recorded from Morocco.

This paper is the first contribution relating specifically to the Mycetophilidae species of Morocco. New findings increase the number of Moroccan Mycetophilidae to 64. Of these, 54 species of Mycetophilidae are recorded for the first time in Morocco of which 38 species are new to North Africa.

Material and methods

A total of 724 specimens of Mycetophilidae (576 males and 148 females) were collected using Malaise traps and by sweeping, between 2012 and 2018. Forty sites distributed over mountainous areas, such as the Rif, Beni Snassen, and Middle Atlas, were sampled.

Most of the material was collected by O. Banamar, O. Driauach, and B. Belqat. Additional material was provided by Dr M. Ebejer that he had collected in Morocco and some Moroccan Mycetophilidae deposited in the Natural History Museum London, UK (**BMNH**) and the Musée National d'Histoire Naturelle, Paris, France (**MNHN**). All the material preserved in 70% ethanol, was identified by P. Chandler. If not otherwise stated, the examined material is deposited in the Abdelmalek Essaâdi University, Tétouan, Diptera collection.

A list of sampling sites, with coordinates and altitudes, is given in Table 1, and the locations of the sites are shown in Figure 1, which was prepared with ArcGis (version 9.3).

A first checklist of Moroccan Mycetophilidae, in alphabetical order, is given to summarize the species inventory presently known from Morocco. One (*) asterisk indicates that the species is the first record from Morocco; two (**) asterisks indicate that the species represents the first record for Morocco and North Africa.



Figure 1. Map showing all collecting localities for Mycetophilidae in this study; numbers correspond to those in the Table 1.

List of species

Family Mycetophilidae Subfamily Mycetophilinae Tribe Exechiini Genus Allodiopsis Tuomikoski, 1966

*Allodiopsis rustica Edwards, 1941

Literature records. Cited from North Africa (Tunisia) by Chandler et al. (2005).

Province	Station	Locality	Elevation (m)	Geographical coordinates
Rif				
Tétouan	1. Marabout El Khaloua	Dar Khennouss	788	35°29.039'N, 5°20.678'W
Tanger	2. Grotte d'Hercule	Tanger	12	35°45.566'N, 5°56.350'W
Chefchaouen	3. Aïn El Ma Bared	Bouzthate	1267	35°00.333'N, 5°12.105'W
	4. Aïn El Malâab	Parc National Talassemtane	1278	35°05.509'N, 5°09.443'W
	5. Aïn Ras El Ma	Majjou	856	35°06.873'N, 5°11.388'W
	6. Aïn Sidi Brahim Ben Arrif	Larache	897	35°20.398'N, 5°32.712'W
	7. Aïn Takhninjoute	Bab Rouida	1512	35°06.881'N, 5°08.270'W
	8. Aïn Tiouila	Parc National Talassemtane	1502	35°07.194'N, 5°09.978'W
	9. Bab El Karne	Tamakoute	1248	34°58.510'N, 5°11.838'W
	10. Cascade Chrafate	Chrafate	820	35°03.997'N, 5°06.434'W
	11. Daya Afersiw	Mezine	303	35°06.069'N, 5°20.337'W
	12. Daya Amsemlil	Jbel Bouhachem	1059	35°15.596'N, 5°25.917'W
	13. Daya avant Taïda	Taïda	425	35°22.426'N, 5°31.662'W
	14. Daya Fifi	Fifi	1202	35°01.367'N, 5°12.335'W
	15. Daya Jbel Zemzem	Jbel Zemzem	216	35°45.457'N, 5°22.189'W
	16. Daya Mtahen	Jbel Bouhachem	966	35°16.195'N, 5°26.158'W
	17. Daya Tazia	Route Moulay Abdessalam	721	35°20.814'N, 5°33.139'W
	18. Douar Abou Boubnar (Marabout Sidi Gile)	Parc National Talassemtane	1247	35°10.812'N, 5°07.500'W
	19. Douar Kitane	Kitane	52	35°32.412'N, 5°20.393'W
	20. Douar Tizga	Amsa	516	35°26.237'N, 5°13.694'W
	21. Forêt-Adrou	Parc National Bouhachem	580	35°13.538'N, 5°19.405'W
	22. Forêt-Aïn Boughaba	Jbel Bou Bessoui	1526	34°58.779'N, 4°46.366'W
	23. Forêt-Jbel Lekraa	Parc National Talassemtane	1541	35°06.825'N, 5°08.077'W
	24. Forêt-Taghzoute	Parc National Bouhachem	556	35°22.056'N, 5°32.034'W
	25. Maison forestière	Parc National Talassemtane	1674	35°08.076'N, 5°08.262'W
	26. Oued Aârate	Dardara	269	35°07.381'N, 5°17.456'W
	27. Oued Amsemlil	Jbel Bouhachem	1059	35°15.614'N, 5°25.943'W
	28. Oued à 15 Km de Fifi	Bouzthate	1256	35°00.805'N, 5°12.365'W
	29. Oued Kelâa	Akchour	303	35°14.268'N, 5°10.452'W
	30. Oued Majjou	Majjou Village	799	35°06.186'N, 5°10.935'W
	31. Oued Majjou (Hafa Meqlouba)	Chefchaouen	825	35°06.175'N, 5°10.836'W
	32. Oued Sidi Yahya Aârab	Sidi Yahya Aârab	62	35°17.545'N, 4°53.503'W
	33. Oued Tisgris	Hmmadesh	490	35°22.079'N, 5°32.064'W
	34. Oued Tkarâa	Jbel Bouhachem	959	35°16.063'N, 5°25.829'W
	35. Route Ksar El Kébir-Chefchaouen	Tattofte	133	35°01.735'N, 5°45.593'W
Beni Snassen (Eastern Morocco)			
Berkane	36. Grotte des Pigeons	Beni Snassen	676	34°49.044'N, 5°24.329'W
	37. Grotte du Chameau	Beni Snassen	427	34°50.447'N, 2°21.532'W
	38. Oued Tafoughalt	Tafoughalt	751	34°48.941'N, 2°24.471'W
Middle Atlas				
Meknès	39. Aïn Walili	Sidi Moulay Idriss Zerhoun	490	34°03.216'N, 5°31.050'W
Ifrane	40. Forêt-3.5 km S. Azrou	Azrou	1450	33°25.491'N, 5°12.393'W

Table 1. Sampling sites (in alphabetical order) harbouring the species collected in Morocco, in the present study, with localities, geographical coordinates and altitudes.

New record. Rif: Daya Tazia, 1 di 12/V/2015.

Genus Anatella Winnertz, 1864

**Anatella concava Plassmann, 1990

New record. Rif: Oued Aârate, 13, 26/III/2014.

Genus Brevicornu Marshall, 1896

*Brevicornu intermedium (Santos Abréu, 1920)

Literature records. Cited from North Africa by Chandler and Ribeiro (1995).

New records. Rif: Forêt-Jbel Lekraa, 1, 1, 1/VI/2013, coll. Ebejer; Oued Tisgris, 1, 25/III/2014; Oued Aârate, 1, 26/III/2014; Daya Tazia, 1, 25/IV/2014; Oued Majjou (Majjou Village), 2, 10/V/2014; Douar Tizga, 1, 25/VI/2014; Maison forestière, 2, 5, 9, 07/VI-17/VI/2014, Malaise trap; Daya Jbel Zemzem, 1, 2/II/2015; Aïn Takhninjoute, 1, 21/IV/2015; Forêt-Adrou, 1, 25/IV/2015, coll. Ebejer; Daya Amsemlil, 2, 23/IV/2016.

**Brevicornu griseicolle Staeger, 1840

New records. Rif: Daya Fifi, 13, 23/XI/2012; Oued Aârate, 13, 26/III/2014, 233, 07/V/2015; Daya Tazia, 13, 25/IV/2014; Oued Majjou (Majjou Village), 3333, 799, 10/V/2014; Aïn El Malâab, 233, 299, 17/V/2014; Aïn El Malâab, 1233, 17/V/2014; Maison forestière, 13799, 18/V/2014, 633, 17/VI/2014; Douar Tizga, 133, 25/VI/2014; Aïn Takhninjoute, 1333, 21/IV/2015; Daya Amsemlil 1333, 2999, 23/IV/2016; Daya Mtahen, 13333, 16/V/2016; Daya avant Taïda, 133333, 20/IV/2018.

*Brevicornu sericoma (Meigen, 1830)

Literature records. Recorded from North Africa (Tunisia) (Chandler and Ribeiro 1995; Chandler et al. 2005).

New records. Rif: Chefchaouen, VII/1975, 13, coll. J. Beaucournu (MNHN); Daya Fifi, 13, 23/XI/2012; Forêt-Jbel Lekraa, 13, 12/VI/2013, coll. Ebejer; Daya Fifi, 233, 26/III/2014; Oued Majjou (Majjou Village), 13, 10/V/2014; Maison forestière, 17/VI/2014; Douar Tizga, 13, 25/VI/2014; Oued Amsemlil, 233, 28/ II/2015; Grotte d'Hercule, 333, 29/III/2015; Forêt-Adrou, 13, 25/IV/2015, coll. Ebejer; Cascade Chrafate, 13, 28/IV/2015; Oued Aârate, 1033, 07/V/2015; Bab El Karne, 233, 25/XII/2015; Daya Amsemlil, 233, 16/V/2016.

*Brevicornu verralli (Edwards, 1925)

Literature records. Recorded from North Africa (Tunisia) (Chandler 1994, Chandler and Ribeiro 1995).

New records. Rif: Daya Afersiw, 1♂, 11/VI/2013; Forêt-Jbel Lekraa, 1♂, 12/VI/2013, coll. Ebejer.

Genus Cordyla Meigen, 1803

Cordyla crassicornis Meigen, 1818

Literature records. Recorded from Morocco (Chandler and Ribeiro 1995), based on 1 male in MNHN, which was from Chefchaouen, VII/1975, coll. J. Beaucournu.

New records. Rif: Douar Abou Boubnar, 13, 18/V/2014; Maison forestière, 633, 19, 17/VI/2014, Forêt-Adrou, 13, 25/IV/2015, coll. Ebejer; Oued Sidi Yahya Aârab, 13, 19, 25/IV/2015, coll. Ebejer. Beni Snassen: Oued Tafoughalt, 13, 25/XII/2014.

** Cordyla insons Laštovka & Matile, 1974

New record. Rif: Oued Majjou (Majjou Village), 1∂, 09/IV/2013.

** Cordyla murina Winnertz, 1864

New record. Rif: Forêt-Aïn Boughaba, 1⁽²⁾, 24/V/2013.

** Cordyla styliforceps (Bukowski, 1934)

New records. Rif: Maison forestière, 1♂, 4/VII/2013, 12♂♂, 17/VI/2014, 1♂, 17/ III/2015; Oued Tkarâa, 1♂, 1♀, 16/V/2016; Oued Sidi Yahya Aârab, 1♂, 25/IV/2015.

Genus Exechia Winnertz, 1864

** Exechia bicincta (Staeger, 1840)

New records. Rif: Oued Kelâa, 1° , 13/II/2013; Oued Aârate, 1° , 26/III/2014. Beni Snassen: Grotte des pigeons, 1° , 25/XII/2014; Oued Tafoughalt, 1° , 25/XII/2014.

** Exechia dorsalis (Staeger, 1840)

New record. Rif: Bab El Karne, 13, 25/XII/2016.

Exechia fulva Santos Abreu, 1920

= Rymosia exornata Séguy in Séguy 1941: 26

New records. Rif: 20 km west of Targuist, Ketama, 23/IV/1966, 633, 399, coll. A.M. Hutson (BMNH); Chefchaouen, VII/1975, 2133, 2099, coll. J. Beaucournu (MNHN); Oued Kelâa, 433, 499, 13/II/2013; Forêt-Aïn Boughaba, 733, 599,24/V/2013; Forêt-Jbel Lekraa, 13, 12/VI/2013, coll. Ebejer; Daya Fifi, 1433, 1199,26/III/2014; Aïn Sidi Brahim Ben Arrif, 133, 25/IV/2014; Oued Majjou (Majjou Village), 133, 10/V/2014; Aïn Takhninjoute, 433, 19, 17/V/2014; Maison forestière, 3733, 3299, 07/VI-17/VI/2014, Malaise trap; Oued Amsemlil, 233, 399, 28/II/2015; Daya Jbel Zemzem, 133, 02/III/2015; Aïn Takhninjoute, 4333, 599, 25/XII/2015; Bab El Karne, 22333, 499, 25/XII/2015; Daya Fifi, 3333, 599, 25/XII/2015; Daya Amsemlil, 233, 23/IV/2016.

*Exechia fusca (Meigen, 1804)

Literature records. Cited from North Africa (Tunisia) (Chandler 1994; Chandler and Ribeiro 1995).

New records. Rif: Oued Kelâa, 2 3 3, 13/II/2013; Forêt-Jbel Lekraa, 1 3, 12/ VI/2013, coll. Ebejer; Douar Kitane, 1 3, 01/I/2015; Daya Amsemlil, 1 3, 23/ IV/2016.

Genus Exechiopsis Tuomikoski, 1966

*Exechiopsis coremura (Edwards, 1928)

Literature records. Cited from North Africa (Algeria) (Hackman et al. 1988). New record. Rif: Cascade Chrafate, 1♂, 1♀, 28/IV/2015.

Genus Pseudexechia Tuomikoski, 1966

**Pseudexechia tuomikoskii (Kjærandsen, 2009)

New record. Rif: Source Aheramen, 13, 10/V/2014.

Genus Rymosia Winnertz, 1864

*Rymosia affinis Winnertz, 1864

Literature records. Cited from North Africa (Algeria) (Burghele-Balacesco 1967). New records. Rif: Maison forestière, 1♀, 17/VI/2014; Daya Amsemlil, 1♂, 28/ II/2015; Aïn Tiouila, 1♂, 02/V/2015; Daya Fifi, 1♂, 25/XII/2015.

Rymosia beaucournui Matile, 1963

Literature records. Cited from Morocco (Chandler and Ribeiro 1995; Chandler et al. 2005). Records of the species (9 males, 3 females) based on specimens in MNHN from Rabat, Oued y Kern, V/1973, coll. H. Choumara.

New record. Beni Snassen: Grotte des pigeons, 1Å, 25/XI/2014.

Rymosia pseudocretensis Burghele-Balacesco, 1966

Literature records. Cited from Morocco (Chandler 1994; Chandler et al. 2005), based on a specimen (1 male) in MNHN from Rabat, Oued y Kern, V/31973, coll. H. Choumara.

Genus Stigmatomeria Tuomikoski, 1966

** Stigmatomeria crassicornis (Stannius, 1831)

New records. Rif: Chefchaouen, VII/1975, 1 \bigcirc , coll. J. Beaucournu, MNHN; Forêt-Jbel Lekraa, 1 \bigcirc , 12/VI/2013, coll. Ebejer; Daya Fifi, 1 \bigcirc , 26/III/2014; Aïn Takhn-injoute, 1 \bigcirc , 17/V/2014; Maison forestière, 1 \bigcirc , 18/V/2014, 1 \bigcirc , 17/VI/2014; Daya Amsemlil, 1 \bigcirc , 23/IV/2016.

Genus Tarnania Tuomikoski, 1966

* Tarnania dziedzickii (Edwards, 1941)

Literature records. Cited from North Africa (Algeria) (Burghele-Balacesco 1967).
New records. Rif: Maison forestière, 1♀, 18/V/2014; Daya Amsemlil, 1♂, 28/II/2015; Cascade Chrafate, 1♂, 1♀, 28/IV/2015; Daya Amsemlil, 1♀, 23/IV/2016.
Grotte-Aïn El-Aouda, 1♂, 1♀, 2/V/1914, MNHN.

Tribe Mycetophilini

**Mycetophila alea Laffoon, 1965

New records. Rif: Chefchaouen, VII/1975, 13333, 699, coll. J. Beaucournu, MNHN; Aïn El Ma Bared, 19, 06/V/2014; Maison forestière, 13, 399, 17/VI/2014; Oued Aârate, 3333, 07/V/2015; Bab El Karne, 2333, 25/XII/2015.

Mycetophila britannica Laštovka & Kidd, 1975

Literature records. Recorded from Morocco (Chandler and Ribeiro 1995), based on material in MNHN, for which precise locality data was not noted.

New records. Rif: Forêt-Aïn Boughaba, $2\Im$, 24/V/2013; Forêt-Jbel Lekraa, $2\Im$, $1\Im$, 12/VI/2013, coll. Ebejer; Douar Kitane, $1\Im$, 13/III/2014, Malaise trap; Aïn El Malâab, $11\Im$, 17-V-2014; Aïn Takhninjoute, $1\Im$, 17/V/2014; Oued à 15 km de Fifi, $2\Im$, 06/V/2014; Aïn El Ma Bared, $3\Im$, 06/V/2014; Maison forestière, $2\Im$, 18/V/2014; Oued Majjou (Hafa Meqlouba), $1\Im$, 10/V/2014; Oued Majjou (Majjou Village), $1\Im$, 10/V/2014; Aïn Takhninjoute, $1\Im$, 17/V/2014; Maison forestière, $2\Im$, 18/V/2014; Grotte d'Hercule, $3\Im$, $2\Im$, $29\Im$, 29/III/2015; Aïn Takhninjoute, $1\Im$, 21/IV/2015; $1\Im$, 24/VI/2015; Oued Aârate, $1\Im$, 07/V/2015; Bab El Karne, $1\Im$, 25/XII/2015; Daya Amsemlil, $1\Im$, $1\Im$, 23/IV/2016; Daya Mtahen, $1\Im$, 16/V/2016; Daya avant Taïda, $1\Im$, 20/IV/2018; Forêt-Taghzoute, $1\Im$, $1\Im$, 25/IV/2015, coll. Ebejer.

**Mycetophila deflexa Chandler, 2001

New records. Forêt-Taghzoute, 1, 25/IV/2015; Route Ksar El Kébir-Chefchaouen, 2, 5/VI/2013, coll. Ebejer.

**Mycetophila edwardsi Lundström, 1913

New records. Rif: Daya Fifi, $2\sqrt[3]{3}$, 26/III/2014; Daya Tazia, $1\bigcirc$, 25/IV/2014; Oued Tkarâa, $1\bigcirc$, 16/V/2016; Forêt-Jbel Lekraa, $1\bigcirc$, 12/VI/2013, coll. Ebejer; Forêt-Taghzoute, $1\bigcirc$, 25/IV/2015, coll. Ebejer. Beni Snassen: Grotte d'Hercule, $1\bigcirc$, 29/III/2015.

**Mycetophila formosa Lundström, 1911

New records. Rif: Forêt-Jbel Lekraa, 13, 12/VI/2013, coll. Ebejer; Oued Amsemlil, 13, 28/II/2015, Daya Amsemlil, 13, 25/XII/2015; Daya Amsemlil, 233/IV/2016; Daya avant Taïda, 133, 20/IV/2018.

**Mycetophila marginata Winnertz, 1864

New records. Rif: Chefchaouen, VII/1975, 4 3, coll. J. Beaucournu, MNHN; Aïn Ras El Ma, 13, 3/V/2013; Oued Majjou (Majjou Village), 33, 10/V/2014; Maison forestière, 13, 17/VI/2014; Daya Amsemlil, 33, 23/IV/2016.

*Mycetophila perpallida Chandler, 1993

Literature records. Cited from North Africa (Chandler 2009).

New records. Rif: Forêt-Aïn Boughaba, 1♂, 1♀, 24/V/2013; Aïn El Malâab, 1♂, 14/VII/2013; Maison forestière, 2♂♂, 17/VI/2014; Bab El Karne, 1♂, 25/XII/2015; Daya Amsemlil, 3♂♂, 1♀, 23/IV/2016; Douar Kitane, 5♂♂, 1♀, 29/XII/2016.

Mycetophila pictula Meigen, 1830

Literature record. Cited from Morocco (Chandler and Ribeiro 1995), based on 1 male and 2 females in MNHN, which were from Chefchaouen, VII/1975, coll. J. Beaucournu.

New record. Rif: Forêt-Jbel Lekraa, 1♀, 12/VI/2013, coll. Ebejer; Oued Majjou (Majjou Village), 1♂, 10/V/2014.

Mycetophila sordida van der Wulp, 1874

Literature record. Cited from Morocco (Chandler 1994), based on 1 male in MNHN, which was from maison forestière de Khenolap-el-Ouaer, 1580 m, VII/1975, coll. J. Beaucournu.

New record. Rif: Forêt-Jbel Lekraa, 1⁽²⁾, 12/VI/2013, coll. Ebejer.

**Mycetophila spectabilis Winnertz, 1864

New records. Rif: Forêt-Jbel Lekraa, 13, 12/VI/2013, coll. Ebejer; Forêt-Aïn Boughaba, 13, 24/V/2013; Oued à 15 km de Fifi, 13, 06/V/2014; Aïn El Malâab, 13, 17/VI/2014.

*Mycetophila strigatoides (Landrock, 1927)

Literature records. Cited from North Africa (Tunisia) (Chandler 1994).

New records. Rif: Forêt-Taghzoute, 1♂, 25/IV/2015, coll. Ebejer; Oued Aârate, 1♂, 26/III/2014.

***Mycetophila unicolor* Stannius, 1831

New record. Rif: Oued Kelâa, 13/11/2013.

**Mycetophila vittipes Zetterstedt, 1852

New records. Rif: Forêt-Jbel Lekraa, 233, 12/VI/2013, coll. Ebejer; Maison forestière, 133, 193, 18/V/2014, Daya Amsemlil, 7333, 25/IV/2016.

Genus Phronia Winnertz, 1864

Phronia biarcuata (Becker, 1908)

Literature records. Recorded from Morocco (Chandler 1994; Chandler and Ribeiro 1995, Chandler et al. 2005), based on specimens in MNHN, which were from Chefchaouen, VII/1975, coll. J. Beaucournu.

New records. Rif: Daya Tazia, 1, 25/IV/2014; Aïn El Ma Bared, 1, 06/V/2014; Aïn El Malâab, 1, 17/V/2014; Aïn Takhninjoute, 1, 17/V/2014, 1, 21/IV/2015; Maison forestière, 1, 17/VI/2014; Grotte d'Hercule, 1, 29/III/2015; Daya Amsemlil, 4, 3, 3, 2, 23/IV/2016.

**Phronia cinerascens Winnertz, 1864

New record. Rif: Daya Amsemlil, 1⁽²⁾, 28/II/2015.

**Phronia nitidiventris (van der Wulp, 1858)

New records. Rif: Daya Afersiw, 1⁽²⁾, 11/VI/2013; Oued Aârate, 1⁽³⁾, 26/III/2014.

*Phronia tenuis Winnertz, 1864

Literature records. Recorded from North Africa (Tunisia and Algeria) (Chandler 1994). New records. Rif: Oued Kelâa, 1♂, 1♀, 13/II/2013; Oued Aârate, 1♂, 3♀♀, 26/ III/2014, 1♂, 07/V/2015; Oued Majjou (Majjou Village), 1♂, 10/V/2014; Aïn Takhninjoute, 2♂♂, 17/V/2014; Grotte d'Hercule, 1♂, 29/III/2015.

**Phronia tyrrhenica Edwards, 1928

New records. Rif: Forêt-Jbel Lekraa, 1, 12/VI/2013, coll. Ebejer; Maison forestière, 1, 18/V/2014; Daya Amsemlil, 2, 28/II/2015; Aïn Takhninjoute, 6, 5, 9, 21/IV/2015; Daya Amsemlil, 3, 3, 1, 23/IV/2016.

**Phronia willistoni Dziedzicki, 1889

New records. Rif: Forêt-Jbel Lekraa, 1 \Diamond , 12/VI/2013, coll. Ebejer; Oued Aârate, 1 \Diamond , 26/III/2014; Maison forestière, 1 \Diamond , 1 \bigcirc , 18/V/2014; Daya Amsemlil, 3 \Diamond \Diamond , 3 \bigcirc \bigcirc , 28/II/2015, 1 \Diamond , 1 \bigcirc , 23/IV/2016; Cascade Chrafate, 1 \Diamond , 28/IV/2015; Bab El Karne, 14 \Diamond \Diamond , 1 \bigcirc , 25/XII/2015.

Genus Sceptonia Winnertz, 1864

**Sceptonia intestata Plassmann & Schacht, 1990

New records. Rif: Maison forestière, 13, 17/VI/2014; Aïn El Malâab, 13, 17/V/2014.

**Sceptonia membranacea Edwards, 1925

New records. Rif: Oued à 15 km de Fifi, 233, 06/V/2014; Oued Aârate, 133, 07/V/2015.

Genus Trichonta Winnertz, 1864

** Trichonta foeda Loew, 1869

New records. Rif: Aïn Takhninjoute, 1♂, 21/IV/2015; Bab El Karne, 3♂♂, 1♀, 25/ XII/2015; Daya Amsemlil, 1♂, 23/IV/2016; Oued Tkarâa, 1♂, 16/V/2016.

** Trichonta icenica Edwards, 1925

New record. Beni Snassen: Grotte du chameau, 1⁽²⁾, 24/XI/2015.

*Trichonta vitta (Meigen, 1830)

Literature records. Recorded from North Africa (Algeria) (Hackman et al. 1988; Chandler 1994).

New records. Rif: Forêt-Jbel Lekraa, 1 \bigcirc , 12/VI/2013, coll. Ebejer; Bab El Karne, 1 \Diamond , 25/XII/2015.

** Trichonta vulcani Dziedzicki, 1889

New record. Beni Snassen: Grotte du Chameau, 1∂, 24/XI/2015.

Genus Zygomyia Winnertz, 1864

***Zygomyia humeralis* (Wiedemann, 1817)

New record. Rif: Maison forestière, 1∂, 17/VI/2014.

**Zygomyia valida Winnertz, 1864

New records. Rif: Aïn Ras El Ma, 13, 19, 3/V/2013; Oued Aârate, 13, 26/III/2014.

Subfamily Leiinae Genus Docosia Winnertz, 1864

**Docosia gilvipes (Walker, 1856)

New records. Rif: Forêt-Jbel Lekraa, 13° , 12/VI/2013, coll. Ebejer; Maison forestière, 13° , 07/VI-17/X/2014, Malaise trap; Maison forestière, 13° , 17/VI/2014; Aïn Takhninjoute, 13° , 21/IV/2015; Daya Amsemlil, 12° , 23/IV/2016.

Genus Leia Meigen, 1818

*Leia arsona Hutson, 1978

Literature records. Cited from North Africa (Tunisia) (Chandler 1994; Chandler and Gatt 2000).

New records. Rif: Oued Majjou (Majjou Village), 1♂, 09/IV/2013; Oued Sidi Yahya Aârab, 1♀, 25/IV/2015. Middle Atlas: Aïn Walili, 1♂, 18/II/2016.

*Leia beckeri Landrock, 1940

Literature records. Cited from North Africa (Algeria) (Hackman et al. 1988; Chandler 2009).

New record. Rif: Aïn Ras El Ma, 1^{\bigcirc} , 27/III/2013.

Leia bimaculata (Meigen, 1804)

Literature records. Cited from Morocco (Chandler et al. 2005), based on 1^{\uparrow} and 1^{\uparrow} from Forêt-Ifrane, 12/V/1961, coll. P.N. Lawrence (BMNH).

New records. Rif: Daya Tazia, 1, 25/IV/2014; Maison forestière, 1, 07/VI-17/X/2014, Malaise trap; Aïn El Ma Bared, 1, 25/XII/2015. Middle Atlas: Forêt-3.5 km S. Azrou, 1, 8/V/2012, coll. Ebejer.

Genus Novakia Strobl, 1893

*Novakia scatopsiformis Strobl, 1893

Literature records. Cited from North Africa (Tunisia) (Hackman et al. 1988; Chandler 1994).

New record. Rif: Maison forestière, 1033, 19, 07/VI-17/VI/2014, 13, 17/XI/2015, Malaise trap.

**Novakia simillima Strobl, 1910

New records. Rif: Oued Aârate, 1♂, 26/III/2014; Maison forestière, 11♂♂, 07/VI-17/VI/2014, 9♂♂, 17/XI/2015, Malaise trap.

Subfamily Gnoristinae Genus *Boletina* Staeger, 1840

**Boletina gripha Dziedzicki, 1885

New records. Rif: Daya Fifi, $3 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 23/XI/2012; Oued Aârate, $1 \stackrel{\circ}{\circ}$, 26/III/2014; Daya Fifi, $1 \stackrel{\circ}{\circ}$, 26/III/2014; Aïn Sidi Brahim Ben Arrif, $1 \stackrel{\circ}{\circ}$, 25/IV/2014; Daya Amsemlil, $2 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 28/II/2015; Grotte d'Hercule, $1 \stackrel{\circ}{\circ}$, 29/III/2015, Cascade Chrafate, $2 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 28/IV/2015; Oued Sidi Yahya Aârab, $1 \stackrel{\circ}{\circ}$, 25/IV/2015; Aïn El Ma Bared, $2 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 25/XII/2015; Bab El Karne, $2 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 25/XII/2015. Middle Atlas: Forêt-3.5 km S. Azrou, $2 \stackrel{\circ}{\circ} \stackrel{\circ}{\circ}$, 8/V/2012, coll. Ebejer.

Genus Coelosia Winnertz, 1864

** Coelosia fusca Bezzi, 1892

New records. Rif: Daya Fifi, 1 \bigcirc , 23/XI/2012; Oued Kelâa, 1 \circlearrowright , 13/II/2013; Daya Fifi, 1 \circlearrowright , 26/III/2014; Oued Amsemlil, 2 \circlearrowright \circlearrowright , 2 \bigcirc \bigcirc , 28/II/2015, 1 \circlearrowright , 31/I/2017; Aïn Takhninjoute, 1 \circlearrowright , 21/IV/2015; Cascade Chrafate, 2 \circlearrowright \circlearrowright , 28/IV/2015; Bab El Karne, 1 \bigcirc , 25/XII/2015; Daya Amsemlil, 1 \bigcirc , 23/IV/2016; Daya avant Taïda, 2 \circlearrowright \circlearrowright , 20/IV/2018.

Genus Synapha Meigen, 1818

**Synapha fasciata Meigen, 1818

New records. Rif: Aïn Sidi Brahim Ben Arrif, 1 \Diamond , 25/IV/2014; Daya Tazia, 1 \Diamond , 25/IV/2014; Forêt-Adrou, 1 \bigcirc , 25/IV/2015, coll. Ebejer; Daya Amsemlil, 1 \Diamond , 23/IV/2016; Daya avant Taïda, 1 \Diamond , 20/IV/2018.

**Synapha vitripennis (Meigen, 1818)

New record. Rif: Daya Amsemlil, 1⁽²⁾, 23/IV/2016.

Genus Tetragoneura Winnertz, 1846

** Tetragoneura ambigua Grzegorzek, 1885

New records. Rif: Forêt-Aïn Boughaba, 1♂, 24/V/2013. Beni Snassen: Oued Tafoughalt, 1♂, 25/XII/2014.

Subfamily Mycomyinae Genus *Mycomya* Rondani, 1856

**Mycomya flavicollis (Zetterstedt, 1852)

New records. Rif: Aïn El Malâab, 13, 17/V/2014; Maison forestière, 4033, 29, 07/VI-17/VI/2014, Malaise trap.

**Mycomya pygmalion Väisänen, 1984

New records. Rif: Oued Amsemlil, 6 3, 1, 28/II/2015; Aïn Sidi Brahim Ben Arrif, 2 3, 25/IV/2014.

***Mycomya tumida* (Winnertz, 1864)

New record. Rif: Daya Fifi, 2♂♂, 26/III/2014.

Subfamily Sciophilinae Genus Azana Walker, 1856

*Azana anomala Staeger, 1840

Literature records. Cited from North Africa (Algeria) (Hackman et al. 1988). New records. Rif: Oued Majjou (Majjou Village), 1♂, 09/IV/2013; Maison forestière, 46♂♂, 1♀, 17/VI/2014.

Genus Sciophila Meigen, 1818

Sciophila iberolutea Chandler & Blasco-Zumeta, 2001

Literature records. Cited from Morocco: Rabat, Oued y Kern, V/1973, coll. H. Choumara, MNHN: (Chandler and Gatt 2000; Chandler and Blasco-Zumeta 2001, Bechev and Koç 2006).

New records. Rif: Maison forestière, 13, 4/VII/2013, 433, 299, 07/VI-17/X/2014, Malaise trap, 13, 19, 17/VI/2014; Daya Jbel Zemzem, 13, 02/III/2015; Oued Sidi Yahya Aârab, 13, 25/IV/2015; Bab El Karne, 13, 25/XII/2015; Marabout El Khaloua, 13, 03/VI/2018.

Discussion

The majority of the species recorded here are widespread in the Mediterranean region and also more widely in Europe and the Palaearctic Region. In addition to these, 10 species considered to be new to science were also found, and these will be treated elsewhere. These new species belong to the genera *Rymosia*, *Docosia*, *Leia*, *Megophthalmidia*, *Ectrepesthoneura*, and *Mycomya*; *Docosia* and *Megophthalmidia* in particular are diverse in the Mediterranean region, and the discovery of additional species in North Africa is not surprising. A female of *Allocotocera* resembling the Greek *A. scheria* Chandler, Bechev & Caspers, 2005 was also found, but males will be needed to establish if it is conspecific with *A. scheria*.

Knowledge of the North African Mycetophilidae is otherwise poor, with a relatively small number of species recorded from Algeria and Tunisia. Seven species were recorded from Algerian caves by Burghele-Balacesco (1967), while the citation of others (Chandler 1994; Chandler and Ribeiro 1995; Chandler and Gatt 2000; Chandler et al. 2005) was based on specimens in the collections of MNHN and BMNH. Altogether, only 21 species have been recorded from Algeria and 13 species from Tunisia, with a combined total of 31 species, of which 19 are in common with the present Moroccan list. The additional 12 species are all widespread in Europe, and can also be expected to occur in Morocco. The Atlantic Islands fauna was dealt with by Chandler and Ribeiro (1995), with four species added by Chandler and Báez (2002); of the 68 species recorded, 23 are in common with Morocco, while 27 are apparently endemic to the islands. Of the 39 species found in the Canary Islands, 16 are in common with Morocco and 13 are island endemics.

The Mycetophilidae of the Iberian Peninsula are much better known, with published records of 247 species, but this is a diverse region for which a direct comparison is not practical, and compared to other European countries, a much greater total can be expected with more recording. Not surprisingly, 56 of the species recorded here from Morocco are in common with the Iberian Peninsula. Otherwise, the study of the Mediterranean fauna has been piecemeal, but there have been detailed accounts of the fauna of Israel (Chandler 1994: 64 species, 28 also in Morocco), Malta (Chandler and Gatt 2000: 21 species, 11 in Morocco), Greece and Cyprus (Chandler et al. 2005: 151 species, 46 in Morocco; for Cyprus 54 species, 25 in Morocco) and Sardinia (Chandler 2009: 102 species, 44 in Morocco). Thus, more than 40% of the species for each studied country or region are in common with Morocco, except for the larger land areas of mainland Greece and the Iberian Peninsula where more central European species are expected to be present.
Moroccan species whose distribution is entirely or principally Mediterranean are the following, with the distribution outside Morocco stated in each case:

Anatella concava (Corsica, mainland Spain)
Cordyla styliforceps (Canary Islands, widespread in southern Europe, most northerly Switzerland and Ukraine (Crimea))
Exechiopsis coremura (Algeria, Corsica, Iberian Peninsula)
Leia beckeri (Canary Islands, Algeria, mainland Spain, Sardinia)
Rymosia beaucournui (Iberian peninsula, Sardinia, Greece including Lesbos and Crete, southern France and Switzerland)
R. pseudocretensis (Iberian Peninsula, southern France, mainland Italy, Crete)
Phronia tyrrhenica (mainland Spain, Corsica, Greece, Cyprus, southern France and Switzerland)
Sceptonia intestata (mainland Spain, Greece, Cyprus)
Novakia simillima (mainland Spain, most northerly Austria)
Mycomya pygmalion (Iberian Peninsula, Greece including Crete, Cyprus, Lebanon, Israel)
Sciophila iberolutea (mainland Spain, Malta).

Acknowledgments

We are grateful to Dr Martin Ebejer who kindly provided material that he collected in Morocco and for permitting us to publish his new records. We also thank the authorities of BMNH and MNHN for facilitating examination of specimens by PC and enabling the inclusion of those records here.

References

- Bechev D, Koç H (2006) Two new species of *Sciophila* Meigen (Diptera: Mycetophilidae) from Turkey, with a key to the Western Palaearctic species of the *S. lutea* Macquart group. Zootaxa 1253: 61–68.
- Burghele-Balacesco A (1967) Les Mycetophilidae (diptères) cavernicoles de la collection Biospeologica (IVe–VIIIe séries des «Grottes visitées»). International Journal of Speleology 2(4): 319–334. https://doi.org/10.5038/1827-806X.2.4.3
- Chandler PJ (1994) The fungus gnats of Israel (Diptera: Sciaroidea, excluding Sciaridae). Israel Journal of Entomology 28: 1–100.
- Chandler PJ (2009) The fungus gnats (Diptera: Bolitophilidae, Keroplatidae, Mycetophilidae) of Sardinia, with description of six new species. In: Cerretti P, Mason F, Minelli A, Nardi G, Whitmore D (Eds) Research on the terrestrial arthropods of Sardinia (Italy). Zootaxa 2318: 450–506. https://doi.org/10.11646/zootaxa.2318.1.19

- Chandler PJ, Ribeiro E (1995) The Sciaroidea (Diptera) (excluding Sciaridae) of the Atlantic Islands (Canary Islands, Madeira and the Azores). Boletim do Museu municipal do Funchal (História Natural), Suplemento 3: 1–170.
- Chandler PJ, Gatt P (2000) Fungus gnats (Diptera, Bolitophilidae, Keroplatidae and Mycetophilidae) from the Maltese Islands. Studia dipterologica 7: 69–81.
- Chandler PJ, Báez M (2002) Mycetophilidae. In: Carles-Tolrá Hjorth-Andersen M (Ed.) Catálogo de los Diptera de España, Portugal y Andorra (Insecta). Monografías Sociedad Entomológica Aragonesa 8: 59–64.
- Chandler P, Blasco-Zumeta J (2001) The fungus gnats (Diptera, Bolitophilidae, Keroplatidae and Mycetophilidae) of the Monegros Region (Zaragoza, Spain) and five other new European species of *Pyratula* Edwards and *Sciophila* Meigen. Zapateri 9: 1–24.
- Chandler PJ, Bechev DN, Caspers N (2005) The fungus gnats (Diptera: Bolitophilidae, Diadocidiidae, Ditomyiidae, Keroplatidae and Mycetophilidae) of Greece, its islands and Cyprus. Studia Dipterologica 12: 255–314.
- Hackman W, Laštovka P, Matile L, Väisänen R (1988) Family Mycetophilidae (Fungivoridae). In: Soós A, Papp L (Eds) Catalogue of Palaearctic Diptera (Vol. 3), Ceratopogonidae-Mycetophilidae. Elsevier, Amsterdam, 220–327.
- Hutson AM, Ackland DM, Kidd LN (1980) Mycetophilidae (Bolitophilinae, Ditiomyiinae, Diadocidiinae, Keroplatinae, Sciophilinae and Manotinae). Diptera, Nematocera. Handbooks for Identification of British Insects 9: 1–109.
- Pape T, Blagoderov V, Mostovski MB (2011) Order Diptera Linnaeus, 1758. In: Zhang Z-Q (Ed.) Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. Zootaxa 3148: 222–229. https://doi.org/10.11646/zootaxa.3148.1.42
- Séguy E (1941) Recoltes de R. Paulian et A. Villers dans le haut Atlas marocain, 1938, 17, Dipteres. Revue Francaise d'Entomologie 8: 25–33.
- Søli GE, Vockeroth JR, Matile L (2000) A. 4. Families of Sciaroidea. In: Papp L, Darvas B (Eds) Contributions to a Manual of Palaearctic Diptera. Appendix. Science Herald, Budapest, 49–92.
- Yakovlev EB (1994) Palearctic Diptera associated with fungi and myxomycetes. Karelian Research Center, Russian Academy of sciences, Forest Research Institute, Petrozavodsk, 127 pp. [In Russian, with English summary.]

RESEARCH ARTICLE



Tachinid (Diptera, Tachinidae) parasitoids of Lobesia botrana (Denis & Schiffermüller, 1775) (Lepidoptera, Tortricidae) and other moths

Pier Luigi Scaramozzino¹, Filippo Di Giovanni¹, Augusto Loni¹, Silvia Gisondi^{2,3}, Andrea Lucchi¹, Pierfilippo Cerretti²

I Department of Agriculture, Food and Environment, University of Pisa, via del Borghetto 80, 56124, Pisa, Italy 2 Department of Biology and Biotechnology "Charles Darwin", Sapienza University of Rome, Piazzale A. Moro 5, 00185, Rome, Italy 3 Natural History Museum of Denmark, Universitetsparken 15, 2100, Copenhagen, Denmark

Corresponding author: Filippo Di Giovanni (aphelocheirus@gmail.com)

Academic editor: Torsten Dikow Received 5 February 2020 Accepted 17 March 2020 Published 19 May 2020								
http://zoobank.org/EDC09BA5-7C72-4E79-AE3B-50C2988EBBAA								

Citation: Scaramozzino PL, Di Giovanni F, Loni A, Gisondi S, Lucchi A, Cerretti P (2020) Tachinid (Diptera, Tachinidae) parasitoids of *Lobesia botrana* (Denis & Schiffermüller, 1775) (Lepidoptera, Tortricidae) and other moths. ZooKeys 934: 111–140. https://doi.org/10.3897/zookeys.934.50823

Abstract

The present paper reports data on the biology of eleven species of tachinid flies collected in Italy and Spain on different host plants and emerged from different host larvae. An annotated list of the eleven species emerged from the collected lepidopterans is provided; information about distribution and biology are given as well as the description of their puparia. Two new parasitoid species of the European Grapevine Moth (EGVM) *Lobesia botrana* were recorded: *Clemelis massilia*, whose host preferences were unknown so far, and *Neoplectops pomonellae*. A list of lepidopteran pest species with their associated plants and tachinid parasitoids is then given in order to highlight the relationships among the three components of the biocenosis (plant, herbivore and parasitoid). Eventually, due to the great economic importance of *L. botrana* in viticulture, a preliminary identification key to the puparia of its tachinid parasitoids is provided.

Keywords

biological control, *Cacoecimorpha pronubana*, *Daphne gnidium*, *Ephestia unicolorella* subsp. *woodiella*, Erebidae, *Euproctis chrysorrhoea*, puparia, *Quercus* spp., *Tortrix viridana*, *Vitis vinifera*

Introduction

Every year world agricultural yield is reduced by 10–16% both by pre- and post-harvest pests (Bradshaw et al. 2016). Crop losses caused by arthropods appear to be higher in modern industrial agriculture than in traditional agriculture which employs more environmentally friendly and sustainable practices (Culliney 2014, Lucchi and Benelli 2018). Every year, 35 million hectares of forest, especially in temperate and boreal areas, are damaged by outbreaks of harmful insects (FAO 2010, Kenis et al. 2019). With the increase in the volume and speed of international trade, together with climate change, the incidence of these outbreaks is also increasing (FAO 2010, Kenis et al. 2019). Lepidoptera is one of the main groups of plant feeding insects which can be potentially dangerous to both agriculture and forestry.

Biological control is a sustainable and environment-respectful method used for the containment of harmful insects. Among the biological control agents (BCAs), in most cases parasitoid insects are renowned for their effectiveness and specificity. The main orders of insect parasitoids are Hymenoptera and Diptera. Notwithstanding the great knowledge that has been acquired on this topic, many aspects of the parasitoid behaviour and action towards the host are still awaiting clarification. In this context, taxonomy plays a key role for a better understanding of the species to be used as BCAs, and their relative host range. Sometimes rather large host ranges may be an indication of a poorly investigated parasitoid taxon. In other cases, however, they can be due to inaccurate identifications of both the host or the parasitoid, as often occurs with old reports. Presenting data on host-parasitoid relationships can help verify and possibly confirm old records. Moreover, they also increase the amount of data available for future studies focusing on the host range extension and its possible variation under different regional conditions.

Among Diptera, Tachinidae is a megadiverse family, representing one of the most diverse lineages of parasitoids (Stireman et al. 2019). Despite being a wellinvestigated family in Europe, some biological aspects, mostly concerning their host-association, are still poorly known (Mückstein et al. 2007). Most of the biological information available so far was recently resumed in the Preliminary Host Catalogue of Palaearctic Tachinidae (Tschorsnig 2017), making comparative studies easier to develop. Among all the tachinid hosts, the European Grapevine Moth (EGVM), Lobesia botrana (Denis & Schiffermüller, 1775), represents a key pest in viticulture (Ioriatti et al. 2011); this moth is present in the grape-growing regions of Europe, Near East, southern Russia, northern and western Africa, and it was accidentally introduced in North and South America (Ioriatti et al. 2012, Cooper et al. 2014). The most common wild host plant of EGVM is the spurge flax, Daphne gnidium L. (Thymelaeaceae), which possibly represents its native host from which EGVM later expanded towards vineyards (Scaramozzino et al. 2017a). Both grapevine and *D. gnidium* are hosts of other moths, which can be in turn exploited by the same parasitoid community associated with EGVM (Villemant et al. 2012, Scaramozzino et al. 2017b).

In the present paper we report parasitoid-host records for eleven species of tachinids collected in Italy and Spain on EGVM and other lepidopteran hosts feeding on different plant species. Three new host records are here reported: *Clemelis massilia* Herting, 1977 developing on *L. botrana* (Denis & Schiffermüller, 1775) living on shoots and inflorescences of *D. gnidium* in Tuscany, *Clausicella suturata* Rondani, 1859 on *Ephestia unicolorella* subsp. *woodiella* Richards & Thomson, 1932 and eventually *Neoplectops pomonellae* (Schnabl & Mokrzecki, 1903) on *L. botrana*. The parasitoidhost issue is addressed on three different levels: first we report parasitoid-host records for eleven species of tachinids collected in Italy and Spain on various lepidopteran hosts; then we refer to the parasitoid-host relationships between plants and different lepidopteran species; lastly, due to the great importance of *L. botrana* in viticulture, we provide a preliminary identification key to the puparia of its tachinid parasitoids.

Materials and methods

Tachinid flies emerged from caterpillars collected in Piedmont, Tuscany, Apulia and Spain on plants belonging to three different plant families: *Quercus* ssp. (*Q. pubescens* and *Q. robur*) (Fagaceae) in Piedmont, grapevine (*Vitis vinifera*, Vitaceae) in Piedmont, Tuscany and Apulia, and *Daphne gnidium* (Thymelaeaceae) in Tuscany and Spain. Puparia were studied by PLS whereas the adult flies, once emerged, were mounted on pins and identified by PC. Moths were mounted on pins and identified by Graziano Bassi, AuL, AnL, and PLS.

Digital images were taken on a Leica Z16 APO stereoscope equipped with a Nikon D5300 digital camera and stacked in a single in-focus image using Helicon Focus 3D (version 3.9.7W) and Zerene Stacker software (version 1.04). All specimens are currently preserved in the collection of the Department of Agriculture, Food and Environment of Pisa University.

Section A – Annotated list of the Tachinidae records. The list follows an alphabetical order. Subfamily, tribe, species name, label information, distribution, biological information and puparium description are reported. Additional information may be found under 'Notes'. Tachinid subfamily, tribe and general distribution are listed accordingly to O'Hara et al. (2019) and Cerretti (2010) for the Italian distribution. Biological and host record information for each species are based on Tschorsnig (2017) and on Cerretti and Tschorsnig (2010). The morphological terminology and characterisation of the tachinid puparia follow Greene (1922), Ziegler (1998) and O'Hara (2005).

Section B – Annotated list of records by host plant and Lepidoptera. The list by host plant and Lepidoptera follows an alphabetical order. The lepidopteran species names refer to Fauna Europaea (de Jong et al. 2014).

Section C – Preliminary key to the puparia of tachinid flies associated with *L. botrana.* The key is based both on direct observations and on illustrations already available in the literature.

Results

A.Annotated list of Tachinid records

Subfamily: Exoristinae Tribe: Blondeliini

A1. Compsilura concinnata (Meigen, 1824)

Fig. 1

Label information. Italy, Piedmont: Torino, Santena, oak-hornbeam lowland forest, collected 20.v.1986, emerged 09.vi.1986 ex *Euproctis chrysorrhoea* on *Quercus* sp., P. L. Scaramozzino leg., 1Å, P. Cerretti det.

Distribution. Subcosmopolitan. Italian distribution: north and south Italy, Sicily, Sardinia.

Biology. Parasitoid on a wide range of Lepidoptera and Hymenoptera Symphyta. In Italy it has already been reported on *E. (Euproctis) chrysorrhoea* (Linnaeus, 1758) (Erebidae) in Emilia-Romagna (Faggioli 1937; Cerretti and Tschorsnig 2010) and Sardinia (Delrio and Luciano 1985).

Puparium (Fig. 1C–E): cylindrical with rounded posterior edges, subshiny, dark red, smooth with circular anterior spinose bands; posterior spiracular plates slightly above level of longitudinal axis and scarcely raised above surface of puparium; each posterior spiracular plate with three linear openings; button round, scarcely defined; anal opening dark, below longitudinal axis at about the same distance of posterior spiracular plates from longitudinal axis.

Notes. In Piedmont three other species of Tachinidae emerged from *E. chrysor-rhoea*: *Blondelia nigripes* (Fallén, 1810), *Exorista larvarum* (Linnaeus, 1758) and *Townsendiellomyia nidicola* (Townsend, 1908) (Currado et al. 1988).

Tribe: Eryciini

A2. Carcelia falenaria (Rondani, 1859)

Fig. 2

Label information. Italy, Piedmont: Torino, Stupinigi, oak-hornbeam lowland forest, 03.vi.1986, ex *Amata* sp. on *Quercus* sp., P. L. Scaramozzino leg., 233, P. Cerretti det.

Distribution. Palaearctic. Italian distribution: north and south Italy, Sicily.

Biology. Parasitoid on Lepidoptera Erebidae of the genus *Amata* Fabricius, 1807. In Italy it has been obtained in Veneto on *A. kruegeri* (Ragusa, 1904) and in Sicily on *Amata* sp. (Cerretti and Tschorsnig 2010).

Notes. Two adults emerged from the same host larva; the larvae pupated within the body of the host larva and the adults emerged from cut-like openings made on the host exoskeleton.



Figure 1. *Compsilura concinnata* (Meigen, 1824). **A** Male, habitus, dorsal view **B** male, habitus, lateral view **C** puparium, dorsal view **D** puparium, posterior end **E** puparium, spiracular plates showing openings.

A3. Phryxe cf. nemea (Meigen, 1824)

Label information. Italy, Piedmont: Torino, Venaria, La Mandria, oak-hornbeam lowland forest, vi.1988, ex *Tortrix viridana* on *Quercus robur*, P. L. Scaramozzino leg., 1Å, P. Cerretti det. The specimen emerged from the cocoon with wings still partially folded.



Figure 2. Carcelia falenaria (Rondani, 1859), two males emerged from Amata sp. larva.

Distribution. Palaearctic. Italian distribution: north and south Italy, Sardinia.

Biology. Parasitoid on a wide range of Lepidoptera and seldom Hymenoptera Symphyta. In Italy it has already been obtained from *T. viridana* Linnaeus, 1758 (Tortricidae) on *Q. robur* in Sardinia (Delrio et al. 1988).

Puparium (Fig. 3A–D): cylindrical with rounded posterior edges, dull, light brown, surface transversally striated, with circular anterior spinose bands; posterior spiracular plates on longitudinal axis and scarcely raised above surface of puparium; each posterior spiracular plate with four serpentine openings; button round and large; anal opening concolourous, below longitudinal axis, located at some distance from posterior spiracular plates.

A4. *Pseudoperichaeta nigrolineata* (Walker, 1853) – First record on *C. pronubana* in Italy

Fig. 4

Label information. Italy, Tuscany: Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 29.viii.2017, ex *Cacoecimorpha pronubana* on *Daphne gnidium*, A. Loni & P. L. Scaramozzino leg., 1⁽²⁾, P. Cerretti det.

Distribution. Palaearctic and Oriental. Italian distribution: north and south Italy, Sicily, Sardinia.

Biology. Parasitoid on several lepidopteran families. It has been reared from *C. pronubana* (Hübner, [1799]) (Tortricidae) in France (IOBC-List 2 1957), Ukraine (Richter 1996) and United Kingdom (Collin 1909; Ford et al. 2000). This is the first record for this species on *C. pronubana* in Italy. This species is also recorded as parasitoid of *L. botrana* (Tab. 2).

Puparium (Fig. 4C–F): cylindrical with rounded posterior edges, subshining, light yellowish-brown, smooth with circular anterior spinose bands; posterior spiracular plates slightly above longitudinal axis and on surface of puparium; each posterior spiracular plate with four linear or slightly curved openings; button round and large; anal opening dark, below longitudinal axis, located at some distance from posterior spiracular plates.

Tribe: Exoristini

A5. Bessa parallela (Meigen, 1824) – First record on *T. viridiana* in Italy Fig. 5

Label information. Italy, Piedmont: Torino, Grange di Brione, mixed oak forest, 17.v.1990, ex *Tortrix viridana* on *Quercus* sp., P. L. Scaramozzino leg., 1^Q, P. Cerretti det.

Distribution. Palaearctic and Oriental. Italian distribution: north and south Italy.

Biology. Parasitoid mainly on Lepidoptera, with Coleoptera or Hymenoptera Symphyta as unusual hosts. It has already been recorded on *T. viridana* in several regions of



Figure 3. *Phryxe* cf. *nemea* (Meigen, 1824). **A** Puparium, dorsal view **B** puparium, lateral view **C** puparium, posterior end **D** puparium, spiracular plates showing openings.

North, Central and East Europe. This is the first record for this species on *T. viridana* in Italy. This species is also recorded for *L. botrana* (Tab. 2), even if the single record in literature (Jordan 1915) is from specimens obtained from lab parasitisation tests (Tschorsnig 2017).

Puparium (Fig. 5C–E): cylindrical with rounded posterior edges, subshiny, yellowish-brown, smooth with circular anterior spinose bands; posterior spiracular plates slightly above level of longitudinal axis and scarcely raised above surface of puparium; each posterior spiracular plate with three linear openings; button round, scarcely defined; anal opening dark, below longitudinal axis and very remote from posterior spiracular plates on ventral surface.

Tribe: Goniini

A6. Clemelis massilia Herting, 1977 – First host-record Fig. 6

Label information. Italy, Tuscany: Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 28.v.2015, ex *Lobesia botrana* on *Daphne gnidium*, A. Loni & P. L. Scaramozzino leg., 1, P. Cerretti det.

Distribution. Palaearctic. Italian distribution: north and south Italy.

Biology. This is the first known host record for *C. massilia*. A similar and more common species, *C. pullata* (Meigen, 1824), has been obtained from several families of Lepidoptera, including Tortricidae as *Archips podana* (Scopoli, 1763), *A. rosana* (Lin-



Figure 4. *Pseudoperichaeta nigrolineata* (Walker, 1853). **A** Male, habitus, dorsal view **B** male, habitus, lateral view **C** puparium, lateral view, anterior end detached **D** puparium, posterior end **E** puparium, posterior end, ventral view, showing anal opening **F** puparium, spiracular plates showing openings.

naeus, 1758), *Choristoneura diversana* (Hübner, [1814–1817]) and *Pandemis heparana* (Denis & Schiffermüller, 1775).

Puparium (Fig. 6C–F): sub-cylindrical with posterior edge slightly depressed dorsally and broadly rounded ventrally, subshiny, yellowish-brown, smooth with incomplete, anterior spinose circular bands; posterior spiracular plates clearly above longitudinal axis and on surface of puparium; each posterior spiracular plate with three linear or curved openings; button round, scarcely defined; anal opening dark, below longitudinal axis and remote from posterior spiracular plates, half the distance from ventral surface.



Figure 5. *Bessa parallela* (Meigen, 1824). **A** Female, habitus, lateral view **B** female, habitus, dorsal view **C** puparium, lateral view **D** puparium, posterior end **E** puparium, spiracular plates showing openings.

Notes. The adult we obtained emerged from a puparium inside the host cocoon together with the remains of a mature larva of *L. botrana*.

Tribe: Winthemiini

A7. Nemorilla maculosa (Meigen, 1824) – First record on L. botrana in Italy Fig. 7

Label information. Italy, Tuscany: Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 24.ix.2015 ex *Lobesia botrana* on *Daphne gnidium*, A. Loni & P. L. Scaramozzino leg., 1 larva with two macrotipic eggs; 01.x.2015, same data, 1 specimen (sex not determinable), P. Cerretti det.; same data, 07.vi.2017, 1 specimen (sex not determinable); same data, 29.viii.2017, 1 puparium; same data, 14.ix.2017, 1 specimen (sex not determinable); same data, 07.vi.2018, 1^Q.



Figure 6. *Clemelis massilia* Herting, 1977. **A** Male, habitus, dorsal view **B** male, head, lateral view **C** puparium, lateral view **D** puparium, dorsal view **E** puparium, posterior end, lateral view **F** puparium, anal opening and spiracular plates showing openings.



Figure 7. *Nemorilla maculosa* (Meigen, 1824). **A** Female, habitus, dorsal view **B** female, head, lateral view **C** puparium next to remains of *Lobesia botrana* chrysalis on *Daphne gnidium* **D** larva of *L. botrana* with two macrotipic eggs **E** puparium, ventral view **F** puparium, lateral view **G** puparium, posterior end, dorsal view **H** puparium, posterior end, posterior view **I** puparium, spiracular plates showing openings.

Distribution. Palaearctic and Oriental. Italian distribution: north and south Italy, Sicily, Sardinia.

Biology. Parasitoid of a wide range of lepidopteran families. It has already been obtained from *L. botrana* in Bulgaria (Trenchev 1980), Iran (Shoukat 2012), Spain (Coscollá 1981) and Ukraine (Telenga 1934). This is the first record for this species on *L. botrana* in Italy. In Morocco, *N. maculosa* was found on *Cryptoblabes gnidiella* (Millière, 1867) (Pyralidae), which often cohabits the same nests built by *L. botrana* on *D. gnidium* (Scaramozzino et al. 2017b). The biology and preimaginal stages of *N. maculosa* have been studied and illustrated in detail by Mellini (1964).

Puparium (Fig. 7E–I): sub-cylindrical with posterior edge slightly depressed dorsally and broadly rounded ventrally, shining, yellow, smooth with not well defined circular anterior spinose bands; posterior spiracular plates clearly above longitudinal axis and slightly raised above surface of puparium; each posterior spiracular plate with three small linear openings and with some scars in between; button round and large, defined; anal opening red, below longitudinal axis and remote from posterior spiracular plates, half the distance from ventral surface.

Notes. According to Tschorsnig (2017), records of *Nemorilla floralis* (Fallén, 1810) on *L. botrana* (Telenga 1934, Trenchev 1980, Coscollá 1981) are probably misidentifications for *N. maculosa*. The puparium of this tachinid was found inside the cocoon of *L. botrana*, next to the remains of the chrysalis or the mature larva (Fig. 7C). Moreover, during our observations, we found the eggs of a tachinid (Fig 7D) on the pronotum of two mature EGVM larvae. The first larva only had one egg from which emerged a malformed and unidentifiable tachinid fly, though the remains of its puparium were very similar to those of *N. maculosa*. The second larva bore two tachinid eggs but it unfortunately died before parasitoid emergence. This species was obtained from *L. botrana* in two different periods of the year: in June, and from the last days of August to the end of September.

Subfamily: Tachininae Tribe: Graphogastrini

A8. Phytomyptera nigrina (Meigen, 1824)

Label information. Italy, Piedmont: Cuneo, Barbaresco, vineyard, 31.v.2018, ex Lobesia botrana on Vitis vinifera, R. Ricciardi leg., $1 \stackrel{<}{\circ} 2 \stackrel{\bigcirc}{\circ} \stackrel{\bigcirc}{\circ}$, P. Cerretti det. Italy, Tuscany: Livorno, Castagneto Carducci, vineyard, 14.vi.2005, ex Lobesia botrana on Vitis vinifera, $1\stackrel{\bigcirc}{\circ}$, P. Cerretti det.; Pisa, Cerreto Guidi, vineyard, 20.vi.2005, ex Lobesia botrana on Vitis vinifera, $1\stackrel{\bigcirc}{\circ}$, P. Cerretti det.; same data, 23.vi.2005, $1\stackrel{\bigcirc}{\circ}$; same data, 28.vi.2005, $1\stackrel{\bigcirc}{\circ}$; same data, 29.vi.2005, $1\stackrel{\bigcirc}{\circ}$; same data, 29.vii.2005, $1\stackrel{\bigcirc}{\circ}$; Pisa, Terricciola, vineyard, 10.viii.2005, ex Lobesia botrana on Vitis vinifera, $1\stackrel{\bigcirc}{\circ}$, P. Cerretti det.; Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 31.viii.2014, ex Lobesia botrana on Daphne gnidium, A. Loni & P. L. Scaramozzino leg., $1\stackrel{\bigcirc}{\circ}$, P. Cerretti det.; same data, 07.vi.2017, $1\stackrel{\bigcirc}{\circ}$. Italy, Apulia:



Figure 8. *Phytomyptera nigrina* (Meigen, 1824). **A** Puparium covered with the host larva skin remains **B** puparium, lateral view **C** puparium, posterior end, lateral view **D** puparium, anal opening and reduced spiracular plates **E** puparium, anal opening and spiracular plates reduced and borne on a subconical projection.

Brindisi, Masseria Maime, vineyard, 15.v.2018, ex *Lobesia botrana* on *Vitis vinifera*, R. Ricciardi leg., 1Å, P. Cerretti det. Spain: Girona, Port de la Selva, overgrown vineyard, 25.viii.2014, ex *Lobesia botrana* on *Daphne gnidium*, M. Generani & P. L. Scaramozzino leg., 3ÅÅ7 ? \$, P. Cerretti det.; Girona, Llança, Serra de Carbet, overgrown vineyard, 21.viii.2014, ex *Lobesia botrana* on *Daphne gnidium*, M. Generani & P. L. Scaramozzino leg., 1, P. Cerretti det.

Distribution. Palaearctic. Italian distribution: north and south Italy, Sicily, Sardinia.

Biology. Parasitoid on about 30 hosts belonging to different lepidopteran families. In Italy, it is a renowned *L. botrana* parasitoid (Scaramozzino et al. 2017a) and it is considered one of the main control agents of *L. botrana* in the vineyards, where it can significantly contribute in reducing the summer population of the moth (Bagnoli and Lucchi 2006; Thiéry et al. 2006); it has been obtained from *L. botrana* in vineyards in Piedmont (Colombera et al. 2001), Trentino (Catoni 1914), Veneto (Marchesini and Dalla Montà 1992; 1994), Tuscany (Bagnoli and Lucchi 2006), Campania (Silvestri 1912), Calabria (Laccone 2007) and Apulia (Laccone 1978) and from *L. botrana* nests on *D. gnidium* in Apulia (Nuzzaci and Triggiani 1982) and Sardinia (Luciano et al. 1988). In Spain, it has been reported from *L. botrana* in vineyards by Coscollá (1981). It also parasitises *Eupoecilia ambiguella* (Hübner, 1796) (Tortricidae), another important pest of the grapevine. The biology and preimaginal stages of *P. nigrina* have been studied and illustrated in detail by Mellini (1954), and the life-history was briefly reviewed by Andersen (1988).

Puparium (Fig. 8A–E): sub-cylindrical with both edges slightly depressed dorsally and broadly rounded ventrally, shining, red-brown, smooth with scarce spines towards edges; posterior spiracular plates slightly above level of longitudinal axis, borne on a subconical projection; posterior spiracular plate reduced, without openings; anal opening round and dark, below longitudinal axis and remote from posterior spiracular plates, half distance from ventral surface. It was covered with remains of host larva cuticle.

Notes. Only one specimen of *P. nigrina* was obtained from EGVM larvae during a 4-year survey on *D. gnidium* in San Rossore Natural Reserve (Tuscany). In this context, *Actia pilipennis* resulted instead the most abundant species of Tachinidae parasitising EGVM. Contrariwise, in other researches on the same plant, it was definitely the most common species among the parasitoids of *L. botrana* (Nuzzaci and Triggiani 1982, Luciano et al. 1988); in Apulia it attacked 30% of the larvae, in Sardinia it was the most common parasitoid on spurge flax while it was completely absent on the vine. In our occasional samplings on *D. gnidium* in the north of Spain (Girona, Catalonia) during the summer, *P. nigrina* was the only parasitoid obtained from EGVM in summer.

Tribe: Leskiini

A9. Clausicella suturata Rondani, 1859 – New record on Ephestia unicolorella subsp. woodiella Richards & Thomson Fig. 9

Label information. Italy, Tuscany: Pisa, Terricciola, vineyard, 08.iii.2006, emerged 20.iii.2006, ex *Ephestia unicolorella* subsp. *woodiella* on *Vitis vinifera* (bark), A. Lucchi leg., $6 \stackrel{\wedge}{\circ} 3 \stackrel{\circ}{\circ} 8 \stackrel{\circ}{\circ}$, P. Cerretti det.

Distribution. Palaearctic. Italian distribution: north and south Italy, Sicily, Sardinia. **Biology.** Parasitoid on Lepidoptera Pyralidae. So far, it has been obtained from *Apomyelois ceratoniae* (Zeller, 1839), *Cadra figulilella* (Gregson, 1871) and *Euzophera bigella* (Zeller, 1848); the latter represents the only Italian host record for this species (Reggiani et al. 2006). This is the first record for this species on *E. unicolorella* subsp. *woodiella* Richards & Thomson, 1932 (Pyralidae).

Puparium (Fig. 9C-F): sub-cylindrical with posterior edge slightly depressed dorsally and broadly rounded ventrally, shining, yellow, smooth with scarce spines towards edges; posterior spiracular plates shining, on longitudinal axis and raised



Figure 9. *Clausicella suturata* Rondani, 1859. **A** Male, habitus, dorsal view **B** male, head, lateral view **C** puparium, covered with host silk **D** puparium, lateral view **E** puparium, posterior end **F** puparium, spiracular plates showing openings.

above surface of puparium; each posterior spiracular plate with three small linear openings on a broad defined ridge; button round and small, defined; anal opening red, below the longitudinal axis and remote from posterior spiracular plates, half distance from ventral surface.

Tribe: Neaerini

A10. Neoplectops pomonellae (Schnabl & Mokrzecki, 1903) – New record on L. botrana

Fig. 10

Label information. Italy, Tuscany: Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 11.ix.2013, emerged 07.x.2013 from *Lobesia botrana* nests in cages collected on *Daphne gnidium*, A. Loni & P. L. Scaramozzino leg., $2\Im \Im$, P. Cerretti det.

Distribution. Palaearctic. Italian distribution: south Italy.

Biology. Parasitoid on Lepidoptera Tortricidae, particularly on *Cydia pomonella* (Linnaeus, 1758). The only known Italian host record for this species is on *Gypsonoma* sp. Meyrick, 1895 (Ford and Shaw 1991). This is the first record for this species on *L. botrana* (Tortricidae).

Notes. Two males of *N. pomonellae* were obtained during the initial trial of our research in San Rossore. Numerous EVGM nests were put together in a cage aiming to a rough estimate of the parasitoid that could be obtained but neither puparia nor adults were found again.

Tribe: Siphonini

A11. Actia pilipennis (Fallén, 1810)

Label information. Italy, Piedmont: Alessandria, Sacro Monte di Crea, mixed oak forest, 19.v.1988, ex Tortrix viridiana on Quercus pubescens, P. L. Scaramozzino leg., $4\Im$ P. Cerretti det.; Torino, Brione, Monte Musiné, mixed oak forest, 31.v.1987, ex Tortrix viridiana on Quercus pubescens, P. L. Scaramozzino leg., 12, P. Cerretti det.; same data, 04.vi.1988, 13; Torino, Cavagnolo, mixed oak forest, 11.v.1988, ex Tortrix viridiana on Quercus pubescens, P. L. Scaramozzino leg., 300 299, P. Cerretti det.; Torino, Stupinigi, oak-hornbeam lowland forest, 26.v.1986, ex Tortrix viridiana on Quercus robur, P. L. Scaramozzino leg., 19, P. Cerretti det.; same data, 03.vi.1986, 19; same data, 10.v.1988, 1 \bigcirc ; same data, 15.v.1988, 4 \bigcirc \bigcirc 2 \bigcirc \bigcirc ; same data, 16.v.1988, 1 \bigcirc . // Italy, Tuscany: Pisa, P. N. San Rossore, coastal mixed forest of stone pine, maritime pine and holm oak, 10.vi.2012, ex Lobesia botrana on Daphne gnidium, A. Loni & P. L. Scaramozzino leg., $3\bigcirc \bigcirc 1\bigcirc$, P. Cerretti det.; same data, 15.vii.2012, 1 \bigcirc ; same data, 11.ix.2013, 1 \bigcirc ; same data, 29.v.2014, 2 \bigcirc \bigcirc ; same data, 15.vii.2014, 1 \bigcirc ; same data, 31.vii.2014, 1³; same data, 11.vi.2015, 1³; same data, 09.v.2017, 1⁹; same data, 24.v.2017, $1\sqrt[3]{1}$; same data, 30.v.2017, $2\sqrt[3]{2}$; further males and females emerged in cages from Lobesia botrana nests, collected on D. gnidium: same data, 27.vi.2014, 2 \bigcirc \bigcirc ; same data, 07.vi.2017, 1 \bigcirc 1 \bigcirc ; same data, 28.vi.2017, 1 \bigcirc 1 \bigcirc .

Distribution. Palaearctic and Oriental. Italian distribution: north and south Italy, Sicily, Sardinia.

Biology. Parasitoid mainly on Tortricidae. It has already been recorded on *T. viridana* in several Palaearctic countries, including Italy (Silvestri 1923). In French vineyards, it has been reported by Martinez (2012) on the tortricid *Sparganothis pilleriana* (Denis & Schiffermüller, 1775) and more recently by Delbac et al. (2015) on *L. botrana*. In Italy, Scaramozzino et al. (2017a) recorded *Actia pilipennis* obtained from *L. botrana* feeding on *D. gnidium*.

Puparium (Fig. 11C–G): suboval with rounded posterior edges, shining, orangeyellow, smooth with incomplete anterior bands of spines; posterior spiracular plates on the longitudinal axis and borne on a cylindrical projection; posterior spiracular plate small, with three small linear openings; button round and small, defined; anal opening concolourous, just below the longitudinal axis.

Notes. In Piedmont, from 1986 to 1988 *A. pilipennis* was the tachinid most frequently attacking *T. viridana* larvae on oaks and it was found inside the host cocoons in the rolled leaves. In San Rossore, it resulted the most abundant tachinid parasitoid of *L. botrana* on *D. gnidium*, as above mentioned. Normally its puparia are found inside the cocoon of the EGVM, near the remains of the host larva (Fig. 11A, B), and only rarely the fly emerges from the mature larva that has not yet woven its cocoon and pupate between the leaves of its nest.

B. Annotated list of records by host plant and Lepidoptera

Species on Quercus spp. [Fagales, Fagaceae]

In Europe, as well as throughout the northern hemisphere, oak is an important component of deciduous forests, representing an extremely species-rich tree. In Britain, Southwood (1961) reports 284 insect species associated with oak, most of them belonging to the order Lepidoptera and Coleoptera (237 species) (Morris 1974). For Western Palaearctic, Soria (1988) lists 453 species of foliage-feeding Lepidoptera, belonging to 37 families. Not all insect species found on oak trees are primarily associated with these plants though, and even fewer are those who can cause considerable damage. Indeed, Klimetzek (1993) reports 136 insect pests associated with oak in Europe. Both the brown tail moth (*Euproctis chrysorrhoea*) and the green oak leaf-roller (*Tortrix viridana*) are considered two of the main pests of oak in Europe (Day and Leather 1997).

B1. *Euproctis (Euproctis) chrysorrhoea* (Linnaeus, 1758) (Lepidoptera, Erebidae, Lymantriinae)

Forty species of Tachinids are reported on *E. chrysorrhoea*: only 27 are certain, whereas the remaining are either dubious or incorrect (Tschorsnig 2017). In Italy, ten species have been reported (Cerretti and Tschorsnig 2010).

Associated parasitoid:

Compsilura concinnata (Meigen, 1824) [A1]



Figure 10. *Neoplectops pomonellae* (Schnabl & Mokrzecki, 1903). **A** Male, habitus, lateral view **B** male, habitus, dorsal view.

B2. Tortrix viridana Linnaeus, 1758 (Lepidoptera, Tortricidae, Tortricinae)

Thirty-four Tachinidae are reported on *T. viridana*: only 22 of them are certain, the remaining are either dubious or incorrect (Tschorsnig 2017). In Italy, eleven species have been reported (Cerretti and Tschorsnig 2010).

Associated parasitoids: Actia pilipennis (Fallén, 1810) [A11] Bessa parallela (Meigen, 1824) [A5] Phryxe cf. nemea (Meigen, 1824) [A3]

Species on Daphne gnidium Linnaeus, 1753 [Malvales, Thymelaeaceae]

Numerous lepidopteran species coexist on the spurge flax, which is considered as the EGVM wild host plant (Nuzzaci and Triggiani 1982, Luciano et al. 1988, Scaramozzino et al. 2017b). In the Natural Reserve of San Rossore, we commonly found the following species on *D. gnidium*: *L. botrana, Cacoecimorpha pronubana* (Lepidoptera, Tortricidae), *Anchinia cristalis* (Scopoli, 1763) (Lepidoptera, Elachistidae), *Phyllobrostis fregenella* Hartig, 1941 (Lepidoptera, Lyonetiidae), *Cryptoblabes gnidiella* (Lepidoptera, Pyralidae), and *Gymnoscelis rufifasciata* (Haworth, 1809) (Lepidoptera, Geometridae). *L. botrana, C. pronubana* and *A. cristalis* are typically "leaf rollers", i.e., their larvae form a shelter (nest) by rolling up the leaves on which they live; *P. fregenella* is a leaf miner, while *C. gnidiella*



Figure 11. *Actia pilipennis* (Fallén, 1810). **A** Puparium inside *Lobesia botrana* cocoon, next to host larva remains **B** puparium next to *L. botrana* mature larva remains **C** puparium, lateral view **D** puparium, dorsal view **E** puparium, posterior end showing anal opening and spiracular plates **F** puparium, posterior end **G** puparium, spiracular plates borne on a cylindrical projection, showing openings.

and *G. rufifasciata* are commonly found inside the nests of *L. botrana. Nemorilla maculosa* [A7], one of the Tachinidae obtained in San Rossore from *L. botrana*, is also mentioned as emerged from *C. gnidiella* (Tschorsnig 2017). *Pseudoperichaeta nigrolineata*, also reported from *L. botrana*, have been found in a single specimen on *C. pronubana*.



Figure 12. *Eurysthaea scutellaris* (Robineau-Desvoidy, 1848). A Puparium, lateral view **B** puparium, posterior end, posterior view **C** puparium, spiracular plates showing openings.

B3. *Cacoecimorpha pronubana* (Hübner, [1799]) (Lepidoptera, Tortricidae, Tortricinae)

Eight species of Tachinidae are reported on *C. pronubana*, two of which have been found in Italy (Cerretti and Tschorsnig 2010, Tschorsnig 2017).

Associated parasitoid:

Pseudoperichaeta nigrolineata (Walker, 1853) [A4]

B4. *Lobesia botrana* (Denis & Schiffermüller, 1775) (Lepidoptera, Tortricidae, Olethreutinae)

See Discussion.

Associated parasitoids: Actia pilipennis (Fallén, 1810) [A11] Clemelis massilia Herting, 1977 [A6] Nemorilla maculosa (Meigen, 1824) [A7] Neoplectops pomonellae (Schnabl & Mokrzecki, 1903) [A10] Phytomyptera nigrina (Meigen, 1824) [A8]

Species on Vitis vinifera Linnaeus, 1753 [Vitales, Vitaceae]

B5. *Ephestia unicolorella* subsp. *woodiella* Richards & Thomson, 1932 (Lepidoptera, Pyralidae)

Larvae of this species can be found inside bunches of grapes and feed on the dried berries. They hibernate as mature larvae in the cocoon, on the woody parts of the vine or on the support poles. So far, no tachinids have been found on this species (Tschorsnig 2017).

Associated parasitoid: *Clausicella suturata* Rondani, 1859 [A9]

B4. *Lobesia botrana* (Denis & Schiffermüller, 1775) (Lepidoptera, Tortricidae, Olethreutinae)

See Discussion. Associated parasitoid: *Phytomyptera nigrina* (Meigen, 1824) [A8]

Species with unidentified host plant

B6. Amata sp. Fabricius, 1807 (Lepidoptera, Erebidae, Arctiinae)

Two *Amata* spp. are present in Piedmont: *A. marjana* (Stauder, 1913) [= *Amata* (*Syntomis*) *kruegeri* (Ragusa, 1904)] and *A. phegea* (Linnaeus, 1758) (Bassi pers. comm.). *Amata marjana* feeds on Dipsacaceae (*Knautia* spp.), Asteraceae (*Centaurea* spp., *Artemisia* and *Achilea* spp.) or Fabaceae (*Oxytropis* and *Anthyllis* spp.) (de Freina 2008), whereas *A. phegea* feeds on Graminee (Robinson et al. 2010). Five tachinid species are known to parasitise *Amata* spp. with *Carcelia falenaria* being the most frequently mentioned (Tschorsnig 2017).

Associated parasitoid: *Carcelia falenaria* (Rondani, 1859) [A2]

C. Preliminary key to the puparia of tachinid flies associated with Lobesia botrana

The present key includes a strict selection of species, mainly based on the ones directly raised for this study. Puparia of *Neoplectops pomonellae* are unknown; description of the puparium of *Elodia morio* is based on Zuska (1963).

1	Posterior spiracular plates rising on a median projection (Figs 8C, 11F)2
-	Posterior spiracular plates not rising on a median projection (Figs 4E, 6E,
2	/ G)
Z	Posterior spiracular plates borne upon two separate projections making the
	posterior end of median projection distinctly bind (see Zuska 1963: fig. 41).
	Posterior spiracular openings fused into a C-shaped pseudoslit (see Zuska
	1963: fig. 55)Elodia morio
-	Posterior spiracular plates not borne on two separate projections, so the pos-
2	Destation of median projection not bind (Figs 8C, 11F)
Э	Posterior spiracular plates with tree linear openings (Fig. 11G). Posterome-
	dian projection subcylindrical (Fig. 11F). Fuparium suboval in snape (Fig.
	11C). Pupariation taking place within the sliky cocoon but outside the
	host's remains; puparium not covered by the cuticle of the host
	Actia pilipennis
-	Posterior spiracular plates very small and openings not clearly visible. Pos-
	teromedian projection subconical (Fig. 8C–E). Puparium subcylindrical in
	shape (Fig. 8B). Pupariation usually taking place within host's remains so that
	puparium is covered by the cuticle of the host larva (Fig. 8A)
,	Phytomyptera nigrina
4	Posterior spiracular plates with four either linear or curved openings (Figs
	4F, 12C). Posterior end of puparium, in lateral view, almost hemispherical,
	i.e., posterodorsal and posteroventral portions of puparium (with respect to
	posterior spiracles) roundly convex (Figs 4C, 12A)5
-	Posterior spiracular plates with tree either linear or sinuous openings (Figs
	5E, 6F, 7I). Posterior end of puparium, in lateral view, with posterodorsal
	and posteroventral portions roundly convex (Fig. 5C) or with posterodorsal
	portion depressed and ventral portion broadly convex (Figs 6C, 7F)6
5	Space between the two posterior spiracular plates as long as the diameter of a
	spiracular plate (Fig. 12C). Spiracular plates with small button (Fig. 12C)
	Eurysthaea scutellaris
-	Space between the two posterior spiracular plates long less than half the di-
	ameter of a spiracular plate (Fig. 4F). Spiracular plates with large button (Fig.
	4F)Pseudoperichaeta nigrolineata
6	Posterior end of puparium, in lateral view, almost hemispherical, i.e., pos-
	terodorsal and posteroventral portions of puparium (with respect to posterior
	spiracles) roundly convex (Fig. 5C); spiracular plates arising at about level of
	midline of puparium in lateral view. Posterior spiracular plate with tree linear
	openings (Fig. 5E)Bessa parallela
_	Posterior end of puparium, in lateral view, not hemispherical, i.e., with pos-
	terodorsal portion slightly depressed anterior to posterior spiracular plate and
	ventral portion broadly convex; spiracular plates arising high above midline
	of puparium in lateral view (Figs 6C, 7F). Posterior spiracular plate with tree
	sinuous (Fig. 6F) or linear openings (Fig. 7I)7

7	Posterior spiracular plates flat, lying on surface of	puparium, with tree sinu-
	ous openings (Fig. 6F)	Clemelis massilia
_	Posterior spiracular plates slightly raised above surfa	ace of puparium, with tree
	small linear openings (Fig. 7I)	Nemorilla maculosa

Discussion

Both Lepidoptera and Tachinidae play a crucial role in agriculture and forestry, the first as pests and the second as potential BCAs. Therefore, information about parasitoidhost relationships may help in better understanding population dynamics of potential pests in different environments.

In this framework, we provided here eleven parasitoid-host records for tachinids in Italy and Spain. Some are new regional records for Italy, i.e., *Compsilura concinnata* on *Euproctis chrysorrhoea*, *Carcelia falenaria* on *Amata* sp., and *Phryxe* cf. *nemea* on *Tortrix viridana*, all collected on their hosts in Piedmont for the first time. *Pseudoperichaeta nigrolineata*, *Bessa parallela*, and *Nemorilla maculosa* are recorded for the first time in Italy on their renown hosts, i.e., *Cacoecimorpha pronubana*, *T. viridana*, and *Lobesia botrana* respectively. *Clausicella suturata* and *Neoplectops pomonellae* are reported for the first time on *Ephestia unicolorella* subsp. *woodiella* and *L. botrana*, respectively. The record of *Clemelis massilia* on *L. botrana* represents the first host record for this species so far.

Three out of these eleven species, *Phryxe* cf. *nemea*, *Bessa parallela*, and *Actia pilipennis*, have been obtained from T. viridana, one of the major defoliator pests of oaks in Europe, North Africa and Near East (Boghenschütz 1991). Five of these eleven species emerged from L. botrana, i.e., C. massilia, N. maculosa, Phytomyptera nigrina, N. pomonellae, and Actia pilipennis. So far, six species of tachinids have been associated with EGVM (Martinez et al. 2006, Delbac et al. 2015, Tschorsnig 2017), two of which (i.e., P. nigrina and *A. pilipennis*) have already been recorded on this pest in Italy (Scaramozzino et al. 2017a). Considering the present records as well as the one from Carlos et al. (2019), which confirms the previous observations made by Forti (in Coscollá 1997) and by Hoffman and Michl (2003), the number of tachinids associated with *L. botrana* rises to nine (Tab. 1). P. nigrina and A. pilipennis have been reared from L. botrana both in vineyards and on Daphne gnidium (Scaramozzino et al. 2017a), while the other three species, C. massilia, N. maculosa and N. pomonellae, have been obtained only from D. gnidium so far. In Spain, P. nigrina has been obtained from L. botrana in the vineyards (Coscollá 1981) and its presence into tortricid nests on D. gnidium in the wild is recorded here for the first time in the country. Among these nine species associated with L. botrana, P. nigrina certainly appears the most common and is also the most cited in the literature (see Tschorsnig 2017). All the other species seem to be occasional parasitoids, which also live at the expenses of other lepidopterans sharing the same host plant (Tab. 2). During our 3-year survey in the Natural Reserve of San Rossore (Tuscany, Italy), the overall parasitisation rate on preimaginal

	Tachinid species	Main citations				
1	Actia pilipennis (Fallén, 1810)*	Delbac et al. 2015, Scaramozzino et al. 2017a				
2	<i>Bessa parallela</i> (Meigen, 1824) [as <i>Bessa selecta</i> in Jordan 1915 and Thomson 1946]	Tschorsnig 2017				
3	Clemelis massilia Herting, 1977	Present paper				
4	Elodia morio (Fallén, 1820)	Martinez et al. 2006, Tschorsnig 2017				
5	Eurysthaea scutellaris (Robineau-Desvoidy, 1848)	Forti (as <i>Dischocaeta hyponomeutae</i>) in Coscollá 1997, Hoffman and Michl 2003, Carlos et al. 2019				
6	<i>Nemorilla maculosa</i> (Meigen, 1824) (= <i>Nemorilla floralis</i> Fallén, 1810, misid.)	Martinez et al. 2006, Tschorsnig 2017				
7	Neoplectops pomonellae (Schnabl & Mokrzecki, 1903)	Present paper				
8	Phytomyptera nigrina (Meigen, 1824)*	Martinez et al. 2006, Tschorsnig and Cerretti 2010, Scaramozzino et al. 2017a, Tschorsnig 2017				
9	Pseudoperichaeta nigrolineata (Walker, 1853)	Martinez et al. 2006, Tschorsnig 2017				

Table 1. Species of Tachinidae reported on *Lobesia botrana* in Europe. An asterisk indicates species previously reported on EGVM in Italy.

Table 2. List of tachinid parasitoids and their related host species. Numbers indicate the total records reported in literature for each species (data from Tschorsnig 2017 and present paper).

Tachinid species	Argyrotaenia ljungiana (Thunberg, 1797)	Cacoecimorpha pronubana (Hübner, 1799)	Cryptoblabes gnidiella (Millière, 1867)	Eupoecilia ambiguella (Hübner, 1796)	<i>Lobesia botrana</i> (Denis & Schiffermüller, 1775)	<i>Sparganothis pilleriana</i> (Denis & Schiffermüller, 1775)
Actia crassicornis (Meigen, 1824)						1
Actia pilipennis (Fallén, 1810)		7			2	2
Bessa parallela (Meigen, 1824)	1	1		1	1	3
Clemelis massilia Herting, 1977					1	
Elodia morio (Fallén, 1820)					1	1
Erynnia ocypterata (Fallén, 1810)						6
Eumea linearicornis (Zetterstedt, 1844)						1
Eumea mitis (Meigen, 1824)						1
Eurysthaea scutellaris (Robineau-Desvoidy, 1848)				1	1	2
Nemorilla floralis (Fallén, 1810)		3				3
Nemorilla maculosa (Meigen, 1824)		1	1	1	4	6
Neoplectops pomonellae (Schnabl & Mokrzecki, 1903)					1	
Pales pavida (Meigen, 1824)		1				1
Phytomyptera nigrina (Meigen, 1824)				2	19	
Pseudoperichaeta nigrolineata (Walker, 1853)		1			1	7
Pseudoperichaeta palesioidea (Robineau-Desvoidy, 1830)		1				
Thelyconychia solivaga (Rondani, 1861)		1				
Zenillia libatrix (Panzer, 1798)	1					

stages of *L. botrana* ranged between 12% and 16%, with tachinids accounting for 2–6% of the parasitoid community (Scaramozzino et al., unpublished data). In this context, they play a role as occasional parasitoids of *L. botrana* and other moths.

Acknowledgments

Thanks are due to Graziano Bassi (Turin) for helping to identify Lepidoptera, and to Daniel Whitmore (State Museum of Natural History Stuttgart, Germany) for providing images of the puparium of *Eurysthaea scutellaris*.

References

- Andersen S (1988) Revision of European species of *Phytomyptera* Rondani (Diptera: Tachinidae). Insect Systematics & Evolution 19(1): 43–80. https://doi.org/10.1163/187631289X00050
- Bagnoli B, Lucchi A (2006) Parasitoids of *Lobesia botrana* (Den. & Schiff.) in Tuscany. IOBC/ WPRS Bulletin 29(11): 139–142.
- Boghenschütz H (1991) Eurasian species in Forestry. In: van der Geest LPS, Evenhuis HH (Eds) Tortricid pests, their biology, natural enemies and control. World Crop Pests vol. 5, Elsevier, Amsterdam, 673–709.
- Bradshaw CJA, Leroy B, Bellard C, Roiz D, Albert C, Fournier A, Barbet-Massin M, Salles J-M, Simard F, Courchamp F (2016) Massive yet grossly underestimated global costs of invasive insects. Nature Communications 7(12986): 1–8. https://doi.org/10.1038/ncomms12986
- Carlos C, Gonçalves F, Villemant C, Paredes D, Salvação J, Torres L (2019) Parasitoids of *Lobesia botrana* (Lepidoptera: Tortricidae) in Douro Demarcated Region vineyards and prospects for enhancing conservation biological control. Integrated Protection in Viticulture, 5–8 November, Vila Real, Portugal.
- Catoni G (1914) Die Traubenwikler (*Polychrosis botrana* Schiff. und *Conchylis ambiguella* Hübn.) und ihre natürlichen Feinde in Südtyrol. Zeitschrift für angewandte Entomologie 1(2): 248–259. https://doi.org/10.1111/j.1439-0418.1914.tb01129.x
- Cerretti P (2010) I Tachinidi della fauna italiana (Diptera Tachinidae), con chiave interattiva dei generi ovest-paleartici. Vol. I/II. Centro Nazionale Biodiversità Forestale, Verona. Cierre Edizioni, Verona, 573 pp. [+ CD-ROM]
- Cerretti P, Tschorsnig H-P (2010) Annotated host catalogue for the Tachinidae (Diptera) of Italy. Stuttgarter Beiträge zur Naturkunde A, Neue Serie 3: 305–340.
- Collin JE (1909) Zenilla (Myexorista) roseanae B. & B., a new British Dipteron. Entomologist 41: 1–2.
- Colombera S, Alma A, Arzone A (2001) Comparison between the parasitoids of *Lobesia botrana* and *Eupoecilia ambiguella* in conventional and integrated vineyards. IOBC/WPRS Bulletin 24(7): 91–96.
- Cooper ML, Varela LG, Smith RJ, Whitmer DR, Simmons GA, Lucchi A, Broadway R, Steinhauer R (2014) Growers, Scientists and Regulators collaborate on European

Grapevine Moth program. California Agriculture 4: 125–133. https://doi.org/10.3733/ ca.v068n04p125

- Coscollá R (1981) Parasitisme de *Lobesia botrana* dans la région de Valencia. Bollettino di Zoologia Agraria e di Bachicoltura 16(2): 12–13.
- Coscollá R (1997) La polilla del racimo de la vid (*Lobesia botrana* Den. y Schiff.). Generalitat Valenciana, Consejerfa de Agricultura, Pesca y Alimentación, Valencia, Spain, 613 pp.
- Culliney T (2014) Crop Losses to Arthropods. Integrated Pest Management Reviews 3: 201–225. https://doi.org/10.1007/978-94-007-7796-5_8
- Currado I, Raviglione M, Scaramozzino PL (1988) Indagine sui limitatori naturali di *Euproctis chrysorrhoea* L. in Piemonte (Lepidoptera, Lymantridae). Atti XV Congresso nazionale italiano di Entomologia, L'Aquila: 981–988.
- Day KR, Leather SR (1997) Threats to forestry by insect pests. In: Watt AL, Stork NE, Hunter MD (eds) Forests and insects. Chapman and Hall, London, 177–205.
- de Freina JJ (2008) Über die Biologie, Morphologie, Phänologie und Taxonomie von Amata (Syntomis) kruegeri (Ragusa, 1904) (Lepidoptera: Arctiidae, Syntominae, Syntomini). Nachrichten des Entomologischen Vereins Apollo N. F. 28(3/4): 97–107.
- de Jong Y, Verbeek M, Michelsen V, de Place Bjørn P, Los W, Steeman F, Bailly N, Basire C, Chylarecki P, Stloukal E, Hagedorn G, Wetzel FT, Glöckler F, Kroupa A, Korb G, Hoffmann A, Häuser C, Kohlbecker A, Müller A, Güntsch A, Stoev P, Penev L (2014) Fauna Europaea – all European animal species on the web. Biodiversity Data Journal 2: e4034. https://doi.org/10.3897/BDJ.2.e4034
- Delbac L, Papura D, Roux P, Thiéry D (2015) Ravageurs de la vigne: les nouveautés dans les recherches sur les tordeuses et la problématique des espèces invasives. Actes du colloque 12e journée technique du CIVB, 3 February 2015, Bordeaux, 68–78.
- Delrio G, Luciano P (1985) I parassiti ed i predatori di *Euproctis chrysorrhoea* L. in Sardegna (Nota preliminare). Atti del XIV Congresso nazionale italiano di Entomologia, 825–832.
- Delrio G, Luciano P, Floris I (1988) I parassiti di *Tortrix viridana* L. in Sardegna. Atti del XV Congresso nazionale italiano di Entomologia, 407–414.
- FAO (2010) Global Forest Resources Assessment 2010. Main report. FAO Forestry Paper 163, Rome. www.fao.org/forestry/fra/fra2010
- Faggioli D (1937) Appunti entomologici. IV. Bollettino dell'Istituto di Entomologia dell'Università di Bologna 9: 184–195.
- Ford TH, Shaw MR (1991) Host records of some West Palaearctic Tachinidae. Entomologist's Record and Journal of Variation 103: 23–38.
- Ford TH, Shaw MR, Robertson DM (2000) Further host records of some West Palaearctic Tachinidae (Diptera). Entomologist's Record and Journal of Variation 112: 25–36.
- Greene CT (1922) An illustrated synopsis of the puparia of 100 muscoid flies (Diptera). Proceedings of the United States National Museum 60(2405): 1–39. [+ 20 plates] https://doi.org/10.5479/si.00963801.60-2405.1
- Hoffmann C, Michl G (2003) Parasitoide von Traubenwicklern ein Werkzeug der naturlichen Schadlingsregulation? Deutsches Weinbaujahrbuch 55: 1–13.
- IOBC-List 2 (1957) Liste d'identification n° 2. Entomophaga 2: 313–332. https://doi. org/10.1007/BF02373601

- Ioriatti C, Anfora G, Tasin M, De Cristofaro A, Witzgall P, Lucchi A (2011) Chemical Ecology and Management of *Lobesia botrana* (Lepidoptera: Tortricidae). Journal of Economic Entomology 104(4): 1125–1137. https://doi.org/10.1603/EC10443
- Ioriatti C, Lucchi A, Verela LG (2012) Grape Berry Moths in Western European vineyards and their recent movement into the New World. In: Bostanian NJ, Vincent C, Isaacs R (Eds) Arthropod Management in Vineyards: Pests, Approaches, and Future Directions. Springer New York, London, 329–359. https://doi.org/10.1007/978-94-007-4032-7_14
- Jordan KHC (1915) Über künstliche Infizierung des Heuwurmes (*Conchylis ambiguella* Hübn. und *Polychrosis botrana* Schiff.) mit Schmarotzerinsekten. Zeitschrift für angewandte Entomologie 2: 149–157. https://doi.org/10.1111/j.1439-0418.1915.tb00336.x
- Kenis M, Hurley BP, Colombari F, Lawson S, Sun J, Wilcken C, Weeks R, Sathyapala S (2019) Guide to the classical biological control of insect pests in planted and natural forests, FAO Forestry Paper No. 182. Rome, FAO. www.fao.org/3/ca3677en/CA3677EN.pdf
- Klimetzek D (1993) Baumarten und ihre Schadinsekten auf der Nordhalbkugel. Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie 8: 505–509.
- Laccone G (1978) Prove di lotta contro Lobesia botrana (Schiff.) (Lepid. -Tortricidae) e determinazione della soglia economica sulle uve da tavola in Puglia. Annali della Facoltà di Agraria dell'Università di Bari 30: 717–746.
- Laccone G (2007) Difesa della tignoletta della vite in base alle sostanze attive. Informatore Agrario 63(26): 67–69.
- Lucchi A, Benelli G (2018) Towards pesticide-free farming? Sharing needs and knowledge promotes Integrated Pest Management. Environmental Science and Pollution Research 25: 13439–13445. https://doi.org/10.1007/s11356-018-1919-0
- Luciano P, Delrio G, Prota R (1988) Osservazioni sulle popolazioni di *Lobesia botrana* (Den. & Schiff.) su *Daphne gnidium* L. in Sardegna. Atti del XV Congresso Nazionale Italiano di Entomologia, L'Aquila, 543–548.
- Marchesini E, Dalla Montà L (1992) Observations sur les facteurs limitants naturels des vers de la grappe. IOBC/WPRS Bulletin 15(2): 10.
- Marchesini E, Dalla Montà L (1994) Observations on natural enemies of *Lobesia botrana* (Den. & Schiff.) (Lepidoptera Tortricidae) in Venetian vineyards. Bollettino di Zoologia Agraria, Bachicoltura e Sericoltura II 26(2): 201–230.
- Martinez M (2012) Clé d'identification des familles, genres et/ou espèces de diptères auxiliaires, parasitoïdes ou prédateurs des principaux insectes nuisables à la vigne. In: Sentenac G (Ed.) La faune auxiliaire des vignobles de France. France Agricole Edition, 315–320.
- Martinez M, Coutinot D, Hoelmer K, Denis J (2006) Suitability of European Diptera tachinid parasitoids of *Lobesia botrana* (Denis & Schiffermüller) and *Eupoecilia ambiguella* (Hübner) (Lepidoptera Tortricidae) for introduction against grape berry moth, *Paralobesia viteana* (Clemens) (Lepidoptera Tortricidae), in North America. Redia 89: 87–97.
- Mellini E (1954) Studi sui ditteri larvevoridi. I. *Phytomyptera nitidiventris* Rond. Bollettino dell'Istituto di Entomologia della Università di Bologna 20: 309–332.
- Mellini E (1964) Studi sui ditteri larvevoridi. XII. Nemorilla maculosa Meig. su Depressaria marcella Rebel (Lepidoptera Gelechiidae). Bollettino dell'Istituto di Entomologia della Università di Bologna 27: 145–169.

- Morris MG (1974) Oak as a habitat for Insect life. In: Morris MG, Perring FH (Eds) The British oak: its history and natural history. Classey, Faringdon, 274–297.
- Mückstein P, Tschorsnig H-P, Vaňhara J, Michalková V (2007) New host and country records for European Tachinidae (Diptera). Entomologica Fennica 18: 179–183. https://doi. org/10.33338/ef.84396
- Nuzzaci G, Triggiani O (1982) Notes on the biocenosis in Puglia of *Lobesia (Polychrosis) botrana* (Schiff.) (Lepidoptera: Tortricidae) exclusive to *Daphne gnidium* L. Entomologica 17: 47–52.
- O'Hara JE (2005) A review of the tachinid parasitoids (Diptera: Tachinidae) of Nearctic *Choristoneura* species (Lepidoptera: Tortricidae), with keys to adults and puparia. Zootaxa 938: 1–46. https://doi.org/10.11646/zootaxa.938.1.1
- O'Hara JE, Henderson SJ, Wood DM (2019) Preliminary checklist of the Tachinidae (Diptera) of the world. Version 1.0. PDF document, 681 pp. http://www.nadsdiptera.org/ Tach/ WorldTachs/Checklist/Worldchecklist.html [accessed 13/03/2019]
- Reggiani A, Dindo ML, Maini S (2006) Notes on *Elodia morio* Fallén and other tachinids reared from field-collected Lepidoptera in Emilia Romagna, northern Italy. Tachinid Times 19: 10–11.
- Richter VA (1996) On the fauna of tachinids (Diptera, Tachinidae) of the Crimea. Entomologiceskoe Obozrenie 75: 908–929.
- Robinson GS, Ackery PR, Kitching IJ, Beccaloni GW, Hernández LM (2010) HOSTS A Database of the World's Lepidopteran Hostplants. Natural History Museum, London. http:// www.nhm.ac.uk/hosts [Accessed on 20 December 2019]
- Scaramozzino PL, Loni A, Lucchi A (2017a) A review of insect parasitoids associated with Lobesia botrana (Denis & Schiffermüller, 1775) in Italy. 1. Diptera Tachinidae and Hymenoptera Braconidae (Lepidoptera, Tortricidae). ZooKeys 647: 67–100. https://doi. org/10.3897/zookeys.647.11098
- Scaramozzino PL, Loni A, Gandini L, Lucchi A (2017b) Who's who in the nests molded by *Lobesia botrana* on *Daphne gnidium*? IOBC/WPRS Bulletin 128: 130–134.
- Shoukat GA (2012) Larval parasitoids of *Lobesia botrana* (Denis and Schiffermüller, 1775) (Lepidoptera: Tortricidae) in Orumieh vineyards. Journal of Agricultural Science and Technology 14: 267–274.
- Silvestri F (1912) Contribuzioni alla conoscenza degli insetti dannosi e dei loro simbionti. III. La Tignoletta dell'uva (*Polychrosis botrana* Schiff.) con un cenno sulla Tignola dell'uva (*Conchylis ambiguella* Hb.). Bollettino del Laboratorio di Zoologia Generale e Agraria della Facoltà Agraria in Portici 6: 246–307.
- Silvestri F (1923) Contribuzioni alla conoscenza dei Tortricidi delle Querce. Bollettino del Laboratorio di Zoologia Generale e Agraria della Facoltà Agraria in Portici 17: 41–107.
- Soria S (1988) Relación de lepidópteros paleárticos defoliadores del género *Quercus* L. Boletín de sanidad vegetal, Plagas 14: 11–26.
- Southwood TRE (1961) The number of species of Insects associated with various trees. Journal of Animal Ecology 30: 1–8. https://doi.org/10.2307/2109
- Stireman JO III, Cerretti P, O'Hara JE, Blaschke JD, Moulton JK (2019) Molecular phylogeny and evolution of world Tachinidae (Diptera). Molecular Phylogenetics and Evolution 139: 106358. https://doi.org/10.1016/j.ympev.2018.12.002

- Telenga NA (1934) Parasiten und ihre Bedeutung in der Dynamik des Traubenwicklers (*Polychrosis botrana* Schiff.). Anzeiger für Schädlingskunde 10: 101–106. https://doi.org/10.1007/BF02336199
- Thiéry D, Yoshida T, Guisset M (2006) *Phytomyptera nigrina* (Meigen), a parasite of first generation European grapevine moth larvae in several vineyards in the Roussillon area. The Tachinid Times 19: 1–4.
- Trenchev G (1980) Parasite species of subfamily Exoristinae (Diptera, Tachinidae) in Bulgaria. Rasteniev'd Nauki, Sofia 17(5): 121–126.
- Tschorsnig H-P (2017) Preliminary host catalogue of Palaearctic Tachinidae (Diptera). Version 1.0. PDF document, 480 pp. http://www.nadsdiptera.org/Tach/WorldTachs/CatPal-Hosts/Cat_Pal_tach_hosts_Ver1.pdf [accessed 13/03/2019]
- Villemant C, Delvare G, Martinez M, Sentenac G, Kuntzmann P (2012) Parasitoïdes de tordeuses. In: Sentenac G (Ed.) La faune auxiliaire des vignobles de France. Editions France Agricole, Paris, 119–140.
- Ziegler J (1998) Die Morphologie der Puparien und der larvalen Cephalopharyngealskelette der Raupenfliegen (Diptera: Tachinidae) und ihre phylogenetische Bewertung. Studia dipterologica, supplement 3: 1–244.
- Zuska J (1963) The puparia of the European species of the family Larvaevoridae (Diplera) I (Subfamily Salmaciinae. Part I). Acta Entomologica Musei Nationalis Pragae 35: 333–372.



Hippocampus nalu, a new species of pygmy seahorse from South Africa, and the first record of a pygmy seahorse from the Indian Ocean (Teleostei, Syngnathidae)

Graham Short^{1,2,3}, Louw Claassens^{4,5,6}, Richard Smith⁴, Maarten De Brauwer⁷, Healy Hamilton^{4,8}, Michael Stat⁹, David Harasti^{4,10}

 Research Associate, Ichthyology, Australian Museum Research Institute, Sydney, Australia 2 Ichthyology, California Academy of Sciences, San Francisco, USA 3 Ichthyology, Burke Museum, Seattle, USA 4 IUCN Seahorse, Pipefish Stickleback Specialist Group, University of British Columbia, Vancouver, Canada 5 Rhodes University, Grahamstown, South Africa 6 Knysna Basin Project, Knysna, South Africa 7 University of Leeds, Leeds, UK 8 NatureServe, Arlington, Virginia, USA 9 University of Newcastle, Callaghan, NSW, Australia
 Port Stephens Fisheries Institute, NSW, Australia

Corresponding author: Graham Short (gshort@calacademy.org)

Academic editor: Nina Bogutskaya | Received 13 February 2020 | Accepted 12 April 2020 | Published 19 May 2020 http://zoobank.org/E9104D84-BB71-4533-BB7A-2DB3BD4E4B5E

Citation: Short G, Claassens L, Smith R, De Brauwer M, Hamilton H, Stat M, Harasti D (2020) *Hippocampus nalu*, a new species of pygmy seahorse from South Africa, and the first record of a pygmy seahorse from the Indian Ocean (Teleostei, Syngnathidae). ZooKeys 934: 141–156. https://doi.org/10.3897/zookeys.934.50924

Abstract

A new species and the first confirmed record of a true pygmy seahorse from Africa, *Hippocampus nalu* **sp. nov.**, is herein described on the basis of two specimens, 18.9–22 mm SL, collected from flat sandy coral reef at 14–17 meters depth from Sodwana Bay, South Africa. The new taxon shares morphological synapomorphies with the previously described central Indo-Pacific pygmy seahorses, *H. colemani, H. japapigu, H. pontohi*, and *H. satomiae*, and *H. waleananus*, including diminutive size, twelve trunk rings, prominent cleithral ring and supracleithrum, spines on the fifth and twelfth superior and lateral trunk rings posterior to the head. *Hippocampus nalu* **sp. nov.** is primarily distinguished from its pygmy seahorse congeners by highly distinct spine morphology along the anterior segments of the superior trunk ridge. Comparative molecular analysis reveals that the new species demonstrates significant genetic divergence in the mitochondrial COI gene from the morphologically similar *H. japapigu* and *H. pontohi* (estimated

Copyright Graham Short et al. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

uncorrected p-distances of 16.3% and 15.2%, respectively). *Hippocampus nalu* **sp. nov.** represents the eighth member of the pygmy seahorse clade to be described from the Indo-Pacific, the first confirmed record from the African continent and the Indian Ocean, and an extension of more than 8000 km beyond the previously known range of pygmy seahorses from the Central and Western Indo-Pacific.

Keywords

Africa, COI, cryptobenthic, ichthyology, marine fish, morphology, Sodwana Bay, taxonomy

Introduction

The family Syngnathidae contains more than 300 species within 57 genera of predominantly small-bodied and cryptic marine fishes (Dawson 1985; Hamilton et al. 2017). The family is widely distributed in temperate and tropical habitats among mostly shallow coastal areas of the Atlantic and Indo-Pacific Oceans, including soft sediment habitats, seagrass beds, estuaries, coral and rocky reefs, and mangroves (Foster and Vincent 2004; Kuiter 2009). Members of this family, comprising the seahorses, pipefishes, pipehorses, and seadragons, are uniquely characterised by a fused jaw that allows for alimentation by suction feeding, male brooding, and cryptic morphology and behaviour. Seahorses cluster into pygmy and non-pygmy phylogenetic lineages (Hamilton et al. 2017). Pygmy seahorses are generally diminutive in size, less than 27.3 mm SL, live in obligate association with octocorals or occur freely in clumps of calcareous algae, hydroids or algal turf, and are distinct from the more speciose group of larger (24–350mm SL) non-pygmy species of *Hippocampus* in possessing a single rather than paired gill openings and trunk brooding of their young (Whitley 1970; Kuiter 2003; Lourie and Randall 2003; Lourie and Kuiter 2008; Gomon and Kuiter 2009; Lourie et al. 2016; Short et al. 2018). Seven pygmy seahorse species are currently recognized: H. bargibanti Whitley, 1970, H. denise Lourie & Randall, 2003; H. colemani Kuiter, 2003; H. pontohi Lourie & Kuiter, 2008; H. satomiae Gomon & Kuiter, 2009; H. waleananus Gomon & Kuiter, 2009; and *H. japapigu* Short et al., 2018. The generally free-living H. colemani, H. japapigu, H. pontohi, and the soft and octocoral associating H. satomiae and H. waleananus, respectively, are united by similar meristic and morphometric characters, conserved morphology, and a suite of synapomorphic characters, including twelve trunk rings, prominent cleithra and supracleithrum, diagnostic spines on the fifth and twelfth superior and lateral trunk ridges, respectively, and prominent winglike protrusions present on the first and/or second superior trunk rings posterior to the head (Short et al. 2018). In contrast, the gorgonian octocoral-dwelling species, H. bargibanti and H. denise, are distinct in overall morphological appearance in having an indiscernible coronet, indistinct cleithra, and the presence of large bulbous tubercles. Pygmy seahorses have previously been recorded throughout the central Indo-Pacific with largely sympatric distributions, ranging from Thailand, Indonesia, Philippines, Palau, Papua New Guinea, Australia, Solomon Islands, New Caledonia, Vanuatu, Fiji, to Taiwan and central Japan (Whitley 1970; Kuiter 2003; Lourie and Randall 2003; Senou

et al. 2006, 2007, 2008; Baine and Harasti 2007; Lourie and Kuiter 2008; Motomura et al. 2010; Allen and Erdmann 2012; Smith et al. 2012; Lourie et al. 2016; Short et al. 2018; Heard et al. 2019) with no species heretofore recorded in the Western Indo-Pacific. In 2017, Dive Instructor Savannah Nalu Olivier (Pisces Diving, Sodwana Bay, South Africa), during the course of a scuba dive with beginner divers, observed and photographed multiple individuals of a diminutive seahorse from flat sandy-algal reef habitat in gullies with strong surge currents in Sodwana Bay, South Africa. Subsequent investigation revealed that these diminutive seahorses, although similar to *H. pontohi* and *H. japapigu* in appearance and colouration, differed markedly in a number of characters, and represent a new species and the first confirmed record of a true pygmy seahorse from South Africa, the African continent, and the Indian Ocean, which is described herein.

Materials and methods

Two specimens of *H. nalu* were collected by hand while scuba diving in 12–17 m depth. The holotype (SAMC-F04193) and paratype (SAMC-F04194) were deposited in the fish collection of the Iziko South African Museum (SAM), Cape Town, South Africa. Head and body measurements follow Short et al. (2018) and are expressed as percent of standard length (SL) or head length (HL). Computed tomography (CT) scans of both specimens were obtained at the University of New England, NSW, Australia CT Scanner Facility using a GE v|tome|x S industrial micro-CT scanner with a voxel resolution (slice thickness) of 8 μ m. The resulting CT scan data were visualized and rendered in Horos (http://www.horosproject.org). All digital images were processed using Adobe Photoshop.

Genomic DNA was extracted from the right eye of the 95% ethanol-fixed holotype of *H. nalu* SAM-MB-F041933) using a DNeasy Blood and Tissue Extraction Kit (Qiagen, Inc.) in accordance with the manufacturer's protocols and initial tissue digestion overnight at 56 °C. A shotgun library was prepared from the extracted DNA using an Illumina Nextera DNA Flex library prep kit and sequenced using a MiSeq and 2×150 v3 reagent kit at the Ramaciotti Centre for Genomics (UNSW Sydney, Australia).

The mitochondrial genome was assembled by initially mapping reads to a reference 655 bp COI fragment from *Hippocampus kuda* (Genbank: EU930325) in Geneious v 10.05. When no reads could be further extracted from the shotgun dataset, sequences with a minimum average phred quality score of 30 were filtered out using BBDuk and used to assemble the complete mitochondrial genome with the De Novo Assemble function in Geneious. The mitogenome was annotated by comparison to the *Hippocampus kuda* mitochondrial genome (AP005985) and the Find ORFs function in Geneious using the Vertebrate Mitochondrial translation table. The complete mitochondrial genome of *H. nalu* is available from GenBank under accession number MT053858.

Genetic distances (uncorrected *p*-distances) were calculated based on COI using MEGA v. 7.0.26 (Kumar et al. 2017).

Systematics

Hippocampus nalu sp. nov.

http://zoobank.org/FE8B30CB-3672-45DD-AF96-B4FA574979BE Figures 1–6, Tables 1, 2

Type locality. 2 Mile Reef, Sodwana Bay, South Africa, 27°30'46.6"S, 32°41'10.4"E.

Holotype. SAMC-F041933, 18.9 mm SL, female, 2 Mile Reef, Sodwana Bay, South Africa, 27°30'46.6"S, 32°41'10.4"E, 12–17 meters depth, 18 October 2018, L. Claassens, R. Smith, S. Olivier, scuba diving.

Paratype. SAMC-F041934, 22 mm SL, male, 2 Mile Reef, Sodwana Bay, South Africa, 27°30'46.6"S, 32°41'10.4"E, 12–17 meters depth, 18 October 2018, L. Claassens, R. Smith, S. Olivier, scuba diving.

Comparative material. Published data was obtained for *H. japapigu* (Short et al. 2018); *H. pontohi* and *H. satomiae* (Lourie and Kuiter 2008); *H. colemani* (Kuiter (2003); and *H. waleananus* (Gomon and Kuiter 2009).

Diagnosis. *Hippocampus nalu* sp. nov. is diagnosed by the following combination of characters: tail rings 29–30; dorsal fin rays twelve; pectoral fin rays ten; subdorsal rings four; two pairs of bilateral wing-like protrusions behind the head formed by a pair of large oblong spines projecting anterolaterad on the first superior trunk ridge and a pair of unique double cuspidate spines projecting anteriad on the second superior trunk ridge; double spine above the eyes; absence of spines at the sixth superior trunk and eighth inferior trunk ridges; superior trunk ridge ending with two subdorsal spines protruding laterad; the posteriormost spine greatly enlarged on twelfth trunk ridge.

Description. General body shape as in Figs 1-6. Morphometric, meristic, and morphological characters listed in Tables 1, 2. Distinct, angular coronet; single gillopening on midline behind coronet supported by prominent cleithral ring and supracleithrum; dorsal fin rays twelve; pectoral-fin rays ten; anal fin rays four; trunk rings twelve; dorsal fin base strongly raised dorsally; subdorsal rings four, dorsal fin base starting immediately posterior to ninth trunk ring and ending immediately posterior to first tail ring; tail rings 29-30. Body ornamentation: prominent double spine present dorsally of eye, posteriormost spine large, anteriormost spine small; lateral head spine ventral of coronet on postemporal; two moderately large spines on cleithral ring, upper spine at level of last pectoral fin ray, lower spine at ventral extent of ring; snout spine broad, on midline between eyes; superior trunk ridge with two pairs of bilateral wing-like protrusions formed by a pair of large oblong spines projecting anterolaterad on the first superior trunk ridge and a pair of unique double cuspidate spines projecting anteriad on the second superior trunk ridge; superior trunk ridge ending with two subdorsal spines protruding laterad, the posteriormost spine greatly enlarged on the twelfth trunk ridge; laterodorsal surface of trunk flat; large spines on fifth superior trunk ridge; moderate spines on fifth lateral trunk ridge, large spines on eighth lateral trunk ridge; all inferior trunk ridge spines absent; superior tail ridge spines moderately developed anteriorly, becoming smaller posteriorly, with enlarged spines on fifth, ninth, twelfth, and 16th tail ridges; inferior tail ridge spines absent; caudal fin absent.


Figure 1. *Hippocampus nalu*, preserved specimens **A** SAMC-F041933, holotype female, 18.9 mm SL, and **B** SAMC-F041934, paratype, male, 22 mm SL; South Africa: Sodwana Bay, 2 Mile Reef (photograph Australian Museum Research Institute).

Colouration. In life, *H. nalu* (Figs 5, 6) exhibits cryptic colouration: head, trunk, and tail, honey brown, with overlay of white irregular quadrilateral and pentagonal reticulation; dorsal trunk area from the third to the tenth superior trunk rings with red colouration, white reticulation absent; white reticulation on trunk ventrolaterally, dorsal fin base dorsally, neck dorsolaterally, areas of head (snout, orbitals, and operculum, and along the length of the tail; dermal appendages, thin and red, projecting anteriorly on coronet and fifth superior trunk ridges. In alcohol, head and body background colour typically uniformly pale cream to light brown (Figure 1). The type specimens have retained the reticulated colour pattern of live individuals. Fins hyaline.

Distribution and habitat. *Hippocampus nalu* is currently known only from shallow (12–17 meters depth) waters in Sodwana Bay, South Africa, which falls within the iSimangaliso Wetland Park, a World Heritage Site that stretches from Lake St Lucia in the south to the Mozambique border in the north, and along the north coast of Kwa-Zulu Natal province. However, the new species likely has a wider distribution along



Figure 2. Computed tomography scanned skeleton of *Hippocampus nalu*, SAMC-F041933, holotype, 18.9 mm SL, female SL **A** ventral view **B** lateral view **C** dorsal view.

the East African coast and remains undetected because of its cryptic behaviour and diminutive size, and therefore its occurrence further north off East Africa in Mozambique, Tanzania, and Kenya, and offshore to Madagascar, may be confirmed by future localised ichthyofaunal surveys.

Sodwana Bay is situated near the southern end of the tropical western Indo-Pacific marine ecoregion, and is a subtropical transition zone between the tropics to the north and the warm temperate region to the south; consequently, it maintains the southernmost reef formations dominated by coral in Africa (Glassom et al. 2006). The composition and distribution of marine inshore ichthyofauna in Sodwana Bay are influenced by a complex interplay of south-flowing currents, including the Agulhas, Mozambique, and East Madagascar currents that transport warm waters to the East coast of South Africa, and are therefore likely to act as a main conduit to transport tropical fish species from East Africa and elsewhere in the Western Indo-Pacific south



Figure 3. Computed tomography scanned skeleton of *Hippocampus nalu*, SAMC-F041934, paratype, male, 22 mm SL **A** ventral view **B** lateral view **C** dorsal view.

to Sodwana Bay (Beckley 1995, 2000). Across South Africa, there are four other species of non-pygmy seahorses known to occur: the temperate endemic *H. capensis* and the subtropical–tropical Indo-Pacific *H. camelopardalis*, *H. histrix*, and *H. kuda* (Lockyear 2006; Lourie et al. 2016; Claassens and Hodgson 2018).

The underwater ecosystems where *H. nalu* was observed consisted of flat sandstone-based coral reefs in addition to unique topographic features (Ramsay et al. 1994) comprising low pinnacles, shallow drop offs, and sandy gullies, the latter being exposed to strong currents. *Hippocampus nalu* was found loosely associating with short algal turf, used as a holdfast, which was growing on sand-covered coral bedrock separated by sandy gullies (around 2 meters wide). The ambient seawater temperature averaged approximately 24 °C during the dives, which were conducted in October of 2018. The second and third authors experienced strong swells on the exposed reefs of 2 Mile Reef during data collection. The holotype and paratype appeared to be a mated pair, which



Figure 4. Computed tomography scan of *Hippocampus nalu*, SAMC-F041933, holotype, female, 18.9 mm SL, 2 Mile Reef, Sodwana Bay, South Africa **A** lateral view of head and trunk area **B** anterolateral view of first and second superior trunk ridge spines (STrR1-2) **C** close-up lateral view of second superior trunk ridge cuspidate spines (STrR2). Abbreviations: ES, double eye spines; SOC, supraoccipital; CO, coronet; SC, supracleithrum; STrR1, first superior trunk ridge spine; STrR2, second superior trunk ridge spine; STrR1, first superior trunk ridge spine.

were found within approximately 60 cm distance of each other on the two dives and their behaviour was observed prior to collection. Direct interaction, however, was not observed. Behaviour was very similar to congeners *H. pontohi* and *H. japapigu* (Short et al. 2018). Multiple individuals of *H. nalu*, including a small juvenile, were found in the gullies and observed to be associated with low-growth algal turf. The small juvenile, estimated to be approximately 10 mm SL (Figure 6), retained the dark colouration of a recently settled juvenile pygmy seahorse (Smith 2010).

Etymology. Named after Savannah Nalu Olivier who discovered the new species in Sodwana Bay. In the South African languages, Xhosa and Zulu, *nalu* refers to the expression 'here it is' and therefore we extend its meaning in this case to the simple fact that *H. nalu* was there all along until its discovery. Additionally, the species name *nalu* is also the Hawaiian word that refers to the waves or surf of the moana (ocean), for that reason we find the name relevant as *H. nalu* was observed moving about in strong surge to different locations in the sandy habitat. A noun in the genitive.



Figure 5. *Hippocampus nalu* in situ, SAMC-F041933, holotype, female, Sodwana Bay, South Africa at 14 m depth (photograph Richard Smith / oceanrealmimages.com).

New English Names: Sodwana pygmy seahorse, African pygmy seahorse, and Honeypot seahorse are proposed here for *Hippocampus nalu*.

Mitochondrial genome and COI genetic distances. A total of 7,259,439 forward and reverse reads were recovered from the shotgun library of which 13,133 were used to assemble the mitogenome of *H. nalu* (coverage: mean=117.1, SD=20.3). The mitogenome of *H. nalu* is 16,470 bp in size consisting of 13 protein-coding genes, two rRNA genes, 22 tRNA genes, and a control region (D-loop). Suppl. material 1 shows the genetic distance analysis at the COI gene (uncorrected p distances) between *H. nalu* and the previously sequenced specimens of *H. bargibanti*, *H. denise*, *H. japapigu*, and *H. pontohi* (Hamilton et al. 2017; Short et al. 2018). *Hippocampus nalu* differs from *H. pontohi* by 15.2%, from *H. japapigu* by 16.3%, *H. bargibanti* by 16.5%, and *H. denise* by 17.1%. Reported mtDNA clock rates of approximately 1.2% per million years in marine teleosts (Reece et al. 2010) indicate divergence between *H. nalu* and its congeners *H. pontohi* and *H. japapigu* approximately 12.7 and 13.6 million years ago, respectively.

Comparative remarks. *Hippocampus nalu* shares morphological synapomorphies with its congeners *H. pontohi*, *H. japapigu*, *H. colemani*, *H. satomiae*, and *H. waleananus*,



Figure 6. *Hippocampus nalu* in situ, SAMC-F041934, paratype, male, Sodwana Bay, South Africa at 14 m depth (photograph Richard Smith / oceanrealmimages.com).

	H. nalu	H. nalu	H. japapigu	H. pontohi	H. colemani	H. satomiae	H. waleananus
Voucher	SAMC	SAMC	Short et al.	Lourie and	Kuiter 2003	Lourie and	Gomon and
	F041933	F041934	2018	Kuiter 2008		Kuiter 2008	Kuiter 2009
SL (mm)	18.9	22.0	16.3	16.7	26.9	13.6	17.8
% SL							
Snout depth	86.7	85.1	74.0	84.2	70.5	86.0	95.2
HL	23.5	20.3	18.0	21.7	18.1	22.0	17.7
Trunk length	29.9	30.9	32.6	33.3	32	30.0	31.3
Tail length	46.5	48.9	49.4	45.0	50.0	48.0	63.4
Trunk depth	27.1	28.1	18.7	13.5	19.2	13.0	15.0
at dorsal-fin							
origin							
% HL							
Coronet	48.6	51.2	58.1	47.4	45.6	40.2	48.3
height							
Head depth	63.6	69.1	69.9	60.6	62.6	51.8	67.9
Snout length	25.4	25.6	28.7	23.2	27.7	27.0	26.8
Post-orbital	56.2	54.7	55.3	51.2	52.1	45.0	51.5
length							
Trunk rings	12	12	12	12	12	12	12
Tail rings	29	30	28	28-30	26–28	27-28	32
Dorsal fin	12	12	14	12	14	13	12
rays							
Pectoral fin	10	10	9	9-10	9	9	9
rays							

Table 1. Comparison of relative measurements and counts between *H. nalu*, *H. japapigu*, *H. pontohi*, *H. colemani*, *H. satomiae*, and *H. waleananus* based on type specimens.

	H. nalu	H. pontohi	H. japapigu		
Data source	SAMC F041933-F041934	Lourie and Kuiter 2008	Short et al. 2018		
Single gill opening	present				
Elevated cleithral girdle	present				
Coronet	distinct and elevated				
Cleithral spines	pectoral fin base, ventral of 1st trunk ring				
Subdorsal rings	3 trunk +1 tail				
Lateral head spine	present				
Broad snout spine	present				
Eye spine dorsad	double	double single			
Eye spine ventrad	single				
1 st superior trunk ridge spines	present				
2 nd superior trunk ridge spines	present	present	absent		
Elevated ridge on trunk	absen	present			
5 th superior trunk ridge spines	present				
5 th lateral trunk ridge spines	present				
6 th superior trunk ridge spines	absent		present		
8 th lateral trunk ridge spines	present				
8 th inferior trunk ridge spines	absent present				
Subdorsal trunk ridge spines	11 th ,12 th 10 th ,11 th ,12 th				
Superior tail ridge spines	5 th , 9 th , 12 th				
Inferior tail ridge spines	absent				

Table 2. Comparison of morphological characters between H. nalu, H. japapigu, and H. pontohi.

including meristics, distinct coronet, 12 trunk rings, prominent cleithral ring and supracleithrum, large spines on the fifth and twelfth superior and lateral trunk ridges, respectively, large spine on the eighth lateral trunk ridge, and prominent wing-like protrusions present on the first and/or second superior trunk rings posterior to the head (Table 2, Short et al. 2018: table 10). *Hippocampus nalu* (Figs 1, 5, 6) appears to be most similar in external appearance to *H. japapigu* and *H. pontohi* (Short et al. 2018: figs 1–7). However, as revealed by CT scans, it is more similar morphologically to *H. pontohi*, primarily on the basis of wing-like protrusions formed by two pairs of large spines on the first and second superior trunk ridges (Figure 4; Short et al. 2018: fig. 10), versus a single pair of large spines restricted to the first superior trunk ridge in *H. japapigu* (Short et al. 2018: fig. 9).

Hippocampus nalu shares with *H. pontohi* a pair of large moderately oblong spines that project anterolaterally from the first superior trunk ridge (Figs 2–4; Short et al. 2018: fig. 10), whereas *H. nalu* differs in having a large pair of unique double cuspidate spines projecting anteriad on the second superior trunk ridge (versus large, moderately oblong spines projecting anterolaterally on the second superior trunk ridge in *H. pontohi* [Figs 2–4; Short et al. 2018: fig. 10]). The new species can be further distinguished from *H. pontohi* by the following combination of characters (Table 2): double spine above the eyes (versus single); small spine ventroposterior to eye (versus absent), absence of spines at the sixth superior trunk and eighth inferior trunk ridges (versus presence of small spines); two subdorsal spines with the posteriormost greatly enlarged on the twelfth trunk ridge (versus three subdorsal spines). *Hippocampus nalu* furthermore shares with *H. pontohi* and *H. japapigu*, as revealed by CT scans, the ring and ridge structure of larger seahorses



Figure 7. *Hippocampus nalu* in situ, juvenile, approximately 10 mm SL, Sodwana Bay, South Africa at 14 m depth (photograph Richard Smith / oceanrealmimages.com).

with well-developed ossification of the skeleton, including the strong ossification of the inferior and ventral trunk area (Figs 2, 3; Short et al. 2018: fig. 8) versus the incomplete ossification of the inferior and ventral trunk ridges anteriorly in *H. bargibanti* and *H. denise* (Gomon, 1997; Lourie and Randall 2003; Gomon and Kuiter 2009).

Hippocampus nalu can be distinguished from *H. japapigu* (Table 2) by the absence of a distinct elevated dorsal ridge internally formed by triangular bony mounds in the anterodorsal area of the trunk directly posterior to the head (Short et al. 2018: fig. 9), double spine above the eyes (versus single); absence of spines at the sixth superior trunk and eighth inferior trunk ridges (versus presence of small spines); small spine at eighth lateral trunk ridge (versus presence of prominent spine in *H. japapigu* and a small spine in *H. pontohi*). *Hippocampus nalu* exhibits a similar colour pattern to *H. japapigu* with white reticulation over the head, neck, and trunk areas, and prominent solid red colouration over the dorsal area of the entire trunk.

Hippocampus nalu is similar to *H. colemani* and *H. satomiae* primarily on the basis of two pairs of large spines on the first and second superior trunk ridges, respectively



Figure 8. Distribution of Hippocampus nalu. Type locality in red.

(Short et al. 2018: table 10). Determination of the configuration and structure of the two pairs of large spines for *H. colemani* and *H. satomiae* will have to await the acquisition of collection material. *Hippocampus nalu* also shares with *H. satomiae* double spines above the eye. *Hippocampus colemani* differs in having a low and rounded coronet (versus distinct coronet in *H. satomiae*) and reduced spines at key placements on the trunk and tail ridges (Kuiter 2003), whereas *H. satomiae* differs in extremely small size (14 mm SL), distinct raised coronet with laterally expanded anterior and posterior flanges, and reduced ossification of the inferior and ventral trunk ridges (Lourie and Kuiter 2008) similar to that observed in *H. bargibanti* and *H. denise* (Gomon and Kuiter 2009).

Discussion

Here, we consider *Hippocampus nalu* as a valid species due to its genetic and morphological uniqueness; however, a more comprehensive phylogenetic study is necessary to elucidate its evolutionary relationship to its pygmy congeners. Using micro-computed tomography scans, we have identified key diagnostic characters in the highly distinct spine morphology of the two pairs of bilateral wing-like spines present on the first and second superior trunk ridges that differentiate *H. nalu* from the morphologically

similar *H. japapigu* and *H. pontohi. Hippocampus nalu, H. colemani, H. japapigu, H. pontohi, H. satomiae*, and *H. waleananus* are united by numerous morphological synapomorphies and morphologically conserved to the extent that it is difficult to distinguish the species based on external appearance alone, and appear to form a natural grouping in comparison to the distinct *H. bargibanti* and *H. denise*. However, based on examined specimens so far, *Hippocampus nalu, H. japapigu,* and *H. pontohi* can be primarily distinguished from one another by features of the distinct morphology and number of wing-like spines on the superior trunk ridges as revealed by μ CT scans (Short et al. 2018). *Hippocampus colemani, H. satomiae*, and *H. waleananus* appear to have wing-like spines but their morphology in the anterior segments of the trunk have yet to be determined even though the number of spines have been surmised (Short et al. 2018). Secondary characteristics that distinguish between the species include the presence or absence of snout spines, single or double eye spines dorsally, small eye spines posteriorly, sixth and eighth superior trunk ridge spines, and the number of large subdorsal spines.

Seven new species of pygmy seahorses have been officially described and named within the first two decades of the 21st century (Kuiter 2003; Lourie and Randall 2003; Lourie and Kuiter 2008; Gomon and Kuiter 2009; Short et al. 2018). Previously, *H. bargibanti* was the only pygmy seahorse known to science, having been described in 1970 (Whitley 1970). The occurrence of a new species and first record of a pygmy seahorse, *H. nalu*, in South Africa and the Western Indian Ocean is not unexpected but amazing nevertheless since it has been 50 years to date since the discovery of *H. bargibanti*. Fundamental information on the distribution and abundance of pygmy seahorses is still relatively limited relative to the body of literature for the non-pygmy seahorses to be discovered in the Western Indian Ocean by future ichthyofaunal surveys as this region is not as well documented as the Central and Western Indo-Pacific.

Acknowledgements

We are grateful to the many research colleagues who contributed in the field, lab, observations, and congenial discussions: Savannah Nalu Olivier, Instructor and Dive Master, Pisces Diving, Sodwana Bay, South Africa, for the amazing discovery of *H. nalu* in South Africa; Christo van Jaarsveld and Petro van Jaarsveld from SeaXplore dive centre and lodge, Sodwana Bay, for arranging scuba logistics for specimen collection by second and third authors in Sodwana Bay; David Delport for assistance in the field; Peter Teske, University of Johannesburg, for assistance with collection permits; Christopher Goatley, University of New England, Australia, for μ CT scans of the type specimens of *H. nalu*; Adam Summers, Friday Harbor Laboratories, University of Washington, for use of lab and CT visualization software; Albé Bosman, Collections Manager, Marine Biodiversity Collections, National History Department, Iziko South African Museum, for curatorial assistance; iSimangaliso Wetland Park and Enzemvelo

KZN Wildlife for providing authorisation for the collection of specimens; Amanda Hay, Collections Manager, Department of Ichthyology, Australian Museum, for amazing curatorial assistance. Special thanks to Betsy Royce and Turner Dean for providing convivial friendship and home during the writing of the manuscript. This research was generously supported in part by funding from NSF (DBI-1759637, DEB-170166) to Adam Summers, Friday Harbor Laboratories, University of Washington, and from the Australian Museum Research Institute.

References

- Beckley LE (1995) The Agulhas Current ecosystem with particular reference to dispersal of fish larvae. In Status and Future of Large Marine Ecosystems of the Indian Ocean: A Report of the International Symposium and Workshop. A Marine Conservation and Development Report, IUCN, Gland, Switzerland, 74–91.
- Beckley LE (2000) Species composition and recruitment of tidal pool fishes in KwaZulu-Natal, South Africa. African Zoology 35(1): 29–34. https://doi.org/10.1080/15627020.2000.1 1407188
- Claassens L, Hodgson AN (2018) Monthly population density and structure patterns of an endangered seahorse Hippocampus capensis: a comparison between natural and artificial habitats. Journal of fish biology 92(6): 2000–2015. https://doi.org/10.1111/jfb.13639
- Dawson CE (1985) Indo-Pacific pipefishes (Red Sea to the Americas). Ocean Springs, Mississippi (Gulf Coast Research Laboratory), 230 pp. [1 pl.]
- Glassom D, Celliers L, Schleyer MH (2006) Coral recruitment patterns at Sodwana Bay, South Africa. Coral Reef 25(3): 485–492. https://doi.org/10.1007/s00338-006-0117-6
- Gomon MF, Kuiter RH (2009) Two new pygmy seahorses (Teleostei: Syngnathidae: *Hippocampus*) from the Indo-West Pacific. Aqua 15(1): 37–44.
- Hamilton H, Saarman N, Short G, Sellas AB, Moore B, Hoang T, Grace CL, Gomon M, Crow K, Simison WB (2017) Molecular phylogeny and patterns of diversification in Syngnathid fishes. Molecular phylogenetics and Evolution 107: 388–403. https://doi.org/10.1016/j. ympev.2016.10.003
- Kuiter RH (2003) A new pygmy seahorse (Syngnathidae: *Hippocampus*) from Lord Howe Island. Records of the Australian Museum 55: 113–116. https://doi.org/10.3853 /j.0067-1975.55.2003.1382
- Lockyear F, Hecht T, Kaiser H, Tesk PR (2006) The distribution and abundance of the endangered Knysna seahorse *Hippocampus capensis* (Pisces: Syngnathidae) in South African estuaries. African Journal of Aquatic Science 31(2): 275–283. https://doi. org/10.2989/16085910609503897
- Lourie SA, Randall JE (2003) A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae) from the Indo-Pacific. Zoological Studies 42: 284–291.
- Lourie SA, Kuiter RH (2008) Three new pygmy seahorse species from Indonesia (Teleostei: Syngnathidae: *Hippocampus*). Zootaxa 1963: 54–68. https://doi.org/10.11646/ zootaxa.1963.1.4

- Lourie SA, Pollom RA, Foster SJ (2016) A global revision of the Seahorses *Hippocampus* Rafinesque 1810 (Actinopterygii: Syngnathiformes): Taxonomy and biogeography with recommendations for further research. Zootaxa 4146(1): 1–66. https://doi.org/10.11646/zootaxa.4146.1.1
- Ramsay PJ (1994) Marine geology of the Sodwana Bay shelf, southeast Africa. Marine Geology 120(3–4): 225–247. https://doi.org/10.1016/0025-3227(94)90060-4
- Reece JS, Bowen BW, Smith DG, Larson AF (2010) Molecular phylogenetics of moray eels (Muraenidae) demonstrates multiple origins of a shell-crushing jaw (*Gymnomuraena*, *Echidna*) and multiple colonizations of the Atlantic Ocean. Molecular Phylogenetics and Evolution 57: 829–835. https://doi.org/10.1016/j.ympev.2010.07.013
- Short G, Smith R, Motomura H, Harasti D, Hamilton H (2018) *Hippocampus japapigu*, a new species of pygmy seahorse from Japan, with a redescription of *H. pontohi* (Teleostei, Syngnathidae). ZooKeys 779: 27. https://doi.org/10.3897/zookeys.779.24799
- Smith RE (2010) The biology and conservation of gorgonian-associated pygmy seahorses. PhD thesis, The University of Queensland, Brisbane, Australia.
- Whitley GP (1970) Abstract of proceedings. Ordinary general meeting 26th November 1969. Proceedings of the Linnean Society of New South Wales 94: 292–295.

Supplementary material I

Genetic distance analysis (uncorrected p distances) of COI sequence data from *H. nalu*, *H. bargibanti*, *H. denise*, *H. japapigu*, and *H. pontohi*

Authors: Graham Short, Louw Claassens, Richard Smith, Maarten De Brauwer, Healy Hamilton, Michael Stat, David Harasti

Data type: Genetic data

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/zookeys.934.50924.suppl1