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Depreissia decipiens, an enigmatic canopy spider from Borneo revisited (Araneae, Salticidae), with remarks on the distribution and diversity of canopy spiders in Sabah, Borneo

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Abstract

Depreissia is a little known genus comprising two hymenopteran-mimicking species, one found in Central Africa and one in the north of Borneo. The male of *D. decipiens* is redescribed, the female is described for the first time. The carapace is elongated, dorsally flattened and rhombus-shaped, the rear of the thorax laterally depressed and transformed, with a pair of deep pits; the pedicel is almost as long as the abdomen. The male palp is unusual, characterized by the transverse deeply split membranous tegulum separating a ventral part which bears a sclerotized tegular apophysis and a large dagger-like retrodirected median apophysis. The female epigyne consists of one pair of large adjacent spermathecae and very long copulatory ducts arising posteriorly and rising laterally alongside the spermathecae continuing in several vertical and horizontal coils over the anterior surface. Relationships within the Salticidae are discussed and an affinity with the Cocalodinae is suggested. Arguments are provided for a hypothesis that *D. decipiens* is not ant-mimicking as was previously believed, but is a mimic of polistinine wasps. The species was found in the canopy in the Kinabalu area only, in primary and old secondary rainforest at 200–700 m.a.s.l. Overlap of canopy-dwelling spider species with those in the understorey are discussed and examples of species richness and endemism in the canopy are highlighted. Canopy fogging is a very efficient method of collecting for most arthropods. The canopy fauna adds an extra dimension to the known biodiversity of the tropical rainforest. In southeast Asia, canopy research has been neglected, inhibiting evaluation of comparative results of this canopy project with that from other regions. More use of fogging as a collecting method would greatly improve insight into the actual species richness and species distribution in general.

Keywords
Jumping spiders, canopy spiders, taxonomy, biodiversity, ant-mimicking spiders, wasp-mimicking, Mt. Kinabalu, rainforest, Cocalodinae, Polistine wasps, endemism

Introduction

Lessert (1942) first reported the male of a strange ant-mimicking salticid spider from central Africa for which he established the genus *Depreissia*. *Depreissia myrmex* Lessert, 1942 is a small (3.2 mm total length) dark spider with elongate carapace, flat and low, with palps structured basically different from those of other Salticidae. The female is unknown. Wesołowska (1997) redescribed the type specimen, adding more details of the palp. As to the affinities of this spider, she was unable to indicate any close relationships.

A second species from secondary rainforest in the Kinabalu region of Malaysian Borneo, described as *Depreissia decipiens* Deeleman-Reinhold & Floren, 2003, exhibits remarkably close similarity to the type species. Like its African relative, only the male was known at the time of description (Deeleman-Reinhold and Floren 2003). A female was discovered later in samples from a primary forest near the forest where the male was found; it is described here. How can this disjunct distribution be explained? Are they relict species, only survivors of an ancient fauna, are they linked by intermediate unknown populations and species?

In this paper, the genital organs of male and female are (re)described and analysed. Phylogenetic affinities are suggested based on the structure of the male and female genitalia. Like the genus *Athamas* O. Pickard-Cambridge and the lyssomanine salticids, the eyes of *D. myrmex* are arranged in four rows (this is not so in *D. decipiens*). These groups otherwise seem phylogenetically remote. Only two adult specimens and four immatures of *Depreissia* were found amongst an estimated 15,000 spiders that were extracted from an ecological project of canopy fogging arthropods in a variety of forest types and localities through Sabah, Borneo. Possible models of mimicry are discussed.

Methods

Depreissia specimens were discovered in the vast material designed to serve a large project at University of Würzburg by AF to study the ecology of arthropods living in tree canopies in tropical rainforest of Sabah, northern Borneo and assessing the effects of human disturbance in primary rainforest. In total, he fogged 334 tree canopies at a height of 5–20 meters (trees had an average height of 24 meters) in a variety of forest types including primary and secondary forests of different ages, altitudes and seasons, some adjacent to primary forest, others in isolated stands. Three major geographic areas were visited, ranging from 100–2000 m.a.s.l.,viz. the Kinabalu area, Crocker Range and Tawau Hills (Floren, partly unpublished data).

The majority of the spider material discussed here was obtained between 1992 and 2009 by fogging the lower canopy of 80 trees in Poring Hot Springs in the Mount Kinabalu area, in a mature primary Dipterocarp rainforest at approximately 700 m.a.s.l. Five tree species were focused upon: (*Xanthophyllum affine* [Polygalaceae], three species of *Aporosa* [Phyllanthaceae] and *Aglaia macrophyllum* [Meliaceae]). In 1997, 48 tree samples in secondary forests of different age, adjacent to primary forest were sampled in a lowland Kinabalu site north of Poring (Sorinsim). Here, 18 trees of *Mallotus* (Euphorbiaceae) and 15 *Vitex pinnata* trees (Verbenaceae) were fogged. All spiders were sorted to family and identified as morphospecies and where possible to species and analysed ecologically (Floren and Deeleman-Reinhold 2005). At the moment of writing, 749 morphospecies have been recognised and documented, partly described and named, most still unidentified or unidentifiable. Supplemental samples are still being analysed regularly. All material is deposited in Naturalis Biodiversity Center, Leiden (RMNH).

Drawings were made with a Zeiss Stemi SV 11 stereo dissecting microscope with drawing tube. Photographs were made with NIKON DS-R:1 driven by NIS Elements software and mounted on the M165 C stereomicroscope, using Auto-Montage software version 5.03 (JM), and a Fuji camera Finepix HS 20 with the Zeiss Stemi, (Fig. 5, CD-R). Measurements reported in millimeters.

Taxonomy

Depreissia Lessert, 1942

Type species. *Depreissia myrmex* Lessert, 1942 (♂)

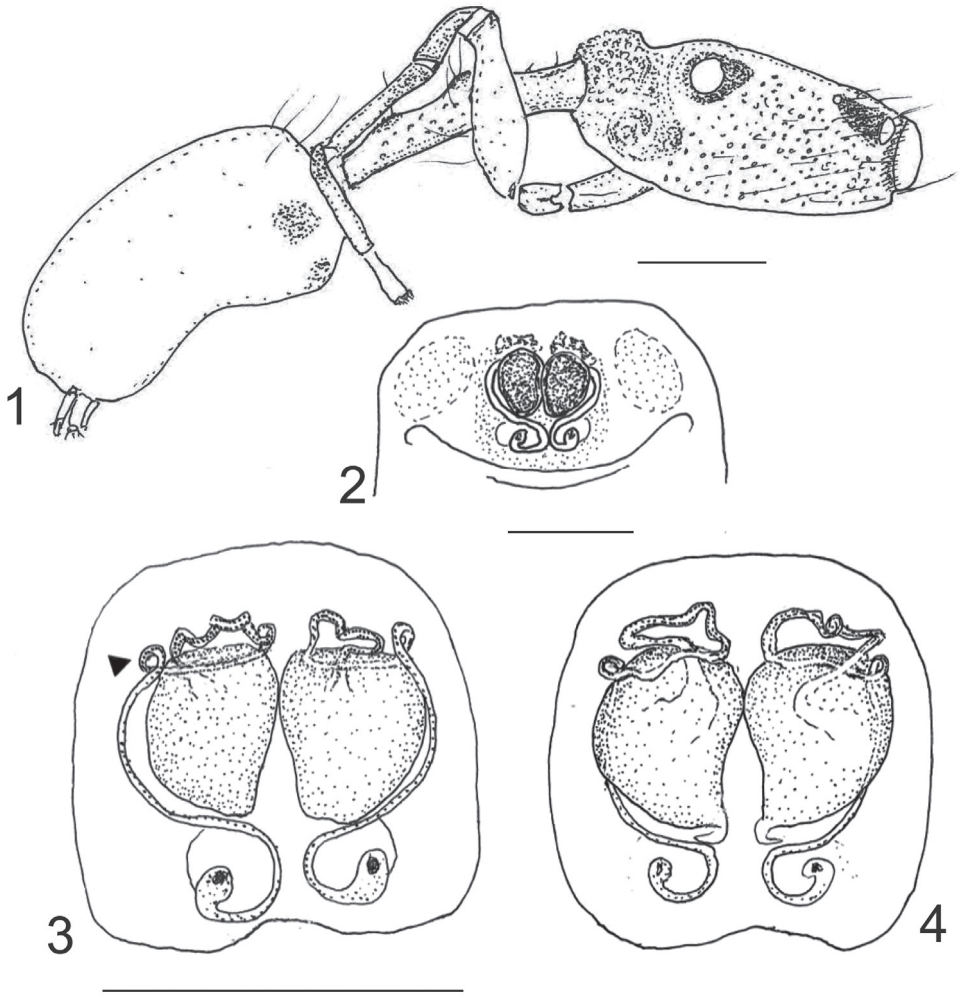
Depreissia decipiens Deeleman-Reinhold & Floren, 2003

Figs 1–14

Depreissia decipiens Deeleman-Reinhold & Floren 2003: 336, figs 1–7 (description ♂ holotype)

Holotype. MALAYSIA (BORNEO): Sabah, Kinabalu area, Sorinsim, ♂, 40 year old secondary forest adjacent to primary forest, 6°17'52"N, 116°42'3"E, 280 m.a.s.l., canopy fogging *Vitex pinnata* (L.), (Verbenaceae), tree 9 fog 1, 8.3.1997.

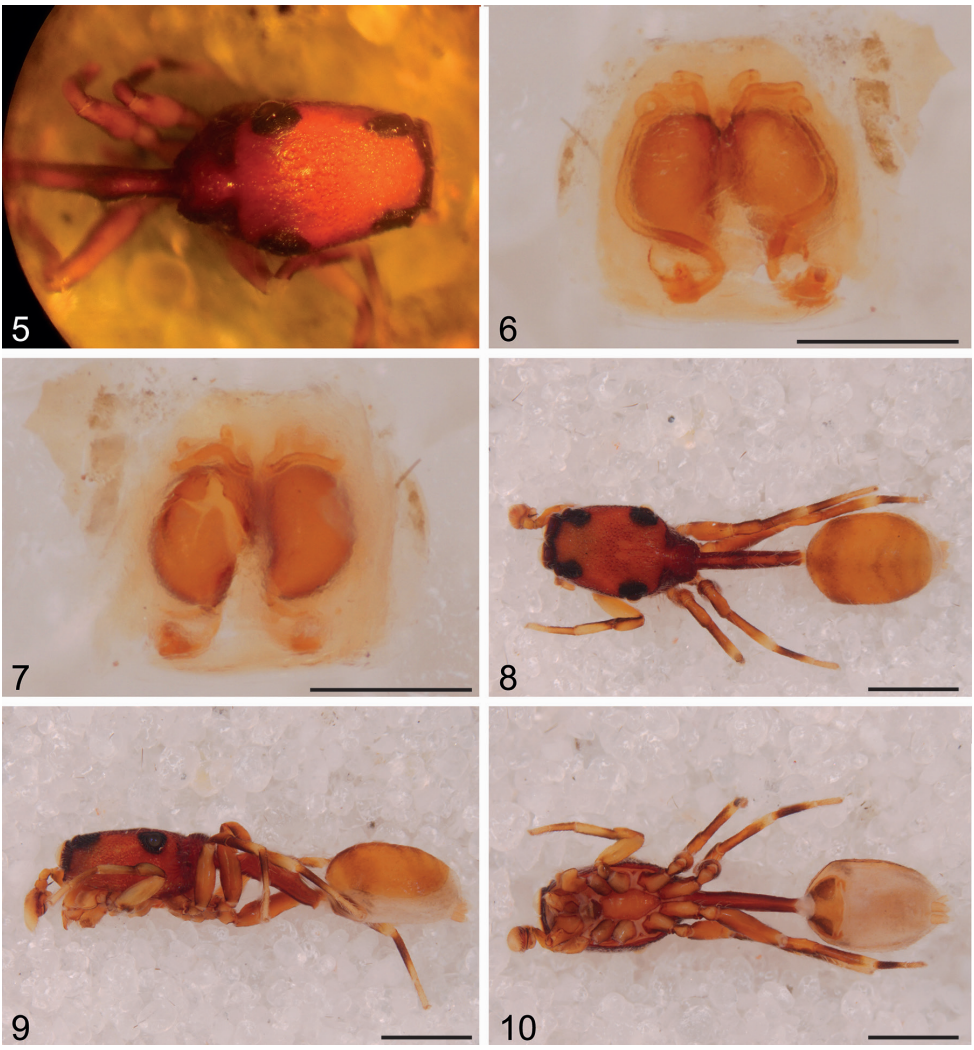
Additional material. Sabah, 1 immature, same as holotype, canopy fogging *Vitex pinnata* (L.) tree 5, fog 1, 7.3.1997; Mt. Kinabalu National Park at Poring Hot Springs, primary forest, 6°2'37"N, 116°41'57"E, 500–700 m.a.s.l., 1♀, canopy fogging, *Aporosa maingayi* tree 6, fog 1, 28.3.1998; Mt. Kinabalu National Park at Poring Hot Springs, 6°2'42"N, 116°41'54"E, 1 immature, canopy fogging , *Aporosa lagenocarpa*, tree 8, fog 1, 29.3.1998; Mt. Kinabalu National Park at Poring Hot Springs, 6°2'58"N, 116°41'58"E 1 immature, *A. lagenocarpa* tree, 19.2.1996; Kinabalu area,



Figures 1–4. *Depreissia decipiens* female **1** Female habitus, lateral **2** epigyne in situ, ventral view **3** epigyne, ventral view, arrow indicates first tight loop **4** vulva, dorsal view. Scale bars: 0.4 mm (**1**), 0.2 mm (**2–4**).

Monggis lowland primary forest, 6°13'17N, 116°44'14"E, 300 m.a.s.l., 2 immatures, canopy fogging *Lithocarpus* sp. (Fagaceae) tree 32, fog 1, 23.9.2006 (Fig. 14). All A. Floren, deposited in Naturalis Biodiversity Center, Leiden (RMNH).

Diagnosis. The palpal structure is unlike that in any known salticid. *Depreissia decipiens* shares with the African species *Depreissia myrmex* the peculiar elongate, dorsally flat rhombus-shaped carapace, and the PLE widely separated and far removed from the anterior eyes. The rear part of the carapace is transformed. The palpal tegulum has a deep constriction, which divides it into an anterior and a posterior part, the latter bearing an elongate bifid tegular apophysis and a large chitinized grooved median apophysis



Figures 5–10. *Depreissia decipiens* **5** Female carapace and pedicel, dorsal view **6** epigyne, ventral view **7** vulva, dorsal view **8** male habitus, dorsal view **9** male habitus, lateral view **10** male habitus, ventral view. Scale bars: 0.2 mm (**6–7**), 1.0 mm (**8–10**).

directed downward along the longitudinal axis. The spermophore and filiform embolus are situated in the anterior part (Figs 12, 13).

Depreissia decipiens male is distinguished from the African species *D. myrmex* by its larger size and accordingly longer legs, pale orange colour rather than dark as in *D. myrmex,* and the ALE positioned posterolaterally instead of directly behind the AME. The posterior end of the carapace in *D. myrmex* has an upturned posterior margin (Wesołowska 1997: fig. 2); in *D. decipiens* there is a central pustulous hump and a pair of large lateral pits (Figs 5, 8, 9; Deeleman-Reinhold and Floren 2003: fig. 6). Cheliceral

promargin with 2 teeth (one in *D. myrmex*). Femora and some other segments of leg I with at least one spine (legs of *D. myrmex* spineless). The pedicel is much longer and arched in *D. decipiens*, shorter and straighter in *D. myrmex*. Palp (Figs 11–13): the embolus runs transversely as half a coil along anterior half of the tegulum (Fig. 13), parallel to the spermophore, whereas there are two full coils in *D. myrmex*. In *decipiens* the membranous tegulum is divided into an anterior and a posterior part, connected by a thin string of soft tissue, the posterior part bears at its base a bifid tegular apophysis (bta in Figs 11, 13) and a strong grooved dagger-like median apophysis which is directed basally (bta and ma, Fig. 13; Deeleman-Reinhold and Floren 2003: fig. 3); in *D. myrmex* the apophysis is spout-like (Wesołowska 1997: figs 3–5).

Redescription of the male. Total length 4.10. Carapace length 1.55, width 1.00, height 0.80. clypeus height 0.10, maxillar height 0.35, width 0.15 at base, 0.25 in the middle, 0.20 distally, chelicerae length 0.50, width 0.25 in the middle, pedicel length 1.25, abdomen length 1.50, width 1.00. Eye sizes: AME 0.30, ALE 0.11, PME 0.03, PLE 0.18. Eye row widths: AME-AME 0.60, ALE-ALE 0.72, PME-PME 0.75, PLE-PLE 0.95.

Leg I (coxa-trochanter-femur-patella-tibia-metatarsus-tarsus = total) 0.25-0.15-0.60-0.30-0.50-0.40-0.20 = 2.40, leg II 0.30-0.10-0.60-0.30-0.50-0.40-0.30 = 2.50, leg III 0.30-0.10-0.70-0.30-0.50-0.50-0.25 = 2.65, leg IV 0.45-0.20-0.90-0.45-0.55-0.50-0.30 = 3.35. Total length of right and left legs differ by approximately 3–4%.

Spider orange, carapace as in diagnosis, maxillae hooked outward at right angle, chelicerae basal half deeply excavated mesally (Deeleman-Reinhold and Floren 2003: fig. 5), promargin with 2 teeth, posterior margin with some granule-based setae. Intercoxal ventral triangles laterally between coxae II and III. Pedicel slightly shorter than abdomen, arched, with two prominent humps dorsally, surface dotted with seta-bearing granules. Legs vaguely banded orange/cream/black; all leg femora have one distodorsal spine; there are two lateral unpaired short thick spines proventrally on tibia I and one similar on metatarsus I; all other segments are spineless. Abdomen oblate with dorsal scutum over 5/6 of the dorsal surface, showing a vague broad dark band anteriorly, continued on the flank and one near the rear and with several chevrons in between. Pulmonary plates large, triangular.

Palp: see diagnosis. Tibial apophysis short and straight (Fig. 11). Cymbium tip lacking central groove, there is a clear rim bordering anteriorly the cavity which hosts the bulb. The embolus is directed retrolaterally, it is not cradled.

Description of the female (Figs 2–7). Total length 4.40, carapace length 1.60, width 1.00, height 0.80, clypeus height 0.10, maxillar height 0.30, width 0.15 at base, 0.25 in the middle; chelicerae slightly excavated, 0.40 long, 0.20 in the middle, pedicel length 1.25, abdomen length 1.70, width 1.00. Legs I and II lost, leg III 0.40-0.20-0.70-0.30-0.60-0.50-0.30 = 3.00, leg IV: 0.50-0.25-0.90-0.40-0.55-0.50-0.30 = 3.40; palp femur length 0.40, width 0.10, tibia length 0.15, patella length 0.15, tarsus length 0.30, width 0.20.

Somatic characters in female similar to male, slightly larger with slightly longer legs. Eyes, sculpture of carapace, colour and integument ornamentation as in male;

Figures 11–13. *Depreissia decipiens*, male palp **11** retrolateral view **te** tip embolus **bta** bifid tegular apophysis **bma** base median apophysis **12** prolateral view **c** membranous connection dorsal and ventral tegulum **13** ventral view **bfe** base free part of embolus **bta** bifid tegular apophysis **ma** median apophysis. Scale bars: 0.2 mm.

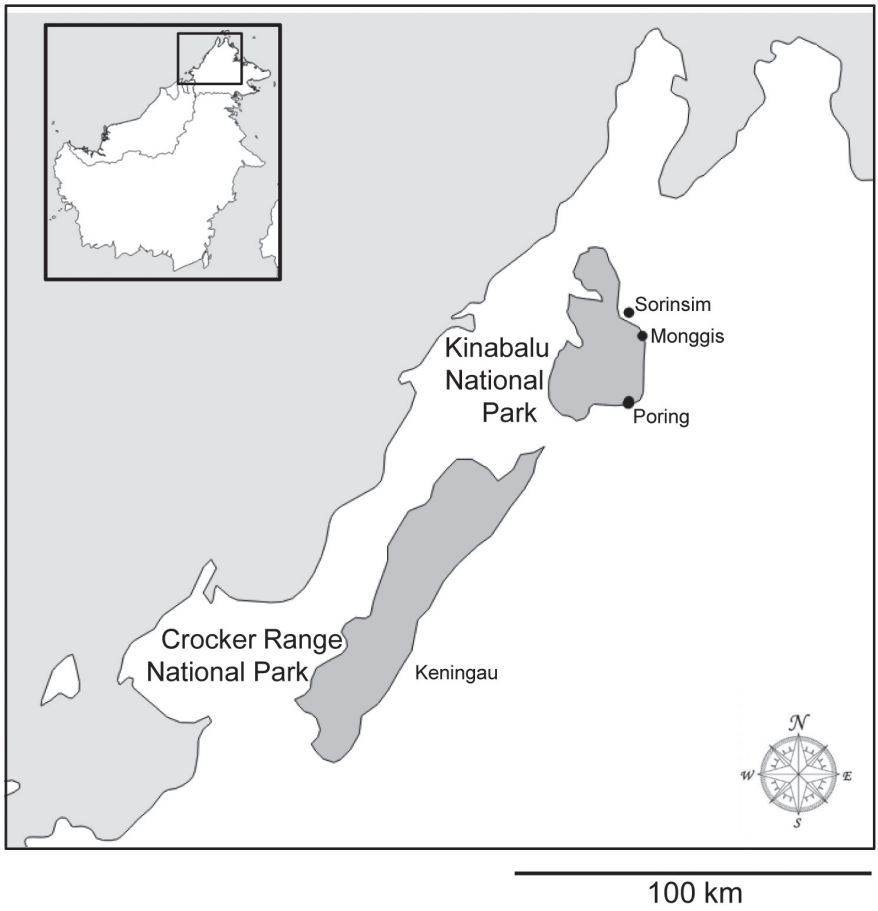


Figure 14. Specimen records of *Depreissia decipiens* (black circles) from the vicinity of Sorinsim, Monggis, and Poring Hot Spring. The locations of Kinabalu and Crocker Range National Parks, and the Keningau area, are shown. Inset shows area of map within Borneo.

maxillae as in male, chelicerae simple, mesal excavation only slight, with two small teeth. Palpal tarsus white, slightly flattened, no claw visible with microscope objective lens 6.6 x enlargement. Intercoxal ventral triangles and pedicel as in male. Femoral spines weak or absent. Abdomen lacking dorsal scutum.

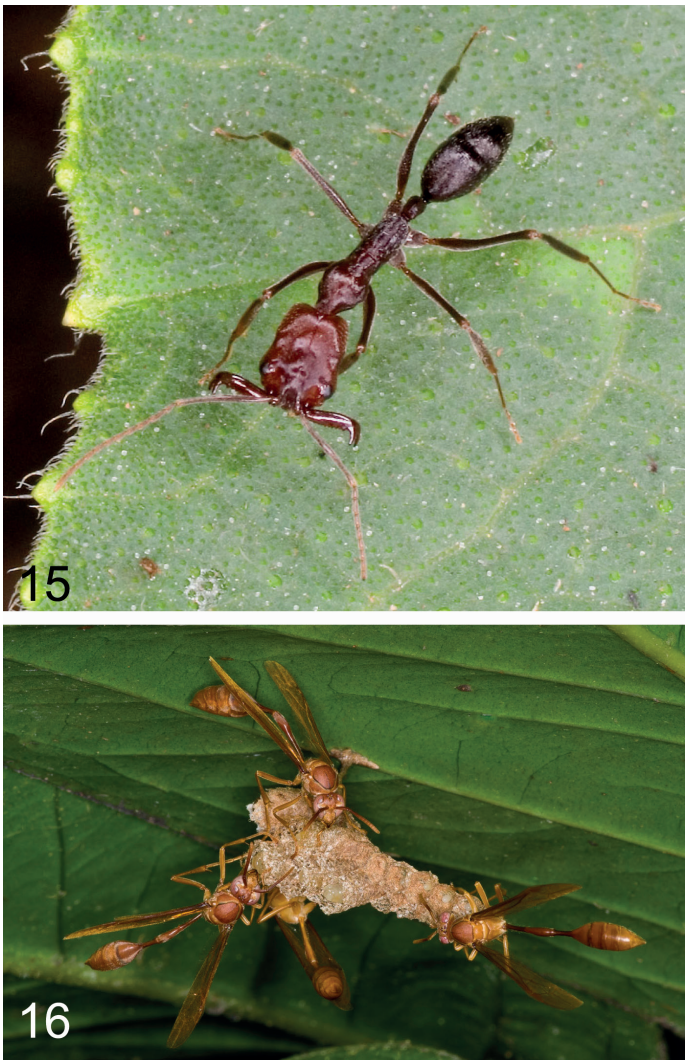
Epigyne: spermathecae relatively large, adjacent to one another in the vertical midline. Copulatory openings posterior, funnel-shaped, with a small atrium and continued in a narrow tubiform duct (insemination duct), almost straight, bordering the spermathecae along lateral-ventral sides. The duct tightly loops mesally (see arrow in Fig. 3), to continue along the dorsal surface of the spermathecae, then returns back lateral-wards in a series of vertical coils; at the lateral end it returns back straight on the ventral side again to dive down at mesal end to merge into the spermathecae.

Note. In many non-salticid spider species with a filiform embolus have it supported during copulation by a sclerite. We suppose that in this salticid the conspicuous s-shaped dagger-like median apophysis ventrally on the tegulum of the male palp serves that purpose. It penetrates the opening of the insemination duct supporting the embolus, the free part of which it matches in length (Fig. 13); this length approximates also the length of the spermathecae, so that the tip of the embolus and median apophysis reach approximately the point of the first tight loop (arrow, Fig. 3). The sperm consequently has to travel on towards the spermathecae through the long trajectory of twists and curls of the insemination duct. It can be expected that the inner wall of the distalmost section is clothed with specialized cells or glands.

Relationships. It is difficult to assess the taxonomic position of *Depreissia* within the Salticidae. There is complete lack of conformity in body shape and structure of genital organs with the ant-mimicking Myrmarachninae. Neither do they fit in Lyssomaninae: eyes in 4 rows instead of 3 characterizes *D. myrmex* but not *D. decipiens* and the genital organs are of a clearly different type. The structure of both palp and epigyne in *Onomastus* Simon has a certain superficial resemblance (Benjamin 2010, Prószyński and Deeleman-Reinhold 2013), but the conformation of genital organs is incompatible with that in *Depreissia*. The bipartite tegulum, the embolus tip not resting on cymbium tip, the presence of a sophisticated median apophysis and the unusual structure of the epigyne are key factors. A median apophysis is found mostly in primitive salticid clades, such as Cocalodinae (Maddison 2009). In *Depreissia*, the median apophysis is positioned on the tegulum clockwise and at some distance from the embolus. The nearest genera with a comparably structured palp with similarly positioned median apophysis can be found in a recently described series of genera from New Guinea (Maddison 2009). We suggest the species of the genus *Cucudeta* Maddison to be at present the nearest known relative of *Depreissia*. This is also supported by the similar structure of the epigyne, with openings in posterior pockets, long ducts rising forwards in lateral arch, looping, and entering the anterior end of the spermathecae (see also Maddison et al. 2016). Although morphology in *Cucudeta* is not particularly ant like, this spider has been observed walking with a specific fluid gait while keeping the second pair of legs in the air (Maddison 2009), suggesting a tendency toward ant mimicry.

Which model is *Depreissia* mimicking?

The most common ant species in the canopy stratum in the Poring area belong to the genera *Camponotus* Mayr, *Polyrhachis* Smith, *Dolichoderus* Lund and *Crematogaster* Lund (Floren et al. 2001, 2002). According to general morphology, these ants can be considered to be the model to any of the numerous ant-mimicking species of *Myrmarachne* MacLeay, *Bocus* Peckham & Peckham and *Agorius* Thorell (Salticidae) and two species of *Corinnomma* Karsch (Corinnidae) found in the canopy of the same trees. It is hard to imagine that any of these ants serves as model for *Depreissia* as well. The general habitus is completely different from that in the mentioned ant-mimicking genera. The



Figures 15–16. Possible hymenopteran models for *Depreissia decipiens* mimicry **15** snap jaw ant (*Odontomachus*) **16** social wasps (Polistinae). Photo credits Paul Zborowski (close-up-photolibrary.com).

division of the cephalothorax into distinct head and thorax regions is prominent in typical ant-mimicking salticids and corinnids; the cephalothorax of *Depreissia* lacks any such division. Characteristic of *Depreissia decipiens* is the very long pedicel. Some snap-jaw ants of the ponarine genus *Odontomachus* Latreille (Fig. 15) have a habitus that could be compared to *Depreissia*, but ants of that genus are barely present in the canopy at Poring (Brühl et al. 1998: fig. 1, p. 289). Ants with long waist are supposed to be mimicked by several *Myrmarachne* species with long pedicel present in the canopy.

Some spiders of the family Corinnidae (*Aetius* O. Pickard-Cambridge, *Coenoptychus* Simon) are known to mimic other hymenopterans, such as mutillid wasps (Karsch

1892, Majumder and Tikader 1991). The elongate head borne horizontally with a conspicuous gap with the pronotum distinguishes all kind of ants from wasps; the latter rather have smaller heads tucked in vertical position underneath the pronotum, producing a better imitation of a spider cephalothorax.

Wasps with long thin pedicel are found in several subfamilies of Vespidae, such as Stenogastrinae and Polistinae. Two genera of paper wasps (Fig. 16), *Belonogaster* Saussure and *Ropalida* Guérin-Méneville, have a habitus similar to *Depreissia*. These genera are widespread in tropical Africa, Madagascar and tropical Asia. Similar wasps have been frequently observed by us in Sabah forests. They have not yet been analysed taxonomically. They are known to build colonial nests among leafy branches.

In mimicry complexes, behaviour of the mimic often reinforces and enhances the efficacy of morphological adaptation. So some clues to the mimicry model may be manifested only as activity of the live animal. For example, mimicry may be actively enhanced by emitting scent, airborne vibrations, or behaviour such as gait and movement of the first legs. Ant-mimicking spiders often hold the first or second leg-pair lifted and stretched forward to mimic antennae. The castianeirine spider *Pranburia mahannopi* Deeleman-Reinhold, 1992 is unique as an ant-mimic, having thick brushes on the first femora; only when disturbed, it joins its first legs in front of the head, creating a quite convincing ant's head with antennae (Deeleman-Reinhold 1993). Behaviour in *Depreissia* remains completely undocumented. It may well be that no human has ever observed one alive.

Distribution and species richness. The existence of two closely related species, sharing an array of unusual characters not seen in other salticids and living isolated on two different continents and habitats is difficult to understand. Both species are extremely rare. *Depreissia decipiens* is known only from two adult specimens from 128 fogged trees in a limited area, (Fig. 14), situated within a biodiversity hotspot (Mittermeier et al. 1998). Mt. Kinabalu is an easily accessible location that has been relatively well surveyed, but no specimens have been found from lower forest strata. Why is it so rare?

The genus *Depreissia* might be considered to be relict of an ancient fauna that has vanished from the large area in between. This is not supported by the estimated young age of the Kinabalu Mountain of 6 million years (Cottam et al. 2013, Merckx et al. 2015). Another possibility could be that speciation occurred after long-distance dispersal. A third explanation is that *Depreissia* is widespread, only the species is rarely found because of low abundance, cryptic life style or living in inaccessible niches within the canopy which would obscure them from the scientific world.

Depreissia decipiens was only found in the canopy. Searching through thousands of photographs posted online depicting *Myrmarachne* and other interesting ant-mimicking spiders and insects, we did not find any capturing *Depreissia*. Photographers do occasionally document rare spiders, such as the corinnid *Pranburia* Deeleman-Reinhold. But *Depreissia* remains unseen for both photographers and scientists. Does *D. decipiens* occur beyond the Mt. Kinabalu region? Are there still undiscovered *Depreissia* species in Asia? We shall have no answers without more arthropod surveys in tropical Asia that include sampling in primary forest canopy.

During a sampling course for students in a forest in Congo (Jocqué et al. 2013: 20), six collecting methods were compared. Canopy fogging was found to be the most productive of these sampling methods. This is also our experience: the fogging method produces larger amounts of material with longer series per species and fewer singletons than in hand-collected material.

Is *Depreissia* part of a fauna which is restricted to the canopy? In Sabah, fogging has provided a large volume of material from the canopy. Unfortunately comparing canopy fauna with that living in the lowest stratum is biased by lack of comparable sample data. Nevertheless, a few anecdotes are available to illustrate consistent differences between canopy spider community and that of spiders living in the understorey. The most convincing example of canopy-restricted spiders is provided by one very successful species of crab spider belonging to an unknown genus. In Poring Hot Springs this was one of the most dominant spiders in the canopy, it kept popping out in almost every tree sample in the primary forest in Kinabalu (but in none of the secondary forests sampled in Sabah), with a maximum of 300 individuals in 11 trees fogged in 1998, (the memorable year that Borneo and Sumatra were on fire). Most remarkable therefore is the single specimen collected by hand of this species in the primary forest at Danum Valley Field Centre, 160 km to the east (CD-R) in the crown of a freshly logged tree.

Certainly one of the best-studied spider genera for Borneo is *Myrmarachne*. Nearly 100 species have been recorded from Southeast Asia (World Spider Catalog 2015). Collectors including Takeshi Yamasaki, Peter Koomen, and others have hunted frequently in the Kinabalu region, focussing on *Myrmarachne*. All told, we recognize 29 species from lower strata in Sabah forests, nearly all from old primary and adjacent secondary forest in the Kinabalu area (Yamasaki and Ahmad 2013, Yamasaki 2010, 2012, Peter Koomen, personal communication). In our canopy samples, we distinguish 23 *Myrmarachne* species, 12 of which have also been found in lower strata.

There are indications from genital anatomy that 11 (43%) of the *Myrmarachne* species associated with the canopy in the Mt. Kinabalu area are taxonomically distinct and should be transferred to a new genus (Prószyński 2015a, 2015b). Of these, 5 are undescribed, often closely related to known species from the ground and are so far known from the canopy only.

Habitat preferences in what may be thought of as true *Myrmarachne* seems to contrast with those of prospective related genera, with true *Myrmarachne* species dominating lower forest strata and the prospective new genera dominating the canopy in primary rainforest in Poring and the Kinabalu mountain forest at 1500–2000 m a.s.l. In the secondary forest canopy in Kinabalu area (Sorinsim) the opposite is true and *Myrmarachne* species are dominant. This tendency may be determined by their models, the ants. Ant research carried out in Poring has found a clear stratification among ant tribes: myrmicines and ponerines dominate the forest floor, whereas formicines are most frequent in the canopy (Brühl et al. 1998: p.289, fig. 1). Any conclusion that distribution of myrmarachnine genera is reflected in that of the mimicked models may be unjustified, as key characters distinguishing myrmarachnine genera are mainly in genital organs, much less in somatic appearance.

How many spider species live in tree canopies in Sabah?

When assessing the identity of canopy spiders in tropical rainforests of Borneo, evidence turned up again and again that not only on the forest floor, but also in the canopy, species ranges are often small and endemism appears to be high; more endemism means higher regional species richness. Experiments in the Sabah canopy project (Floren et al. 2011) were involved with investigating effects of isolation in separated patches of forest. It became clear that a large part of primary forest spider species have a restricted dispersal ability, less than 10 km.

The canopy at the fogging sites in our project has an average height of 24 meter; this means that the volume of the canopy habitat is ten times that of the 2.5 meter understorey, in which traditionally most collecting and inventories of fauna are carried out. It is not surprising that the number of foliage-associated species collected by fogging is very much larger than in ground collecting. Furthermore, the physical conditions of life on shrub and small trees growing on the forest floor in the shadow of big trees are quite different and the species composition differs basically from that higher up towards the crown. The canopy conditions are somewhat similar to that in younger secondary forest. The species richness in the latter is very variable: when influx from adjacent old primary forest is possible it may be very high such as in the older forest at Sorinsim; in isolated secondary forest (Keningau) the species community is much poorer and dominated by versatile widespread species.

With 2/3 of the Sabah canopy material processed, we distinguish 749 morphospecies in 36 families. 173 of these species till now have been assigned to known species, some widespread or even cosmopolitan. Most rich in species are Theridiidae (177), Salticidae (144), Thomisidae (98) and Araneidae (87). Corinnidae, Salticidae, Oxyopidae, Theridiidae and Tetragnathidae are the most versatile and include the highest percentage of widespread species (Floren and Deeleman-Reinhold 2005).

Within the realm of spider taxonomy, Salticidae are an intensively studied group, especially in species-rich areas in the world's tropics (Prószyński 2012, 2015a, 2015b, Prószyński and Caleb 2015). Approximately 710 species in 160 genera are listed for Southeast Asia (excluding China and Pacific) (World Spider Catalog 2015); 127 species are specifically listed for Borneo. In the Sabah project, at present, 144 morphospecies of salticids are recognized in the canopy; as far as possible, of these, 28 species have been identified as described or otherwise registered species from the lower strata.

As we continue processing through the later material, species numbers rise steadily. We would like to mention that we examined two recently recovered additional tree samples from Poring from an under-collected season: one from an *Aporosa* tree contained 11 salticid species, three of which proved to be different from all previously registered species from the whole project. The other sample was from an *Aglaia* tree (Meliaceae) which contained 7 salticid species, two of which were new for the project. There was no overlap between the two trees.

In Thomisidae, 98 morphospecies are listed, including 19 known species, most recorded from various parts in S and SE Asia, sometimes widespread, many described by

the end of the 19th century and not or barely mentioned afterwards. For example, one single, quite distinctive species (*Thomisus perspicillatus* Thorell, 1890) from Sarawak has not been cited since its discovery.

In Clubionidae, 30 species were found in the canopy, only three were found in a wider area, up to Sumatra and probably the Philippines. The number shared with the ricelands in the Philippines (Barrion and Litsinger 1995) is difficult to assess: many species were described, most from one sex only, and with drawings showing minor differences in genitalia. It is worth mentioning here that CD-R examined the Clubionidae from a canopy fogging project in Papua New Guinea (spiders kept in KBIN, Brussels). 84 trees in a one km^2 area in Baitete forest were fogged in 1993–1995, containing 38 clubionid species (maximum of 13 species in one tree) in a more diverse array of genera than in Sabah. Only one widespread species (*Pteroneta saltans* Deeleman-Reinhold, 2001) proved to be in common with the canopy fauna in Sabah (Versteirt et al. 2008, Versteirt et al. 2010). In Castianeirinae, 13 morphospecies have been identified, seven of which are widespread in SE Asia. Tetragnathidae are represented with 17 species, nine of which are well-known and widespread.

According to the Spider Catalog, 155 species of Theridiidae have been recorded for the Malay region, 14 for Borneo (World Spider Catalog 2015). In Kinabalu and Keningau (isolated disturbed lowland forest near Crocker Range) alone we recorded 177 species. Just some examples of genera that we have studied recently: *Molione* Thorell was one of the many dominant genera in the canopy with several hundreds of specimens in nine species. Two species (*M. christae* Yoshida, 2003 and *M. kinabalu* Yoshida, 2003) were found only in their type locality in primary and adjacent secondary forest respectively. *Molione uniacantha* Wunderlich, 1995 is widespread in Malaysia and Borneo; in the canopy it was found only at one site in the Crocker Range, where it was abundant. A species resembling *M. lemboda* Gao & Li, 2010 was found in a fruit plantation in Crocker Range. Most of 5 remaining species were singletons or rare.

The theridiid genus *Borneoridion* Deeleman and Wunderlich brought a surprise. This genus belongs to an aberrant lineage within the Theridiidae and was described recently for a single species found in the canopy of Keningau (Crocker Range lowland) (Deeleman and Wunderlich 2011). In this genus we found a consistent tendency to endemism. In four different forest sites we encountered six more new species, each with clearly distinct genitals in an array of similar somatic characters. No specimens of this genus have at present been found in the understorey.

When scrutinizing the various families in the project, several more poorly known genera emerged that show strong tendency to geographic speciation. One of them is the genus *Gephyrota* (Philodromidae). In this genus, 4 species are known from South and Southeast Asia (two species from juveniles only), all described by Simon before 1910; no records have been published since (World Spider Catalog 2015). In Borneo, we found five new species in the canopy in five different forests, each locality with its own species.

In Araneidae, we found a group of approximately five distinct species (30 adult specimens), possibly near *Chorizopes* O. Pickard-Cambridge, characterized as small (<3 mm) spiders with a cylindrical, strongly ridged warty abdomen that resembles a

tree bud; we found them exclusively in the Kinabalu area and as far as we can ascertain are undocumented in literature.

These examples are representative of many similar cases that have emerged from years of study on the biodiversity of Southeast Asian spiders. High regional diversity is the product of high species richness within locations combined with short-range endemism of many of those species. One lesson from this investigation into the tropical rainforest arthropod community comes through incontrovertibly: the number and variety of life forms, and of their interactions in the tropical forest canopy seems to have no end, and we still know only a fraction so far. Decades after the introduction of fogging as a method for accessing the forest canopy fauna (Erwin 1983), this community remains a scarcely explored frontier of discovery.

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RESEARCH ARTICLE

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Revision of the family Carabodidae (Acari, Oribatida) V. Fourth part. Two new species of the genus *Congocepheus* from the Republic of Rwanda: *Congocepheus rwandensis* sp. n., and *Congocepheus kayoveae* sp. n.

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Abstract

Two new species from Rwanda are described utilizing optical and scanning electron microscope observations: *Congocepheus rwandensis* **sp. n.** and *Congocepheus kayoveae* **sp. n**. are compared to *Congocepheus taurus* Balogh 1961.

Keywords

Congocepheus rwandensis sp. n., *Congocepheus kayoveae* sp. n., Rwanda, comparison

Introduction

Several species of the genus *Congocepheus* have recently been redescribed, namely *Co. heterotrichus* Balogh, 1958, *Co. orientalis* Mahunka, 1987, *Co. hauseri* Mahunka, 1989 (Fernandez et al. 2013c) and *Co. involutus* Mahunka, 1997, with descriptions of new species *Co. gabonensis* Fernandez et al., 2013, *Co. ektactesi* Fernandez et al., 2013 and *Co. germanicus* Fernandez et al., 2014a. A redefinition of *Congocepheus* was given, and the new genus *Cavaecarabodes*, related to *Congocepheus*, was defined and two new species described: *Ca. pulchritude* Fernandez et al., 2014a, and *Ca. anouchkae* Fernandez et al., 2014a.

Cavaecarabodes includes some species previously considered members of the genus *Congocepheus*. Type specimens of *Co. ornatus* Mahunka, 1983, *Co. latilamellatus* Mahunka, 1984 and *Co. velatus* Mahunka, 1986 were studied to establish their position in *Congocepheus*, and at the same time large collections of material were obtained from Rwanda, Zimbabwe, Kenya, Cameroon, the Republic of the Congo, Côte d'Ivoire and Thailand, which are housed at the Natural History Museum of Geneva (NHMG); and from Antilles, Namibia, the Democratic Republic of the Congo, Central African Republic, Tanzania, Ethiopia, Angola, Sudan and South Africa, from the Museum National d'Histoire Naturelle in Paris, France (MNHN). From this material numerous specimens of *Congocepheus* and related genera have been identified. A decision was made to continue with the series of studies of *Congocepheus*, including a number of very interesting new species related to *Co. ornatus*, *Co. latilamellatus* and *Co. velatus*.

In this paper, two new species from Rwanda are described, making use of optical microscopy and SEM. Valuable information was obtained from SEM studies, which would be extremely difficult to obtain with optical microscopy alone.

Material and methods

Specimens studied by means of light microscopy were macerated in lactic acid and observed in the same medium using the open-mount technique (cavity slide and cover slip) as described by Grandjean (1949) and Krantz and Walter (2009). Drawings were made using a Zeizz GFL (West Germany) compound microscope equipped with a drawing tube.

Specimens were also studied by means of scanning electron microscope (SEM). Specimens preserved in ethanol were carefully rinsed by sucking them several times into a Pasteur pipette, after which they were transferred to buffered glutaraldehyde (2.5%) in Sörensen phosphate buffer: pH 7.4; 0.1 m for two hours. After postfixation for 2 hours in buffered 2% OsO4 solution and being rinsed in buffer solution; all specimens were dehydrated in a series of graded ethanol and dried in a critical point apparatus. After mounting on Aluminium-stubs with double sided sticky tape, specimens were gold coated in a sputter apparatus (Alberti and Fernandez 1988, 1990a, 1990b; Alberti et al. 1991, 1997, 2007; Fernandez et al. 1991). SEM observations

were made using a FEI-Quanta Feg 250; with 10 Kv and working distance (WD) variable. Measurements taken: total length (tip of rostrum to posterior edge of notogaster); width (widest part of notogaster) in micrometres (μm).

Leg chaetotaxy studies using standard, polarized and phase contrast microscopes are provisional, due to the fact that only adult specimens were available. Setal formulae of the legs include the number of solenidia (in parentheses); tarsal setal formulae include the famulus (ε).

Morphological terminology and abbreviations

Morphological terms and abbreviations used are those developed by F. Grandjean (1928–1974) (cf. Travé and Vachon 1975; Norton & Behan-Pelletier (in Krantz and Walter 2009); Fernandez et al. 2013; 2013c; 2014). For setal types Evans 1992: 73; and for ornamentation of cuticular surfaces Murley 1951(in Evans *op.cit*: 9) were used.

New taxa descriptions

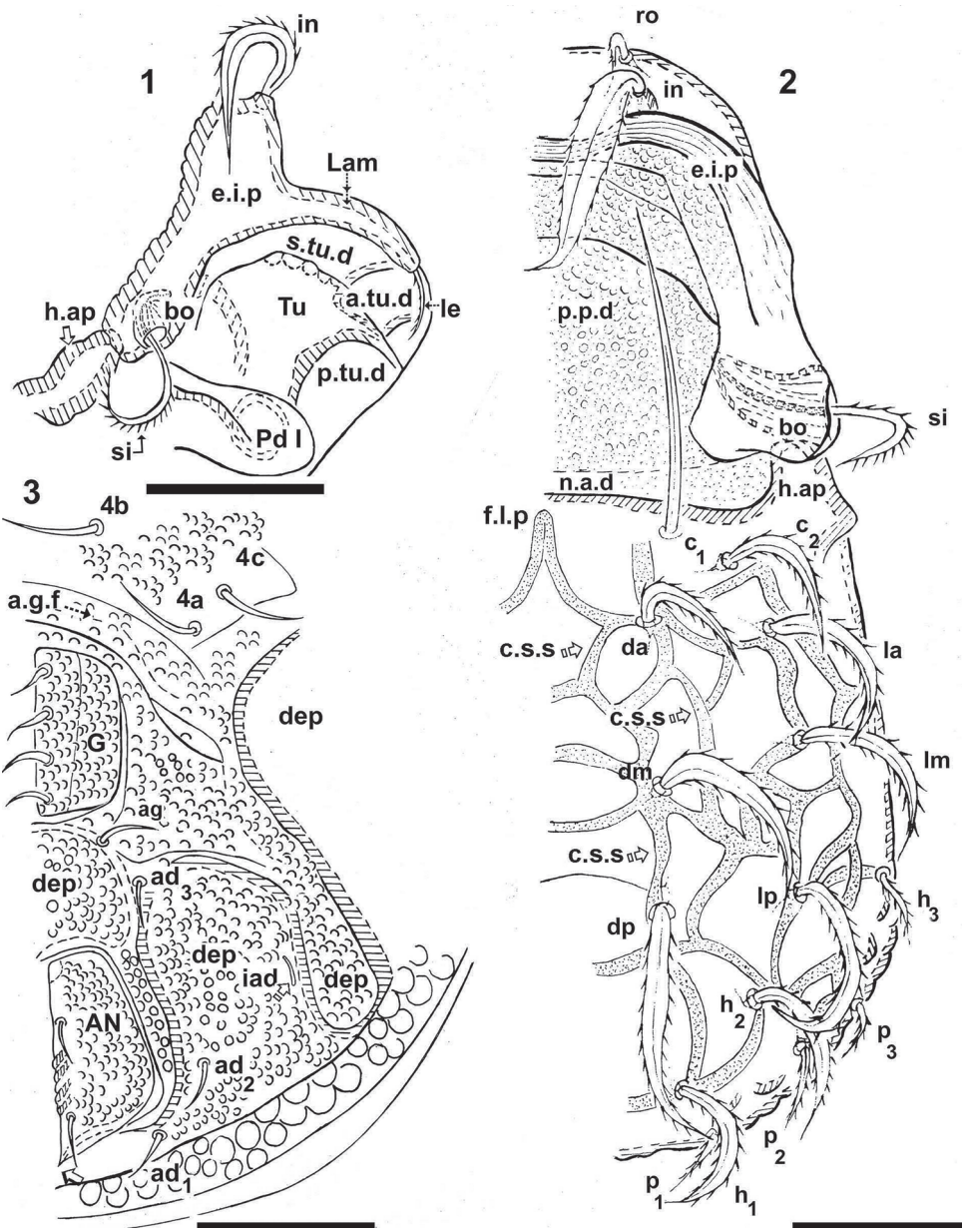
***Congocepheus rwandensis* sp. n.**
http://zoobank.org/6675DD70-7300-426B-A766-0141BFE4C766
Figures 1–18, Table 1

Etymology. The specific epithet is derived from Rwanda, country of origin of the type material.

Material examined. Holotype: Female. "73/2. Kayove-Rwanda; 2100 mts. 15/V/1973" Leg. P.Werner; material deposited in the Collection of the Natural History Museum of Geneva (MHNG), Switzerland; preserved in 70% ethanol.

Paratype: two adult females, same locality and date as Holotype; deposited in Collection of MHNG; preserved in 70 % ethanol. Material studied for SEM: three specimens, not deposited.

Diagnosis adult female. Integumental microsculpture: prodorsal, notogastral and ventral zones smooth to slightly irregularly tuberculate; notogaster with irregular cord-shaped structures and short, fingerlike projection. Setation: with medial dentate vein: rostral setae small; interlamellar setae large, directing backward; lamellar: wide, short with central dentate vein; notogastral, epimeral, genital, aggenital, anal and adanal setae: simple. Prodorsum: wide elevated interlamellar process; *in* setae anteriorly on elevated zone; sensillus: cylindrical, short barbs. Bothridial ring, bothridial tooth present, smooth. Large posterior prodorsal depression. Notogaster: small notogastral anterior depression; fourteen pairs of setae. Lateral zone: tutorium: large lamina, small relative to pedotectum I. Ventral region: epimera slightly elevated; 3-4 fused; epimeral chaetotaxy 3-1-3-3; discidum clearly discernible; anterior genital furrow clearly visible; four pairs of genital setae in a unique line; aggenital setae inserted posterior to genital



Figures 1–3. *Congocepheus rwandensis* sp. n. Adult female, optical observations. **1** prodorsal zone, anterolateral view **2** partial ventral view **3** dorsal view. Abbreviations: see "Material and methods". Scale bars: (**1, 3**) 100 μm; (**2**) 85 μm.

opening. Three pairs of adanal seta; ad_3 near aggenital setae; anal plate polyhedral, sharply tipped; two pairs of anal setae; lyrifissures *iad* between ad_3 and ad_2; conspicuous depressions situated laterally to genital and anal openings.

Description. ***Measurements***. SEM: 475 μm (473–477) × 225 μm (223–227) (measurements on three specimens). Light microscopy: 476 μm (473–478) × 227 μm (228–227) (measurements on three specimens).

Shape. Elongate oval (Figures 4, 7).

Colour. Specimens without cerotegument, light brown to yellowish-brown when observed in reflected light.

Cerotegument. Present on: prodorsum, notogaster, ventral region. Consistently granulated to amorphous layer covering body (1.5–3.0 μm), with adhering soil particles, impeding observation of cuticular ornamentations; on legs thin layer (less than 1 μm) (Figures 4, 6, 7).

Absent on: lamellar lateral border (*Lam*), bothridial ring (*bo.ri*), humeral apophysis (*h.ap*) and bothridium (*bo*) (Figures 5, 7, 8).

Sometimes absent: ventral depression (*dep*) behind leg IV and notogastral zone between *s.c* and notogastral edge (Figure 7).

Integument. Microsculpture: *smooth* to *slightly irregular tuberculate* (Figures 2, 3, 5, 11): prodorsal, notogastral and ventral zones. Lateral zone of notogaster presenting slightly larger tubercles. Fingerlike projection (*f.l.p*) clearly visible on central notogastral zone (Figures 2, 11).

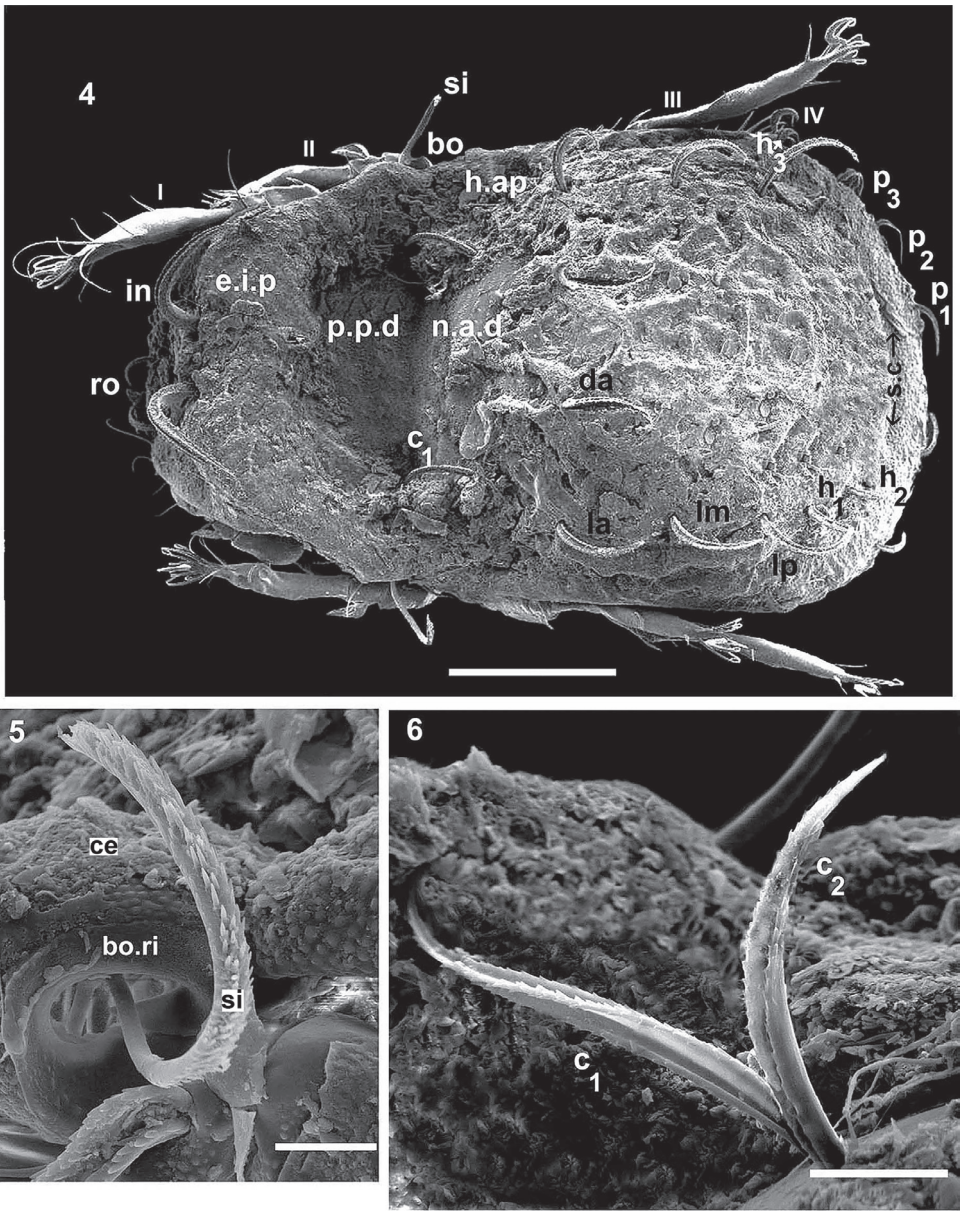
On central notogastral zone, network of irregular cord-shaped structures (*c.s.s*) (indicated byX, Figure 2) extending to setal insertion zone, *c.s.s* terminating in fingerlike projection (*f.l.p*) on anterior notogastral zone.

Setation. SEM-observations were necessary in order to determine setal shapes. Notogastral and prodorsal setae (*ro*, *in*) (Figures 1, 2, 6, 10, 11, 12, 13, 14) with elevated medial vein and dentitions; lateral setal margin dentate (Figure 10); *ro* setae small (Figures 11, 12); *in* large directing backwards (Figures 1, 4). In many cases the setae are twisted, immensely complicating observation; the presence of small particles adhering to setal surfaces, further obscuring observation.

Wide, short *le* setae (Figure 9) with central vein and dentitions. Notogastral setae with medial dentate veins and dentate margin (Figures 10, 14 central vein indicated by X). Epimeral, genital, aggenital, anal and adanal setae simple, sharply tipped (Figure 3).

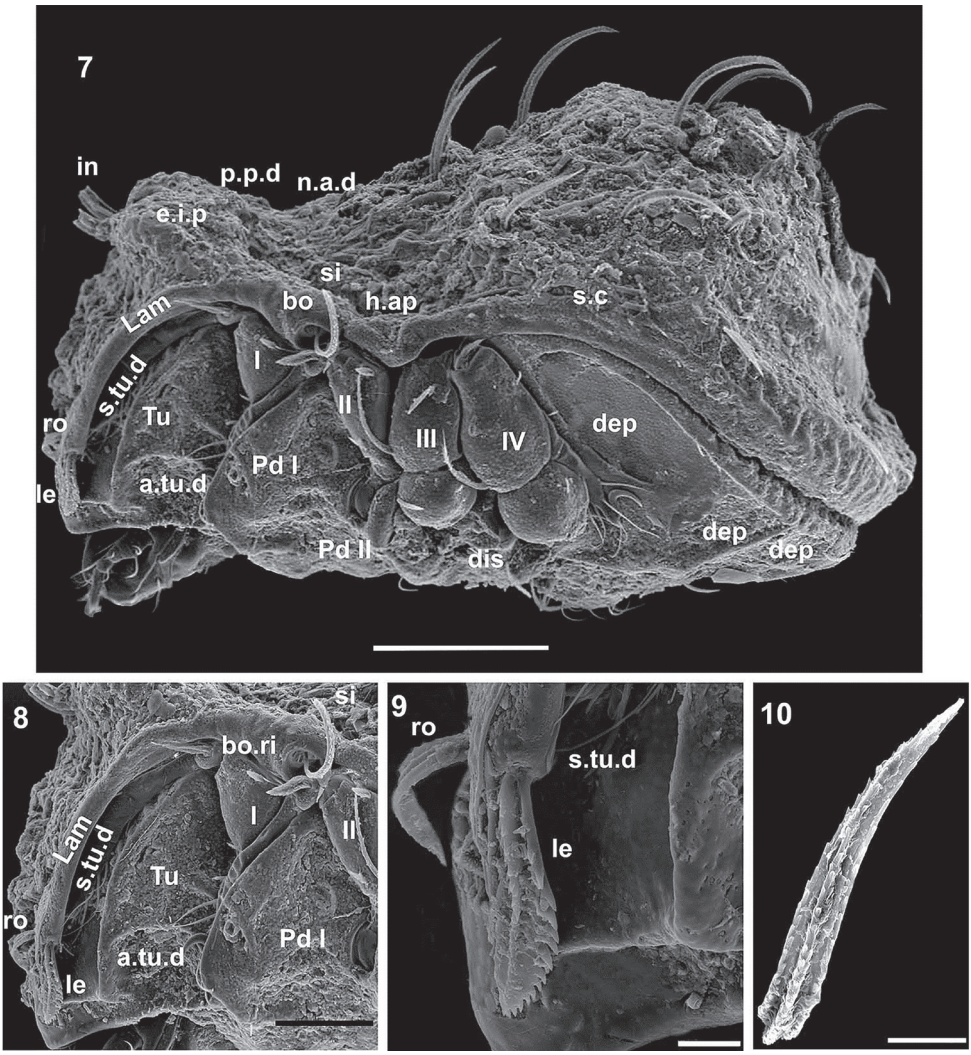
Prodorsum. Polyhedral (dorsal view) (Figure 2, 4); convex polyhedral in lateral view (Figures 1, 7); triangular in frontal view (Figure 11). Elevated wide interlamellar process (*e.i.p*) (Figures 1, 4, 7, 11); *e.i.p* complete, with small depression in medial zone. Anteriorly situated setae *in* on elevated zone of *e.i.p*; *in* setae large (70 ± 5 μm), initially directing forward but tips curving backward; *in* setae inserted antiaxially to medial plane and slightly internally to *ro* insertion level (Figures 1, 2, 11, 13). Clearly visible *ro* setae, length 33 ± 3 μm, curving towards medial zone, apical tips adjacent to each other (Figures 9, 11, 12); *le* setae lateral, length 26 ± 3 μm and 12 ± 3 μm in the wider zone (Figure 9); *ro* setal insertion at level of *le* setal insertion.

Sensillus (*si*) cylindrical with short barbs (Figure 5). Bothridial ring (*bo.ri*) smooth, well defined, with bothridial tooth (Figure 5). Posterior prodorsal depressed zone (*p.p.d*) conspicuous, with notogastral anterior depression (*n.a.d*) (Figures 2, 4, 7) delimiting a large depressed area. Rostral margin slightly rounded to hexagonal (Figure 11). Lamellae lateral; lamellar tip not observed, shallow lamellar furrow not discernible.



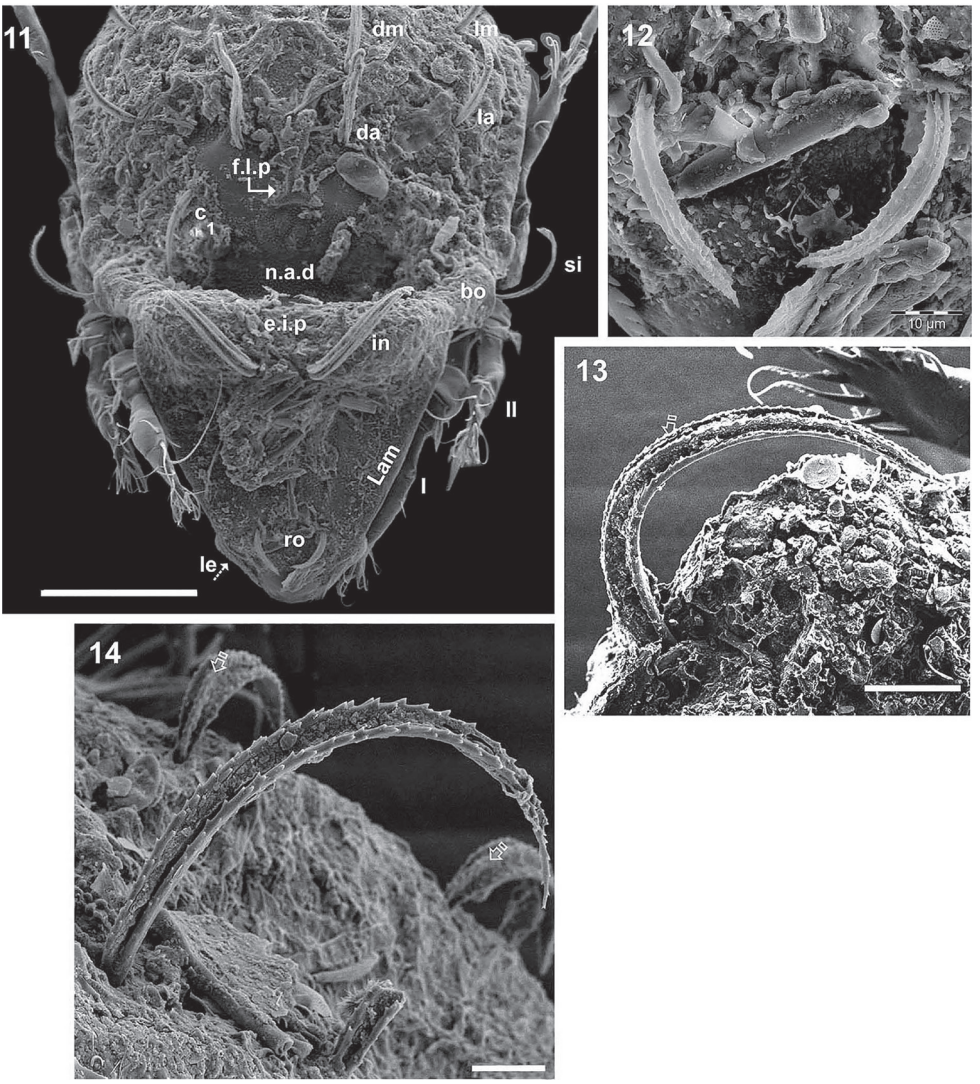
Figures 4–6. *Congocepheus rwandensis* sp. n. Adult female, SEM. **4** dorsal view **5** lateral view of bothridial ring and sensillus **6** lateral view c_1, c_2 setae. Abbreviations: see "Material and methods". Scale bars: (**4**) 100 μm; (**5**) 10 μm; (**6**) 20 μm.

Notogaster. Shape: in dorsal view anterior rectangular, in posterior view oval (Figure 2, 4); in lateral view anterior clearly depressed and rest convex (Figure 7); *d.sj* narrow, slightly rectilinear, well delimited; notogastral anterior depression (*n.a.d*) small (Figures 2, 4).



Figures 7–10. *Congocepheus rwandensis* sp. n. Adult female, SEM. **7** lateral view, without c_1, c_2 setae **8** anterior lateral zone **9** lamellar setae **10** notogastral setae**.** Abbreviations: see "Material and methods". Scale bars: (**7**) 100 μm; (**8**) 50 μm; (**9, 10**) 10 μm.

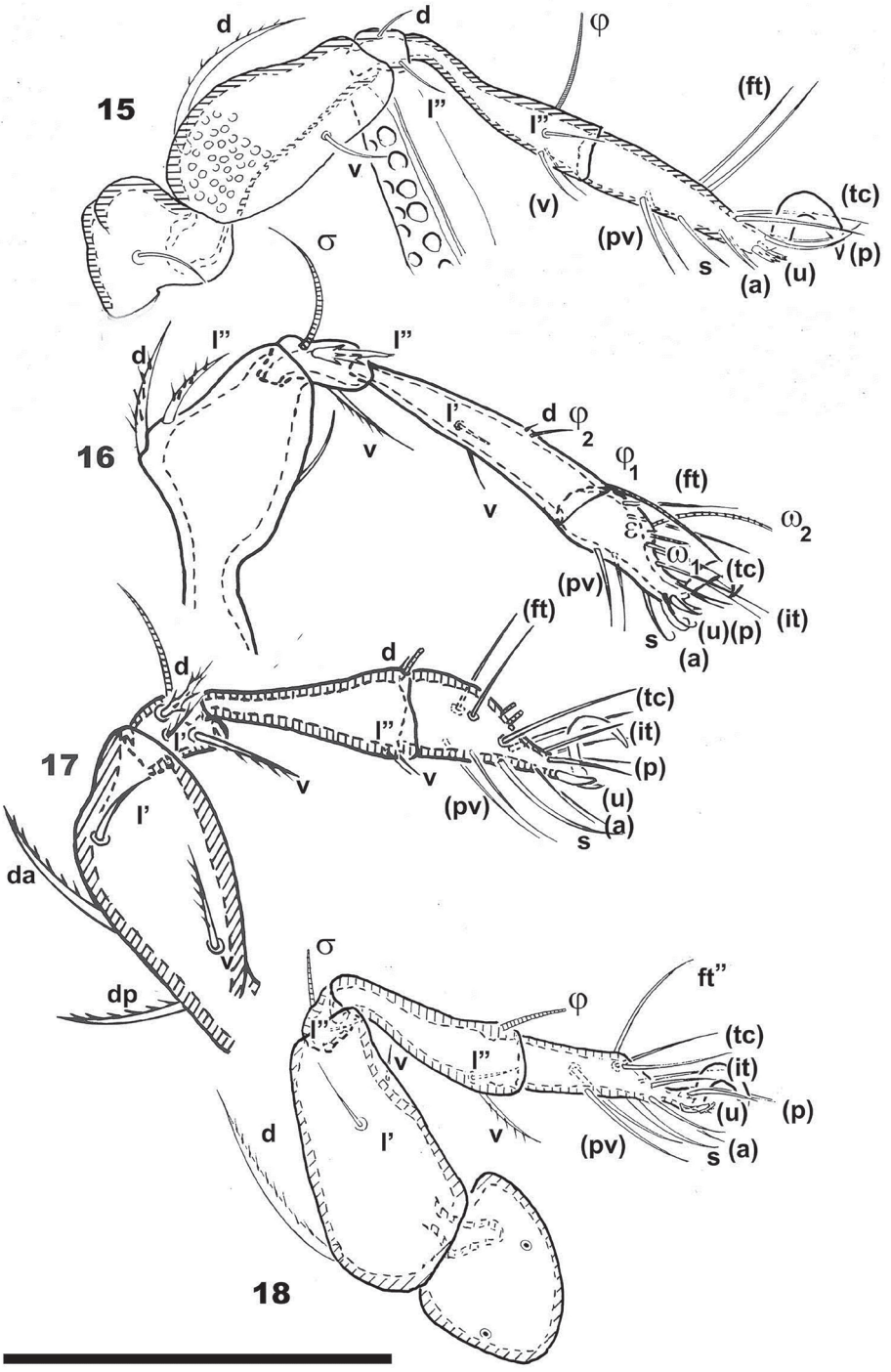
Fourteen pairs of setae: c_1, c_2, *da*, *dm*, *dp*, *la*, *lm*, *lp*, h_1, h_2, h_3, p_1, p_2, p_3; c_1 setae directing forward (Figures 2, 6), other setae directing backward (Figures 2, 4, 7), c_1 largest; h_3, p_1, p_2, p_3 smaller; c_2, *da*, *dm*, *dp*, *la*, *lm*, *la*, h_1, h_2 more or less equal in length. Series of irregular *c.s.s* in central zone converging to form a short *f.l.p* (Figure 2). Circumgastric depression (*s.c*) situated in front of p_1, p_2, p_3, h_3 setae (Figure 4) clearly visible in posterior notogastral area). Humeral apophysis (*h.ap*) very long, clearly visible as large elongate projection resulting in characteristic shape of anterior notogastral zone (Figure 4).



Figures 11–14. *Congocepheus rwandensis* sp. n. Adult female, SEM. **11** frontal view **12** rostral setae **13** interamellar setae **14** notogastral setae. Abbreviations: see "Material and methods". Scale bars: (**11**) 100 µm; (**12, 14**) 10 µm; (13) 20 µm.

Lateral region (Figure 7). Lamellae (*lam*) well discernible, more or less truncate; cuticular surface of lamellar zone smooth, always without cerotegumental layer. Tutorium (*tu*) a prominent curving lamina, margin clearly discernible, smooth cuticula.

Deep supra tutorial depression (*s.tu.d*) running between and parallel to lamellae and tutorium; large pocket depression (*a.tu.d*) anteriorly. Pedotectum I, large extended lamina, covering acetabulum I, rounded apex. Pedotectum II, small ovoid lamina; discidium (*dis*) well discernible, small, triangular, rounded apex.



Figures 15–18. *Congocepheus rwandensis* sp. n. Adult female, optical observations. **15** leg IV, antiaxial **16** leg I, antiaxial **17** leg II, antiaxial **18** leg III, antiaxial. Abbreviations: see "Material and methods". Scale bar: (**15–18**) 130 μm.

Table 1. *Congocepheus rwandensis* sp. n. setae and solenidia.

Leg I	Femur	Genu	Tibia	Tarsus	Claw
setae	*d,l",v*	*l",v*	*v,l',d*	(*ft*),ε,(*tc*),(*it*),(*p*), (*u*),(*a*),*s*,(*pv*)	1
solenidia		σ	φ1, φ2	ω 1, ω 2	
Leg II					
setae	*dp,da,l,v*	*d,l',v*	*v,d,l"*	(*pv*),*s*,(*a*),(*u*),(*p*), (*it*),(*tc*),(*ft*)	1
solenidia		*σ*	*φ*	ω 1, ω 2	
Leg III					
setae	*d,l',v*	*l"*	*l",v*	(*pv*),*s*,(*a*),(*u*),(*p*), (*it*),(*tc*),*ft"*	1
solenidia		σ	φ	-	
Leg IV					
setae	*d,v*	*d,l"*	*l"*(*v*)	(*pv*),*s*,(*a*),(*u*),(*p*), (*tc*),(*ft*)	1
solenidia		-	φ	-	

Bothridia cup-shaped; bothridial opening directing downward (Figures 5, 7); smooth bothridial ring (*bo.ri*) wider in inferior zone, *bo.ri* incomplete with bothridial tooth, clearly discernible. Sensilllus cylindrical with barbs arching toward the tip (Figures 5, 7). Humeral apophysis (*h.ap*): elongate extended structure, rounded apex, basally curved; anterior tip overlapping posterior bothridial part. Clearly visible large depression (*dep*) behind leg IV; two other *dep* present in lateral and posterior anal zones.

Ventral region (Figure 3). Epimera slightly elevated, delimited by a narrow but deep furrow (*bo.1*, *bo.2*, *bo.sj*). Epimera 4 fused, epimeral furrow (*bo.3*) narrow; *apo.1*, *apo.2*, *apo.sj* and *apo.3* well discernible.

Epimeral chaetotaxy 3-1-3-3. Discidum easily discernible; anterior genital furrow (*a.g.f*) clearly visible, situated in front of genital plate. Large genital plate; four pairs of genital setae, simple linear arrangement; all setae more or less equal in length; aggenital setae (*ag*) situated posteriorly to genital opening. Three pairs of adanal seta; ad_3 close to *ag* setae. Anal plate polyhedral, sharply tipped. Two pairs of anal setae. Lyrifissures *iad* well discernible, situated laterally between ad_3 and ad_2. Depressions (*dep*) clearly visible, situated laterally to genital and anal openings.

Legs (Figures 9–12). All legs monodactyle. Setal formulae I (1-3-2-3-16-1) (1-2-2); II (1-4-3-3-15-1) (1-1-2); III (2-3-1-2-14-1) (1-1-0); IV (1-2-2-3-13-1) (0-1-0). See Table 1.

Remarks. The cerotegumental layer impedes clear observation of *c.s.s* and *f.l.p*. Observation of notogastral setae was complicated due their length and the fact that they are twisted. Residues adhering to setal surfaces further hampered clear observation.

Congocepheus kayoveae sp. n.

http://zoobank.org/BFD45F16-4D42-4684-81C2-17A3D5F723C7
Figures 19–47; Table 2

Etymology. The specific epithet is derived from Kayove, Rwanda, where the type material was collected.

Material examined. Holotype Female. "73/2. Kayove- Rwanda; 2100 mts. 15/V/1973" Leg. P.Werner; material deposited in the Collection of the Natural History Museum of Geneva (MHNG), Switzerland; preserved in 70% ethanol. Four adult female paratypes, same locality and date as holotype; deposited in Collection of MHNG; preserved in 70 % ethanol. Material studied by SEM: six specimens, not deposited.

Diagnosis adult female. Integumental microsculpture: notogaster with irregular cord-shaped structures and elongate fingerlike projection.

Setation: *simple*: epimeral, genital, aggenital, anal, adanal, subcapitular; *one central dentate vein, margin dentate*: notogastral; *two dentate veins, margin dentate*: rostral, interlamellar; *flat setae, margin dentate, central dentate vein*: lamellar.

Prodorsum: elevated interlamellar process complete; margin of laterodorsal lamellae slightly elevated. Prominent triangular lamellar tip, lamellar setae situated externally; shallow lamellar furrow terminating near internal limit of lamellar tip. Tutorium spoon-shaped, larger than Pedotectum I. Rostrum: rounded undulate margin, wide, large, projecting forward. Epimera elevated, delimited by deep furrow; deep hollow paraxially to epimere 1; epimeres 3 and 4 unfused. Epimeral chaetotaxy 3-1-3-3. Genital plate rounded; four or five pairs of genital setae; aggenital setae posterior to genital opening, far from ad_3.

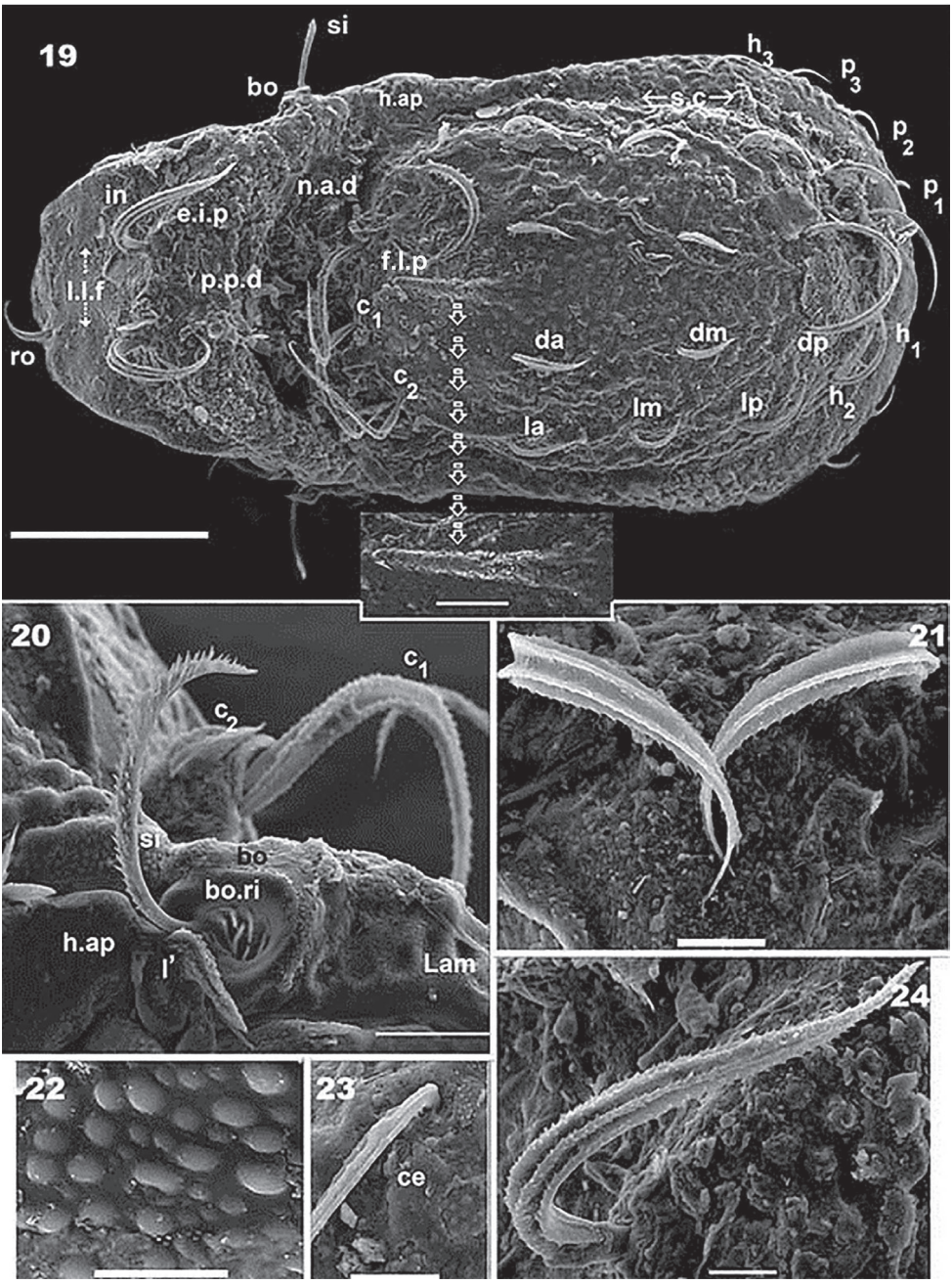
Description. ***Measurements.*** SEM: 464 μm (462–467) × 173 μm (172–180) (measurements on six specimens). Light microscopy: 467 μm (465–468) × 175 μm (173–183) (measurements on five specimens).

Shape. Elongate oval (Figure 19). ***Colour.*** Specimens without cerotegument; light brown to yellowish-brown when observed in reflected light.

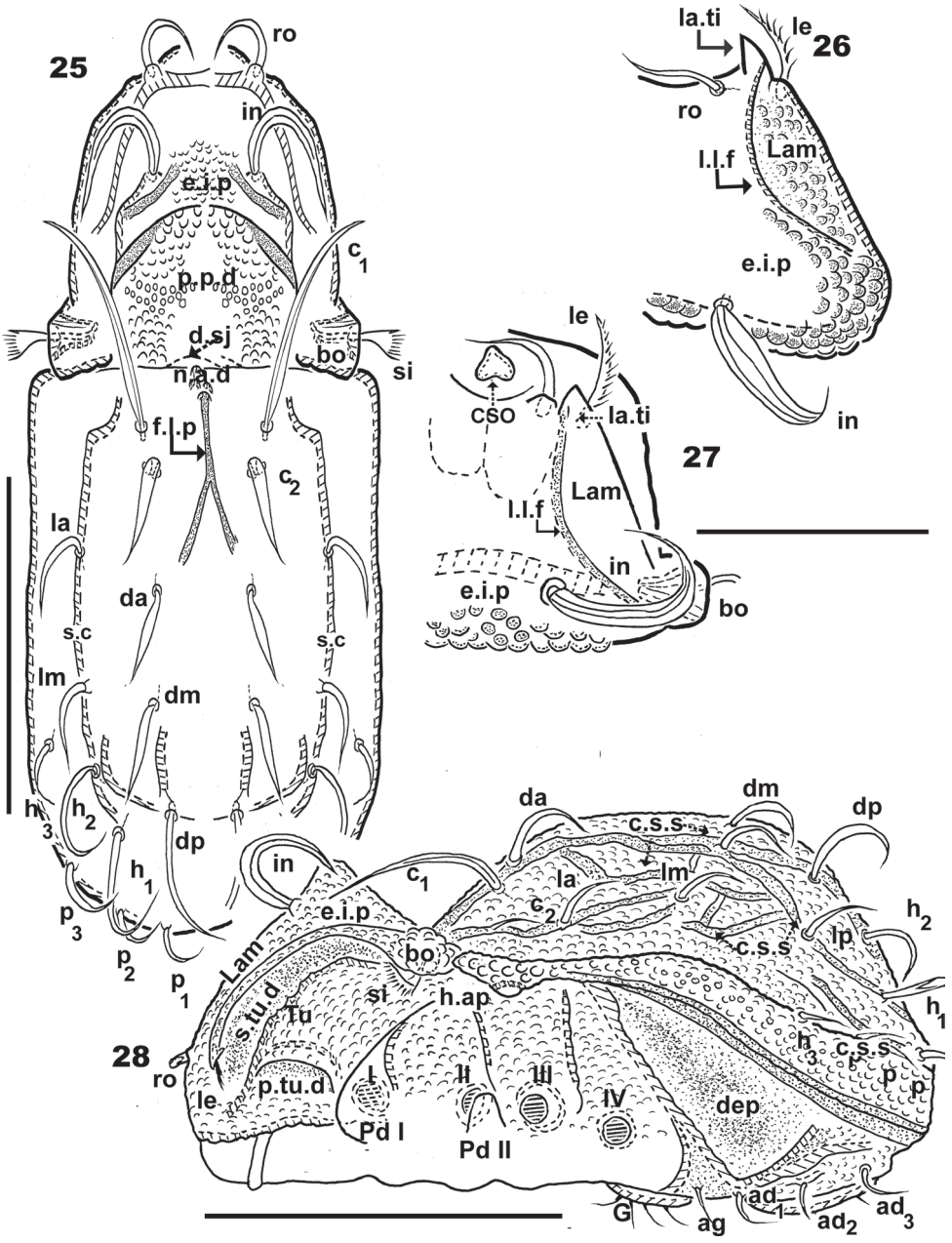
Cerotegument. Present: thin amorphous layer (0,3–0,5 μm) on prodorsum, notogaster, ventral region; with adhering soil particles principally on *e.i.p* and central notogastral zone (Figures 19, 21, 22, 23, 24). Observation of cuticular ornamentation not impeded by cerotegumental layer (Figures 20, 22, 29, 31). Absent: bothridial ring (*bo.ri*) (Figure 20).

Integument. *Pusticulate* (Figure 22): prodorsum: *e.i.p* posterior zone, lamellar margin and bothridial zone; central notogastral zone and humeral apophysis (Figures 19, 20, 29); legs: femurs (Figure 38). Smooth to granulate: prodorsum: anterior *e.i.p* (Figure 19); notogaster: *s.c*, *b.ng* zone (Figure 29); lateral zone: *Tu*, *s.tu.d*, *Pd I*, *Pd II*. Ventral zone: subcapitulum, epimeral, genital, anal and *dep* (Figures 29, 30, 31, 34, 39, 40, 41, 42). Series of irregular *c.s.s.* on notogastral zone, forming central elongate *f.l.p* (Figures 25, 28) (described in detail under notogaster), well visible without cerotegumental layer.

Setation. *Simple*: epimeral (Figures 39, 43), genital (Figures 40, 42), aggenital (Figure 42), anal, adanal (Figure 41), subcapitular (Figure 34) and seta of genu, tibia and tarse of legs. *One central dentate vein and dentate margin*: notogastral (Figures 32, 37); two types of notogastral setae: large c_1, c_2, *dp*, h_1 with upward directing dentate margin (Figure 37); small *da*, *dm*, *la*, *lm*, *lp*, h_2, h_3, p_1, p_2, p_3, dentate margin not directing upward (Figure 32). *Two dentate veins and dentate margin* (Figures 21, 24), *ro* (Figure 21), *in* setae (Figure 24). *Flat setae, dentate margin with central dentate vein*: *le*



Figures 19–24. *Congocepheus kayoveae* sp. n. Adult female, SEM. **19** dorsal view, with detail of fingerlike projection (*f.l.p*) **20** lateral view, bothridium, sensillus and humeral apophysis **21** rostral setae **22** cuticular microsculpture **23** cerotegumental layer and cuticular microsculpture **24** interlamellar setae. Abbreviations: see "Material and methods". Scale bars: (**19**) 100 μm (detail of *f.l.p* = 20 μm); (**20**) 20 μm; (**21, 23, 24**) 10 μm; (**22**) 5 μm.



Figures 25–28. *Congocepheus kayoveae* sp. n. Adult female, optical observations. **25** dorsal view **26** prodorsum, frontal inclined view **27** prodorsum, dorsal inclined view **28** lateral view. Abbreviations: see "Material and methods". Scale bars: (**25, 28**) 220 μm; (**26, 27**) 80 μm.

setae (Figure 36), superior margin presenting few teeth; numerous large teeth on inferior margin. *Barbate, with central dentition*: large femoral setae (legs I-IV) (Figure 38).

Prodorsum. Polyhedral (dorsal view) (Figure 19); slightly convex polyhedral in lateral view (Figure 29); triangular in frontal view (Figure 35). Elevated interlamellar process (*e.i.p.*) almost flat in dorsal view (Figures 19, 25); large surface between *p.p.d* and *in* setae insertion zone (Figures 19, 29, 35), flat in frontal view (Figure 35) (see Remarks); *in* setae (Figure 24) large (82 μm ± 5), curving, directing backward (Figures 19, 29, 30, 31, 35), setae inserted anteriorly on *e.i.p.* (Figures 29, 30, 31) at same longitudinal level as *ro* insertion (Figure 35); *ro* setae (Figure 21) length (38 μm ±3 μm), directing forward and paraxially (Figures 29, 30), curving downward (Figures 29, 36) with criss-crossing tips (Figures 21, 30, 35); *le* setae lateral (Figures 29, 35, 36), length (58 μm ± 3), wider zone (10 μm ± 2); *ro* and *le* setal insertion at same level.

Sensillus (*si*) (Figure 20) (66 μm ± 3) uncinate, curving upward (Figures 29, 30, 31, 35). Bothridial ring (*bo.ri*) smooth, well defined, with bothridial tooth (Figure 20).

Rostral margin slightly rounded, margin undulate (Figure 30 indicated byJ; 35 indicated by Y).

Lamellae running dorsolaterally (Figures 26, 27); semicircular shallow lamellar furrow (*l.l.f*) originating on bothridial zone and terminating near lamellar tip (*la.ti*), clearly discernible when cerotegumental layer absent (Figures 26, 27). Posterior prodorsal depressed zone (*p.p.d*) large, normal (Figures 19, 25).

Notogaster. Ovoid in dorsal view, with slight constriction at level of *da*, *la* setae (Figure 19); in lateral view zone anterior to *da*, *la* setae slightly depressed, rest convex (Figure 29); *d.sj* narrow, slightly rectilinear, well delimited (Figure 25); notogastral anterior depression (*n.a.d*) reduced (Figures 19, 25).

Fourteen pairs of setae: c_1, c_2, *da*, *dm*, *dp*, *la*, *lm*, *lp*, h_1, h_2, h_3, p_1, p_2, p_3; c_1 (86 ± 5 μm); c_2 (75 ± 5 μm) both setae long and thin, direction variable but in most cases directing forward (Figure 19, 31, 35), however not uncommon for these setae to be directing backward (Figure 29). Setae *da* (35 ±3 μm); *dm* (30 ± 3 μm); *dp* (65 ± 3 μm); *la* (35 ± 3 μm); *lm* (27 ± 3 μm); *lp* (42 ± 3 μm); h_1 (48 ± 3 μm); h_2 (45 ± 3 μm); h_3 (25 ± 3 μm); p_1 (13 ± 3 μm); p_2 (15 ± 3 μm); p_3 (17 ± 3 μm).

Cord-shaped structures (*c.s.s*) converging in central anterior zone forming an elongate fingerlike projection (*f.l.p*) (53 ± 5 μm (Figure 25). Circumgastric depression (*s.c*) present, clearly visible (Figures 19, 29), from *h.ap* surrounding notogaster, situated between *la*, *lm* , *lp*, h_2, h_1 and h_3, p_3, p_2, p_1 setae (Figure 19). Humeral apophysis (*h.ap*) large elongate projection (Figure 19).

Lateral region (Figures 29, 31). Lamellae (*lam*) easily discernible; cuticular microsculpture near bothridial zone pusticulate with several round depressions (Figure 20); *le* setal insertion at same level as *ro* setal insertion; conspicuous *la.ti* (Figures 25, 26, 35) (details in frontal view).

Tutorium (*tu*) prominent lamina, curving margin, clearly discernible, smooth cuticula (Figures 29, 31). Deep supratutorial depression (*s.tu.d*) running parallel to and between lamellae and tutorium; *p.tu.d* and *a,tu d* present, large (Figure 31). *Tu* larger than *Pd I*, expanded laterally (Figure 31).

Bothridial ring (*bo.ri*) smooth, with *bo.to*, hardly discernible due to positioning of lateral antiaxial setae (*l"*) of genu II (Figure 20) (see Remarks); *h.ap* triangular, inferior margin rounded; anterior zone of *h.ap* overlapping posterior bothridial zone (Figures 20, 29).

Clearly delimited zone on *s.c* with more or less smooth cuticula, immediately followed by clearly delimited pusticulate zone (Figure 29), and slightly below insertion of setae h_3, p_3, p_2, p_1 to *h.ap*, a smooth zone extending to *b.ng*. Clearly delimited depressed zone behind leg IV. Cuticular ribbon (Figure 29 indicated by X) parallel to *b.ng*.

Frontal view (Figures 26, 27, 30, 35). Actual shape and disposition of: *e.i.p*, *in* setae, *Lam*, *le* setae, *la.ti*, *Tu*, *Pd I*, *s.tu.d.* and characteristics of rostral margin visible in frontal view.

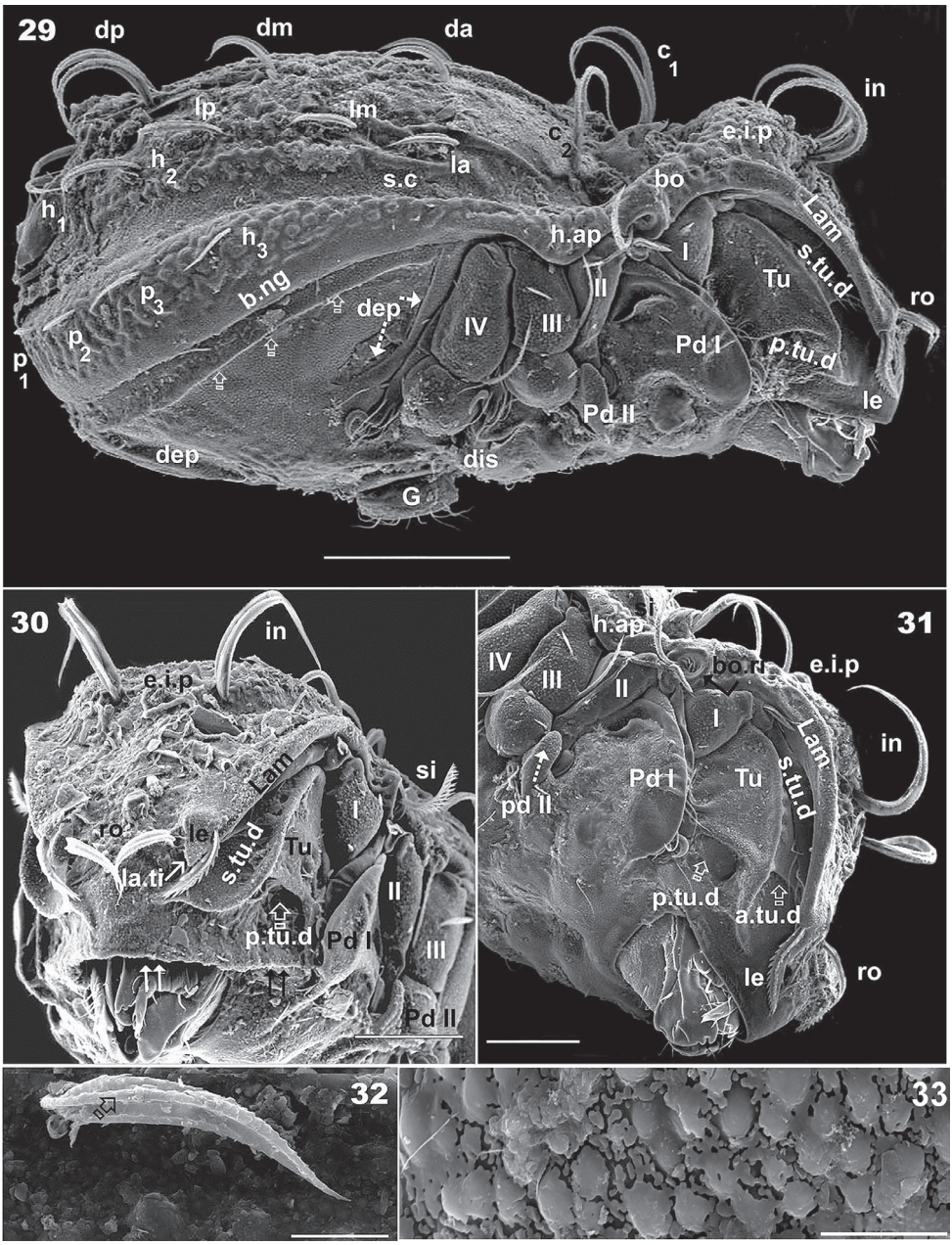
Complete, flat *e.i.p* (Figure 35); *in* setae placed far from *e.i.p* margin; *Lam* present slightly higher up on margin, terminating anteriorly in large triangular *la.ti*, with *le* setae situated in the external limit of *la.ti* (Figures 30, 35) and the *l.l.f* terminating near internal limit of *la.ti* (Figure 26, 27). Insertions of *ro* and *le* setae at the same transverse level (Figure 34). The *l.l.f* is only clearly discernible under optical observation (Figures 26, 27); in SEM observation the zone between *l.l.f* and lamellar margin is a slightly flat zone (Figure 30). Laterally expanded spoon-shaped *Tu* appearing larger than *Pd I* (Figures 30, 35); very deep *s.tu.d* completely concealing leg I (Figure 30). Rounded, undulate rostral margin with prominent forward extension, parallel to *Tu*, extending backward *Pd I* level (Figures 30, 35) (See Discussion).

Ventral region (Figures 34, 39, 40, 41, 42, 43). Large, clearly discernible rostral margin (Figure 34 indicated by X). Elevated epimera delimited by deep furrow (Figure 39); deep hollow zone paraxial to epimere 1(Figure 39, indicated by K); complete epimere *sj*; epimera 3 and 4 well discernible, unfused. Epimeral chaetotaxy 3-1-3-3. Epimeral setae *1a*, *2a*, *3a*, *4a*, largest. Discidum clearly discernible; *a.g.f* clearly visible, situated anterior to genital plate (Figure 40). Genital plate rounded, with four or five pairs of genital setae, (see Remarks) (Figures 40, 42); all setae more or less equal in length; *ag* setae situated posterior to genital opening, far from ad_3 (Figure 39). Three pairs of *ad* seta, more or less equal in length (Figure 41); anal plate polyhedral (Figure 41), sharply tipped; two pairs of anal setae; anterior pairs larger than posterior. Shallow depressions (*dep*) (Figure 39) situated laterally on either side of as well as between genital and anal openings. Subcapitulum diarthric (Figure 34); setae *h* largest.

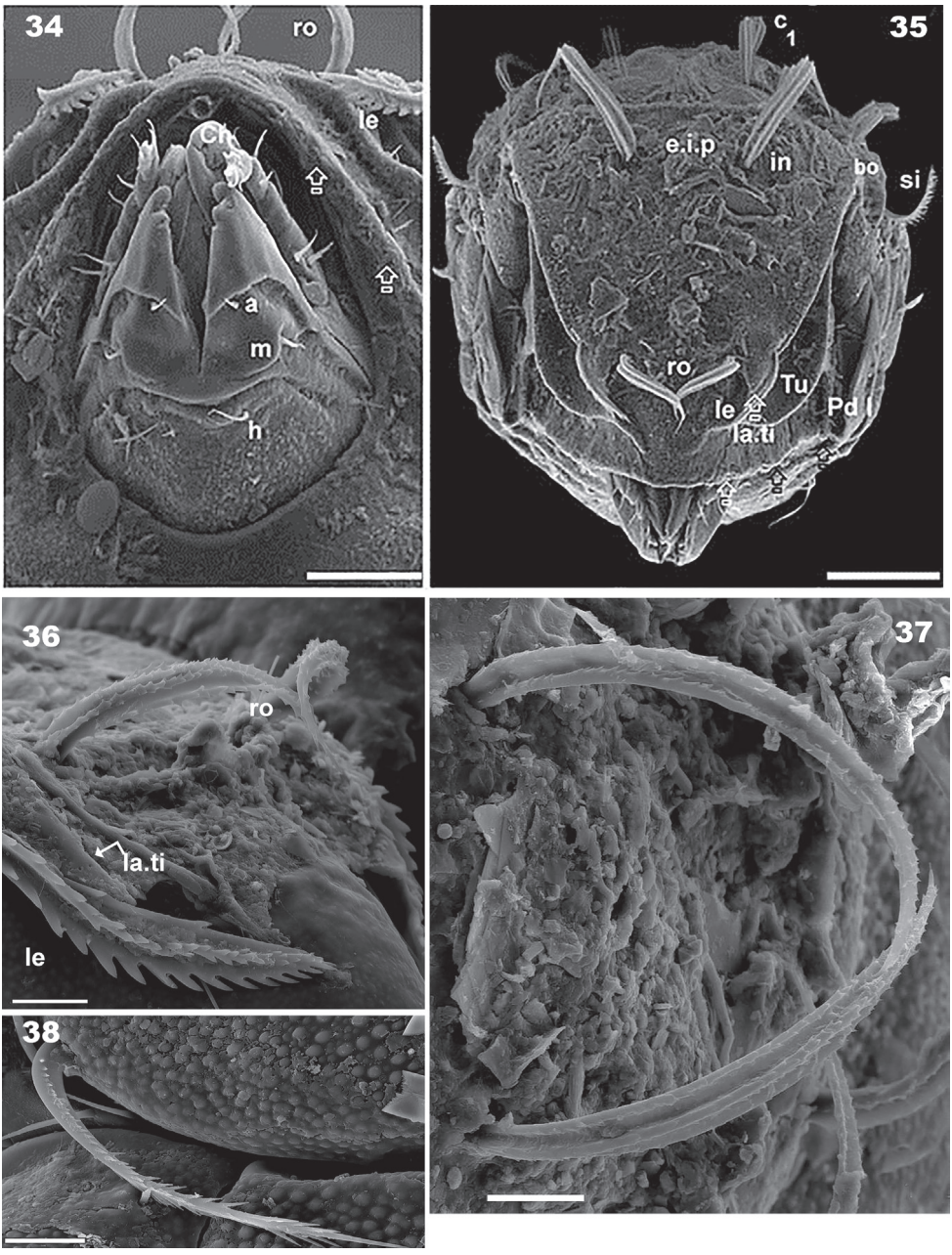
Legs (Figures 44–47). All legs monodactyle. Setal formulae I (1-4-2-4-16-1) (1-2-2); II (1-3-3-3-15-1) (1-1-2); III (2-3-1-2-14-1) (1-1-0); IV (1-2-2-3-12-1) (0-1-0). See Table 2.

Remarks. In some specimens the cerotegumental layer appears damaged (Figure 33), as more than 40 years have passed since collection, preservation of specimens may have been influenced by the quality of the initial diluted alcohol. Material of much greater age has been studied previously without problems, but in this case, the description of the cerotegumental layer must be regarded as provisional.

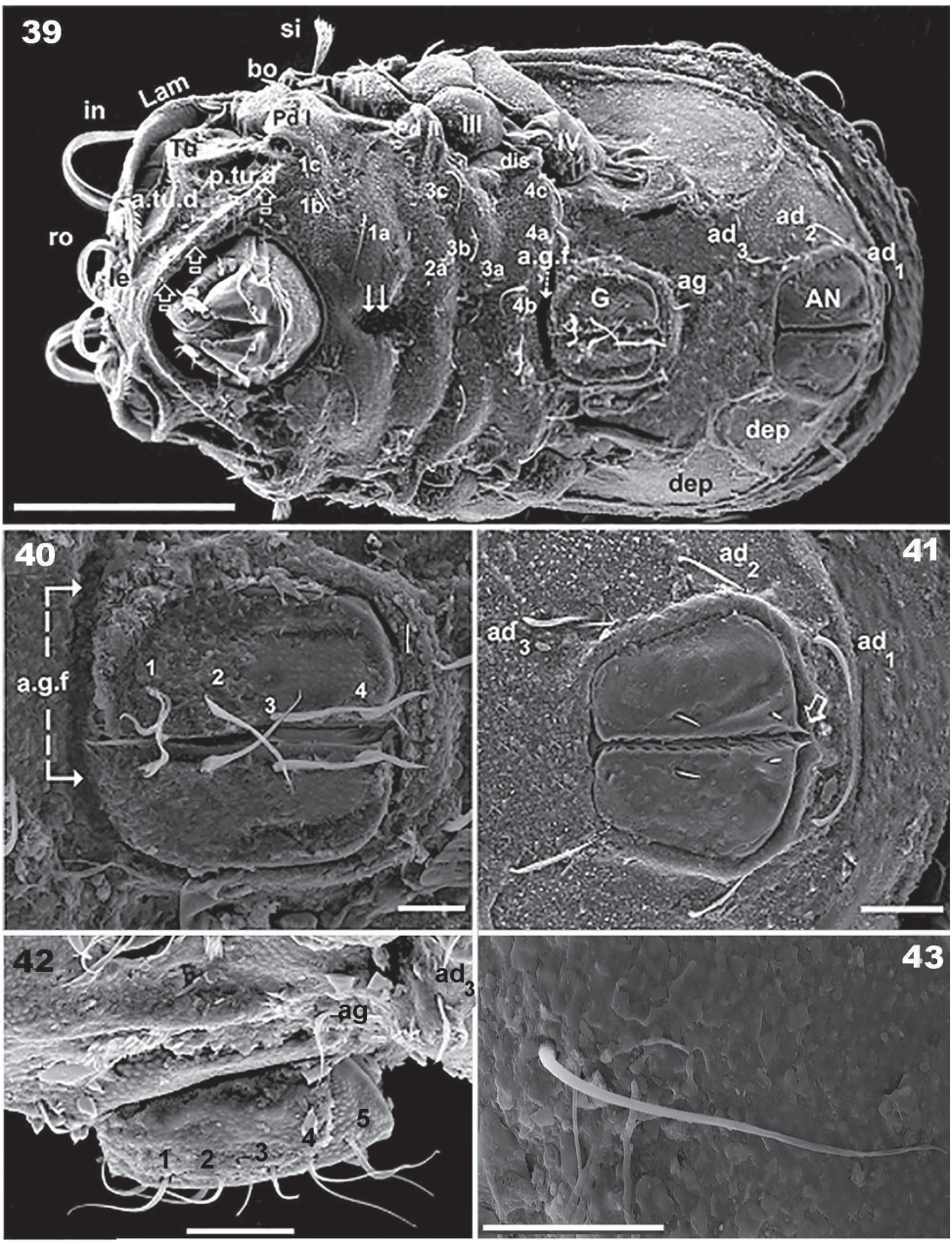
Twisting setae complicate and obscure observation; use of SEM vital in providing adequate information, while small particles adhering to setal surfaces further compli-



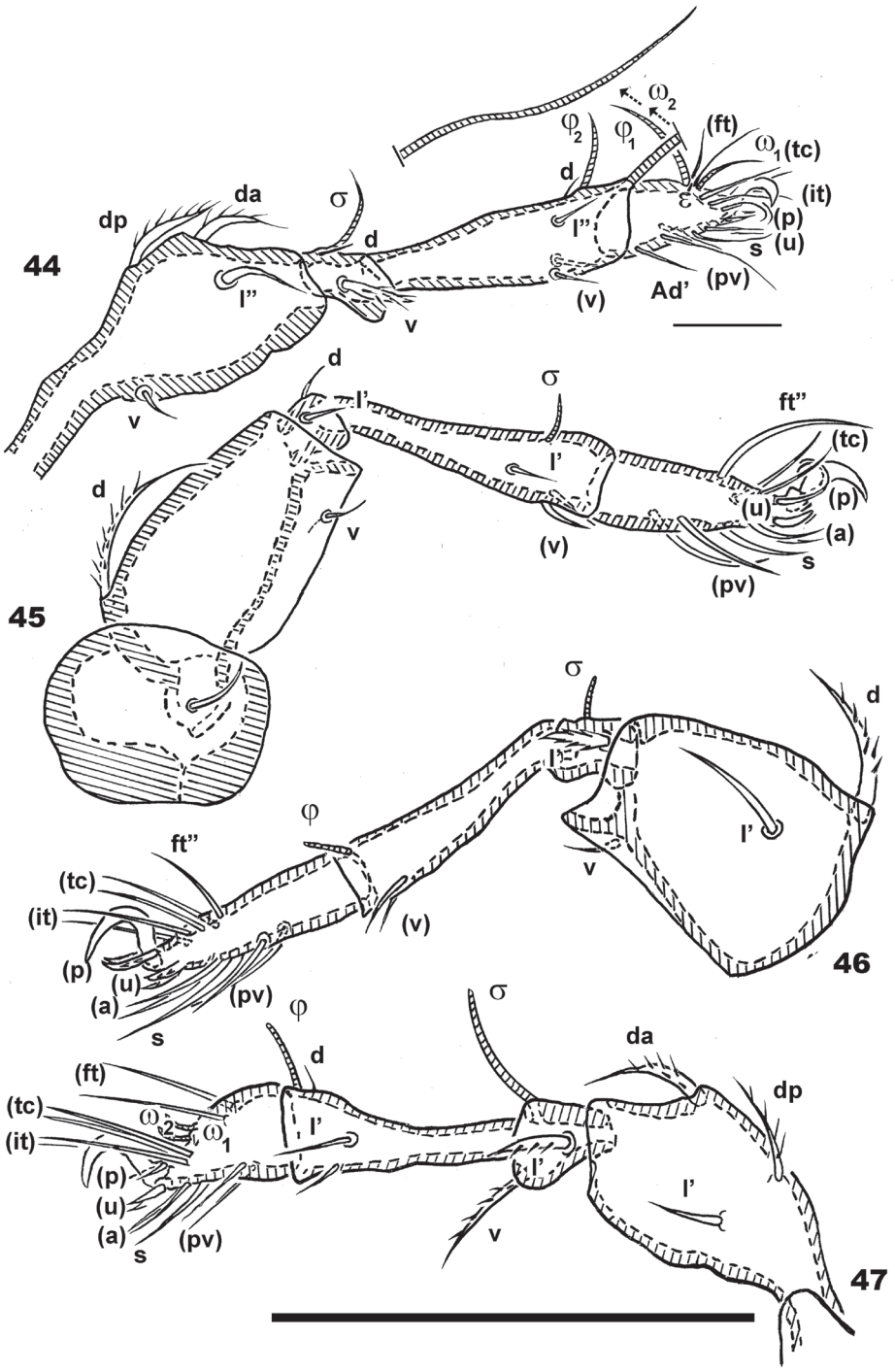
Figures 29–33. *Congocepheus kayoveae* sp. n. Adult female, SEM. **29** lateral view **30** frontal inclined view **31** lateral inclined view **32** notogastral setae **33** damaged cerotegumental layer. Abbreviations: see "Material and methods". Scale bars: (**29**) 100 μm; (**30–31**) 50 μm; (**32**) 10 μm; (**33**) 5 μm.



Figures 34–38. *Congocepheus kayoveae* sp. n. Adult female SEM. **34** subcapitulum, ventral view **35** prodorsum, frontal view **36** lamellar setae (*le*), lateral view **37** setae *dp*, dorsal view **38** seta *d* femur III, lateral view. Abbreviations: see "Material and methods". Scale bars: (**33**) 20 μm; (**34**) 50 μm; (**35–37**) 10 μm.



Figures 39–43. *Congocepheus kayoveae* sp. n. Adult female SEM. **39** ventral view **40** genital plate **41** anal zone **42** genital plate, lateral view **43** epimeral setae. Abbreviations: see "Material and methods". Scale bars: (**39**) 100 μm; (**40, 42, 43, 44**) 10 μm; (**38, 41**) 20 μm.



Figures 44–47. *Congocepheus kayoveae* sp. n. Adult female, optical observations. **44** leg I antiaxial **45** leg IV, antiaxial **46** leg III, antiaxial **47** leg II antiaxial. Abbreviations: see "Material and methods". Scale bar: (**44–47**) 100 μm.

Table 2. *Congocepheus kayoveae* sp. n. setae and solenidia.

Leg I	Femur	Genu	Tibia	Tarsus	Claw
setae	*da*, *dp*, *v*, *l"*	*d*,*v*	(*v*), *l"*,*d*	(*ft*),ε,(*tc*),(*it*),(*p*),(*u*),(*a*), *s*,(*pv*), *Ad"*	1
solenidia		σ	φ_1, φ_2	ω_1, ω_2	
Leg II					
setae	*dp*, *da*, *l'*	*d*,*l'*,*v*	*v*, *d*, *l'*	(*pv*), *s*,(*a*),(*u*),(*p*), (*it*), (*tc*), (*ft*)	1
solenidia		σ	φ	ω_1, ω_2	
Leg III					
setae	*d*, *l'*,*v*	*l'*	(*v*)	(*pv*),*s*,(*a*),(*u*),(*p*),(*it*),(*tc*), *ft"*	1
solenidia		σ	φ	-	
Leg IV					
setae	*d* , *v*	*d*, *l'*	*l'*, (*v*)	(*pv*), *s*,(*a*),(*u*), (*p*), (*tc*), *ft"*	1
solenidia		-	φ	-	

cate observation. In several cases study material presents slight genital neotrichy; in two instances five pairs of setae were observed. One example of neotrichy was observed in *Congocepheus*, with notogastral neotrichy present in *Co. germanicus*; but *Co. kayoveae* is the first observed occurrence of genital neotrichy.

Discussion

The two species described in this paper are related to *Congocepheus taurus* Balogh 1961. Unfortunately, as we were unable to obtain the type material, *Co. taurus* is the only species within the genus *Congocepheus* we were unable to study. The type locality given by Balogh is "Africa Orientalis: Meru", and searching through our material from Tanzania, we were unable to locate this species.

The description given by Balogh 1961 (page 522) is short and imprecise with only two figures, 10 (dorsal) and 11 (lateral) (page 523); figures lack detail, with important omissions. The following comparison is confined to an analysis of characters and figures provided by the author in 1961.

Commonalities: *Co. taurus* and *Co. rwandensis* are similar in terms of body shape; presence of irregular cord-shaped structures on notogaster; one central vein present on setae c_1 and *in*; *e.i.p* elevated with *in* setae situated anteriorly; *p.p.d* and *n.a.d* determine a large depression; presence of *f.l.p*. *Co. taurus* is similar to *Co. kayoveae* with regard to the presence of irregular cord-shaped structures on notogaster; c_1 setae with one central vein; presence of *f.l.p.*

Differences: *Co. taurus* differs from *Co. rwandensis* in terms of very short c_1 setae; *e.i.p* divided; *f.l.p* very different in shape; disposition, direction and shape of notogastral setae. *Co. taurus* differs from *Co. kayoveae* in terms of body shape; very short setae c_1; *p.p.d* and *n.a.d* different in shape and size; greatly differing shape of *e.i.p*; *in* setae with only one vein; disposition and direction of notogastral setae; *f.l.p* very different shape.

The complexity of several structures present in species studied, necessitated observation from many different angles, as was the case in *Antongilibodes paulae* Fernandez et al., 2014 and *Mangabebodes kymatismosi* Fernandez et al., 2014. In the description of *Congocepheus kayoveae* sp. n., Figures 29, 30, 31, and 34 are complementary; lateral, frontal and frontal inclined views permit understanding of several characteristics and aspects not clearly observed (or difficult to interpret) in only the lateral or ventral position. Succinct studies such as that of *Co. taurus*, with a short description and poorly developed figures, confound comparison, and several particularities of this species may go unnoticed.

In *Congocepheus kayoveae* sp. n. a similar situation was observed to that in *Mangabebodes kymatismosi*, Fernandez et al. 2014; where the *tutorium* forms a prominent lateral expansion and is relatively large; considered to be the first instance where this particularity is observed in *Congocepheus*. In *Co. kayoveae* sp. n., the *s.tu.d* is very deep, completely concealing leg I.

Other interesting aspects are the position of the lateral setae (*l"*) of genu II (Figure 20), which during the leg folding process (See Fernandez et al. 2013a) protect the opening of the bothridium, and the perfect coaptation of the legs and depressions during leg folding (Figure 29).

Acknowledgements

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RESEARCH ARTICLE

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Mayflies, stoneflies, and caddisflies of streams and marshes of Indiana Dunes National Lakeshore, USA

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Abstract

United States National Parks have protected natural communities for one hundred years. Indiana Dunes National Lakeshore (INDU) is a park unit along the southern boundary of Lake Michigan in Indiana, USA. An inventory of 19 sites, consisting of a seep, 12 streams, four marshes, a bog, and a fen were examined for mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) (EPT taxa). Volunteers and authors collect 35 ultraviolet light traps during summer 2013 and supplementary benthic and adult sampling added species not attracted by lights or that were only present in colder months. Seventy-eight EPT species were recovered: 12 mayflies, two stoneflies, and 64 caddisflies. The EPT richness found at INDU was a low proportion of the number of species known from Indiana: caddisflies contributed only 32.7% of known state fauna, mayflies and stoneflies contributed 8.4% and 2.3%, respectively. Site EPT richness ranged from one for a seep to 34 for an 8 m-wide stream. Richness in streams generally increased with stream size. Seven new state records and rare species are reported. The number of EPT species at INDU is slightly larger than that found at Isle Royale National Park in 2013, and the community composition and evenness between orders were different.

Keywords

Indiana Dunes National Lakeshore, Indiana Dunes State Park, Ephemeroptera, Plecoptera, Trichoptera, inventory

Introduction

Extinction rates of North America freshwater fauna are 4–5 times higher than in terrestrial species and this trend is predicted to continue well into the future (Ricciardi and Rasmussen 1999). Master et al. (2000) suggest that aquatic invertebrates in the United States are highly imperiled, with mussels (Unionidae), crayfish (Decapoda: mostly Cambaridae), and stoneflies (Plecoptera) being rated as the top three most imperiled freshwater groups. Little is known of the original distribution, biology, and conservation status of most freshwater invertebrate species because they have been so poorly studied (Strayer 2006). Unfortunately, scientists are running out of high quality systems in which to study aquatic invertebrates due to the rapid degradation of their habitat. Large public properties such as United States National Parks may provide the minimally impacted aquatic habitat in which to study the biology of these once more widespread species. Inventory work within these parks may also shed light on the ability of public properties to support a portion of the regional species pool. The United States National Park System will celebrate its 100th anniversary in 2016. This paper is a small tribute to the foresight of the United States government for its willingness to protect unique natural communities across the county.

Indiana Dunes National Lakeshore (INDU) is a unit of the United States National Park Service located in northwestern Indiana along the southern Lake Michigan shoreline. A mosaic of public and private property, it extends 24 km from Gary east to Michigan City (Fig. 1). The USA Congress authorized the park in 1966 after a half century of activism to preserve the unique physical features and associated vegetation (National Park Service 2015). Scientists know Indiana Dunes as the "birthplace of ecology" due to Cowles' (1899) pioneering efforts on vegetative succession.

The Wisconsinan ice sheets receded approximately 10,000 years ago leaving vast deposits of sand that formed the Lake Michigan shoreline. Changing lake levels gave rise to a series of beachfronts, sand dunes, and interdunal swales. Moraines serve as drainage divides that form several streams that flow to Lake Michigan through INDU (Hill 1974). These streams and marshes of INDU provide habitat for a wide range of plants and animals. Interdunal swales are extensive and open, or partly wooded. Several small streams, including Dunes Creek, Kintzele Ditch, and Munson Ditch, enter the swales then reform channels to exit via Lake Michigan.

The largest flowing water resource in INDU, the East Arm of the Little Calumet River, flows from east to west, beginning midway along the Porter and La Porte county line and emptying into Lake Michigan near Ogden Dunes. Most of the river's drainage is not contained within INDU, although the most sinuous and heavily wooded stretches are contained within park boundaries. Much of this highly modified system was channelized early in the 20th century to hasten drainage. Water quality of the East Arm of the Little Calumet River is moderately impaired and advisories against fish consumption related to mercury and PCB contamination and contact due to pathogens have been posted (Lake Michigan Coastal Program 2015). Still, sections of the river upstream of the most industrialized area flow naturally and

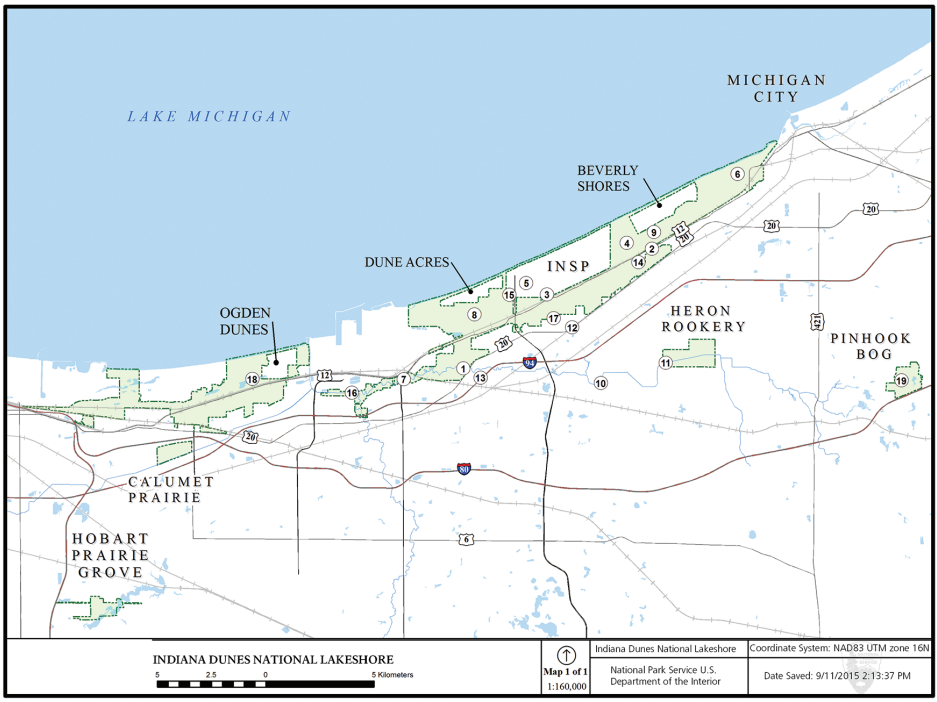

Figure 1. Sampling locations and extent of Indiana Dunes National Lakeshore and Indiana Dunes State Park (INSP). Site numbers in circles are from Table 1.

harbor remnants of the fish and macroinvertebrate communities that have always been present in streams of the region. Near the western end of INDU is Cowles Bog, a fen surrounded by marshland. To the far east is Pinhook Bog, a true acidic bog, supporting a bog plant community.

While vertebrate species abundance and community structure are generally well known for many National Park units, information on the invertebrate assemblages is often lacking. Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT species) are environmentally sensitive aquatic insects that are routinely used in monitoring of water quality (Barbour et al. 1999). Their taxonomy and distribution are relatively well known in the Midwest (Burks 1935, DeWalt et al. 2005, DeWalt et al. 2012, DeWalt and Grubbs 2011, Frison 1935, Grubbs et al. 2012, Houghton 2012, Randolph and McCafferty 1998, Ross 1944, Waltz and McCafferty 1983). This makes EPT an appropriate target for inventories within INDU.

The objectives of this study are to conduct an inventory of the EPT present in INDU, asking the following questions of the resulting data:

1. What is the species richness of EPT and the distribution of species within orders and families within the study area?

Table 1. Locations for sampling of Ephemeroptera, Plecoptera, and Trichoptera at Indiana Dunes National Lakeshore (INDU) and Indiana Dunes State Park (INSP) during 2013 and 2014. Waterbody type or stream wetted width (m) provided.

SiteID	County	Stream		Locality	Latitude	Longitude	Width (m)
1	Porter	East Arm L. Calumet R.	INDU	at Howe Rd.	41.62145	-87.09267	29
2	Porter	Trib. Beverly Rd. Marsh	INDU	at US-12	41.67135	-86.98812	2
3	Porter	Munson Ditch	INSP	9.3 km NE Crocker	41.65613	-87.05671	8
4	Porter	Beverly Dr. Marsh	INDU	9.7 km WSW Michigan City	41.67375	-87.00207	Marsh
5	Porter	Dunes Creek	INSP	9.4 km NE Crocker	41.65706	-87.05788	5
6	Porter	Kintzele Ditch	INDU	3.8 km W Michigan City	41.70249	-86.94065	8
7	Porter	East Arm L. Calumet R.	INDU	3.2 km N Crocker at IN-149	41.61701	-87.12574	29
8	Porter	Cowles Bog	INDU	6.9 km NNE Crocker	41.64396	-87.08664	Fen
9	Porter	Grand Marsh	INDU	E Broadway Ave. at boardwalk	41.67825	-86.98707	Marsh
10	Porter	East Arm L. Calumet R.	INDU	9.3 km ENE Crocker at Brummit Rd.	41.61544	-87.01653	25
11	Porter	East Arm L. Calumet R.	INDU	12.5 km ENE Crocker-Heron Rockery	41.62388	-86.98045	25
12	Porter	Munson Ditch	INDU	9.0 km NE Crocker at Hawleywood Rd.	41.64243	-87.04272	2
13	Porter	Marsh	INDU	Howe Rd.	41.62147	-87.09356	Marsh
14	Porter	Trib. Great Marsh	INDU	US-12 & CR 375E	41.66796	-86.99571	2
15	Porter	Dunes Creek	INDU	8.5 km NNE Crocker at Waverly Rd.	41.65221	-87.06731	5
16	Porter	East Arm L. Calumet R.	INDU	3.4 km ESE Ogden Dunes	41.61137	-87.15446	29
17	Porter	Seep Munson Ditch	INDU	9.0 km NE Crocker	41.64246	-87.04259	Seep
18	Porter	Long Lake	INDU	1.9 km WSW Ogden Dunes at Beach Rd.	41.61692	-87.20969	Marsh
19	La Porte	Pinhook Bog	INDU	6.1 km S Waterford at N. Wozniak Rd.	41.61641	-86.84982	Bog

2. How does INDU EPT richness compare to known richness of EPT in Indiana?
3. Are there trends in EPT richness versus waterbody type and stream wetted width?
4. Are there any species of conservation significance inhabiting INDU?

This project is the second of four studies on the EPT of upper Great Lakes National Parks. A comparison to the results of inventory work on Isle Royale National Park, Michigan is discussed (DeWalt and South 2015).

Methods

Sampling of EPT taxa was greatly facilitated by a dedicated group of volunteers, organized by JEM and WWS, who set up and retrieved UV light traps from various locations in INDU and Indiana Dunes State Park (IDSP). The two locations in IDSP are immediately adjacent to INDU and will from here forward be referred to as INDU sites. Light trap units consisted of a portable camping light modified with a UV spectrum fluorescent bulb, a large white plastic tray, a 250 ml Nalgene ™ bottle, forceps, and a supply of 95% EtOH. Several such units were provided to INDU for volunteer use. Volunteers placed traps in an inconspicuous location near streams or marshes just before dark, often left them unattended, and then reclaimed them after approximately 1.5 hr. The contents of the tray were decanted into a fully labeled sample bottle and returned to park headquarters. Often, more than one waterbody was trapped per night.

Ultraviolet light traps are an efficient means of sampling caddisfly adults. However, mayflies and stoneflies required supplementary sampling in stream sites to collect species that do not come to lights or that emerged as adults in colder times of the year. These sites were sampled with dipnets, beating sheets, and sweepnets on several occasions in May, 2013 and early April, 2014 (Table 2).

Sample sorting was also volunteer facilitated with INDU managers, local high school students, and authors attending a two-day sample sorting workshop at INDU headquarters on October 16-17, 2013. Under supervision of the authors, volunteers sorted EPT by order and body size into separate vials of 95% EtOH. Samples were returned to the Illinois Natural History Survey (INHS) for additional sorting and labeling. Identification was to species where possible. Nomenclature followed that of Mayfly Central (2015), Plecoptera Species File (DeWalt et al. 2015), and the Trichoptera World Checklist (Morse 2015).

All specimens have been accessioned into the INHS Insect Collection (INHS-IC). The INHS provides global access to specimen data through the INHS-IC database portal (http://inhsinsectcollection.speciesfile.org/InsectCollection.aspx). These data are also shared with the Global Biodiversity Information Facility. Raw specimen data are provided as a supplementary comma delimited file (Suppl. material 1).

To answer question one, EPT richness was compiled across all samples at a site and the number of species in each order and family tallied. Comparison of INDU EPT to published Indiana records was conducted using Randolph and McCafferty (1998) for

Table 2. Dates or ranges of dates of sampling events and types of sampling devices used to collect Ephemeroptera, Plecoptera, and Trichoptera in Indiana Dunes National Lakeshore and Indiana Dunes State Park. Date format is month/day/year.

	Sample Dates											
SiteID	**5/4/2013**	**6/27/2013**	**7/1/2013**	**7/10-11/2013**	**7/16-17/2013**	**7/22/2013**	**7/31-8/1/2013**	**8/8-9/2013**	**8/27/2013**	**4/6/2014**	**10/21/2014**	**Events**
1	Dipnet			Dipnet, Sweep, UV			UV		UV	Dipnet	UV	7
2					UV		UV			Dipnet		3
3			UV		UV		UV					3
4		UV			UV							2
5					UV		UV					2
6					UV		UV					2
7									UV			1
8		UV					UV					2
9		UV					UV					2
10				UV				UV				2
11					UV			UV		Dipnet		3
12				UV			UV					2
13			UV				UV			Dipnet		3
14					UV		UV			Dipnet		3
15				Sweep, UV			UV					3
16				UV					UV			2
17				Handpicking								1
18						UV						1
19					UV			UV				2
											Total	46

mayflies, DeWalt and Grubbs (2011) for stoneflies, and Waltz and McCafferty (1983) and Rasmussen and Morse (2014) for caddisflies. The low richness for mayflies and stoneflies necessitated comparison by text alone, but for caddisflies a graphical comparison was possible.

Trends in species richness with stream wetted width (width of water at base flow) were investigated using Spearman Rank Correlation (Lowry 2015). Stream wetted width was estimated at each site from comparison with road widths on satellite images viewed on Acme Mapper 2.1 (http://mapper.acme.com) and recorded to the nearest meter. In addition, wetted width was expressed as three stream size categories (1–2 m, 3–10 m, and 11–30) so that EPT richness mean ± SE could be graphically compared. The average richness of seeps, marshes, a bog, and a fen were similarly compared. Conservation significance was discussed based on species being new state records or having been rarely reported from Indiana.

Results

Volunteers and authors collected 46 samples for an average of 2.4 visits/location at 19 locations (Table 1, Table 2).

What is the species richness of EPT and the distribution of species within orders and families within the study area? A total of 7,321 specimens were collected, resulting in 78 EPT species (Table 3). Mayflies contributed 12 species, most of which were in the families Baetidae (small minnow mayflies, five species) and Heptageniidae (flat-headed mayflies, five species). Stoneflies contributed only two species, one in the Perlidae (summer stone) and one in the Taeniopterygidae (willowfly, a winter-emerging stonefly). Caddisflies dominated EPT species richness with 64 species among13 families (Fig. 2). Four families contributed 78% of all caddisfly species: Leptoceridae (long-horned caddisflies, 18 species), Hydroptilidae (microcaddisflies, 16 species), Hydropsychidae (net-spinning caddisflies, nine species), and Polycentropodidae (finger-net caddisflies, seven species).

How does INDU EPT richness compare to known richness of EPT in Indiana? In Indiana there are at least 143 species of mayflies in 16 families (Randolph and McCafferty 1998). Those found within INDU accounted for only 8.4% of the Indiana fauna. DeWalt and Grubbs (2011) reported 87 species of stoneflies within eight families in Indiana. INDU richness amounted to only 2.3% of the known Indiana fauna. Waltz and McCafferty (1983) listed 190 species of caddisflies from Indiana. Rasmussen and Morse (2014), in their compendium of Nearctic distributions, listed a total of 196 species in 18 families. Samples in INDU recovered only 32.7% of the Indiana caddisfly fauna reported by Rasmussen and Morse (2014) (Fig. 2).

Are there trends in EPT richness versus waterbody type and stream wetted width? Richness of EPT varied greatly across stream sizes and water body types in INDU (Table 3, Fig. 3). At all sites caddisflies dominated richness. Among streams, EPT richness increased with wetted width (Fig. 4), but the correlation was not quite significant

Table 3. Species of Ephemeroptera, Plecoptera, and Trichoptera collected from Indiana Dunes National Lakeshore and Indiana Dunes State Park during 2013 and 2014, Porter and La Porte counties, Indiana. *Indicates new state record.

	Sampling Stations-See Table 1																		
Taxon and Authority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Ephemeroptera-mayflies																			
Baetidae																			
Baetis flavistriga McDunnough	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Baetis intercalaris McDunnough	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callibaetis ferrugineus (Walsh)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callibaetis fluctuans (Walsh)	0	0	1	0	0	0	0	1	10	0	0	0	0	0	0	0	0	0	0
Callibaetis pallidus Banks*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae																			
Caenis amica Hagen	0	0	1	17	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0
Ephemeridae																			
Hexagenia limbata (Serville)	8	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0
Heptageniidae																			
Heptagenia elegantula (Eaton)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maccaffertium exiguum (Traver)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maccaffertium terminatum (Walsh)	112	0	0	0	0	0	2	0	0	92	101	0	0	0	0	4	0	0	0
Maccaffertium vicarium (Walker)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Stenacron interpunctatum (Say)	12		23		119	23	1	0	0	2	9	0	0	0	0	0	0	0	0
Plecoptera-stoneflies																			
Perlidae																			
Perlesta lagoi Stark	0	0	25	0	28	5	0	0	0	3	8	0	0	0	1	2	0	0	0
Taeniopterygidae																			
Taeniopteryx burksi Ricker & Ross	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Trichoptera-caddisflies																			
Dipseudopsidae																			
Phylocentropus placidus (Banks)	0	0	5	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossosomatidae																			

	Sampling Stations-See Table 1																		
Taxon and Authority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Protoptila maculata (Hagen)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Protoptila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Hydropsychidae																			
Cheumatopsyche analis (Banks)	13	10	76	7	29	16	0	1	0	19	167	28	1	0	0	10	0	0	4
Cheumatopsyche campyla Ross	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Cheumatopsyche oxa Ross	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Cheumatopsyche pasella Ross	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cheumatopsyche sp.	150	0	13	0	0	0	0	5	0	60	0	0	1	2	5	8	0	0	1
Hydropsyche betteni Ross	81	3	96	8	12	45	24	0	0	10	254	6	1	20	2	93	0	0	3
Hydropsyche bronta Ross	14	2	13	0	0	1	187	0	0	0	4	0	0	1	0	3	0	0	0
Hydropsyche morosa group	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsyche simulans Ross	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Hydropsyche sparna Ross	2	2	7	1	2	1	0	0	0	4	111	0	0	1	0	5	0	0	2
Hydropsyche sp.	0	0	1	0	217	0	300	2	0	28	34	0	20	3	0	5	0	0	3
Potamyia flava (Hagen)	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	1	0	0	0
Hydroptilidae																			
Agraylea multipunctata Curtis	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0
Hydroptila ajax Ross	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	4	0	0	0
Hydroptila albicornis Hagen	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroptila angusta Ross	1	0	16	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Hydroptila armata Ross	0	0	29	8	1	3	12	0	0	3	0	0	0	0	0	2	0	0	0
Hydroptila consimilis Morton	3	0	7	0	14	32	44	0	0	1	8	0	0	0	1	100	0	1	1
Hydroptila grandiosa Ross	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	1	0	0	0
Hydroptila perdita Morton	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Hydroptila spatulata Morton	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0
Hydroptila waubesiana Betten	57	7	26	24	13	18	13	3	1	12	1	0	1	0	14	27	0	7	1
Hydroptila sp.	0	1	22	0	38	2	275	1	19	78	12	0	0	2	0	94	0	16	13
Ochrotrichia sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

	Sampling Stations-See Table 1																		
Taxon and Authority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Orthotrichia aegerfasciella (Chambers)	0	0	3	8	0	3	0	9	0	0	7	0	0	0	0	1	0	4	0
Orthotrichia cristata Morton	0	0	1	28	0	0	0	0	0	0	2	0	0	0	0	0	0	1	5
Orthotrichia sp.	0	0	0	0	0	0	2	0	9	0	0	0	0	0	0	0	0	0	2
Oxyethira forcipata Mosely*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxyethira pallida (Banks)	2	0	51	366	57	55	41	0	64	0	29	0	1	0	3	41	0	306	71
Oxyethira serrata Ross	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxyethira sp.	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0
Lepidostomatidae																			
Lepidostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Leptoceridae																			
Ceraclea alagma (Ross)	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	1
Ceraclea punctata (Banks)*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	36	0	0	0
Ceraclea tarsipunctata (Vorhies)	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea sp.	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Leptocerus americanus (Banks)	0	0	1	62	0	1	0	247	125	0	2	0	0	0	0	3	0	8	7
Nectopsyche diarina (Ross)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Nectopsyche exquisita (Walker)	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6	0	1	0
Nectopsyche pavida (Hagen)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nectopsyche sp.	0	0	0	3	0	1	0	0	1	0	0	0	0	1	0	7	0	0	1
Oecetis cinerascens (Hagen)	0	3	1	12	0	2	0	0	2	1	5	0	1	1	0	5	0	186	1
Oecetis ditissa Ross	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis inconspicua (Walker)	2	1	15	52	6	21	12	6	13	5	27	0	1	1	2	15	0	75	25
Oecetis n.sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis nocturna Ross	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis ochracea (Curtis)*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis persimilis (Banks)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Oecetis sp.	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Triaenodes aba Milne	1	0	1	270	0	0	0	145	12	0	0	0	0	0	0	0	0	3	1

	Sampling Stations-See Table 1																		
Taxon and Authority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Triaenodes melacus Ross	0	0	11	1	19	3	0	0	0	0	1	0	0	0	0	3	0	0	0
Triaenodes nox Ross	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0	0
Triaenodes tardus Milne	0	0	2	42	0	1	0	3	17	8	1	0	0	0	0	0	0	79	5
Triaenodes sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Limnephilidae																			
Platycentropus radiatus (Say)	0	2	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Pycnopsyche guttifera (Walker)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pycnopsyche sp.	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Molannidae																			
Molanna tryphena Betten*	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Philopotamidae																			
Chimarra obscura (Walker)	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0
Phryganeidae																			
Agrypnia vestita (Walker)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Banksiola crotchi Banks	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	2	1
Phryganea cinerea Walker	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1
Ptilostomis ocellifera (Walker)	0	12	3	0	5	0	0	0	0	1	0	0	0	3	0	1	0	0	0
Ptilostomis postica (Walker)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilostomis sp.	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae																			
Cernotina calcea Ross*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Neureclipsis crepuscularis (Walker)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nyctiophylax moestus Banks	17	0	0	1	0	0	0	0	0	8	61	0	0	0	0	5	0	0	0
Plectrocnemia cinerea (Hagen)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0
Plectrocnemia clinei Milne*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Plectrocnemia crassicornis (Walker)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropus confusus Hagen	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0
Polycentropus sp.	1	0	1	0	0	0	0	0	0	27	0	0	0	0	0	9	0	1	0

	Sampling Stations-See Table 1																		
Taxon and Authority	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Psychomyiidae																			
Lype diversa (Banks)	7	0	1	1	0	0	2	0	0	4	21	0	0	0	0	1	0	0	0
Psychomyia flavida Hagen	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Total count	522	46	463	939	570	276	945	430	307	372	876	34	28	38	29	588	1	701	156
Ephemeroptera richness	6	0	3	2	1	2	3	1	2	3	3	0	0	0	0	1	0	0	0
Plecoptera richness	0	0	1	0	1	1	0	0	0	1	2	0	0	0	1	1	0	0	0
Trichoptera richness	16	10	30	26	13	21	16	11	12	16	21	2	7	11	7	29	1	16	19
Total EPT richness	22	10	34	28	15	24	19	12	14	20	26	2	7	11	8	31	1	16	19

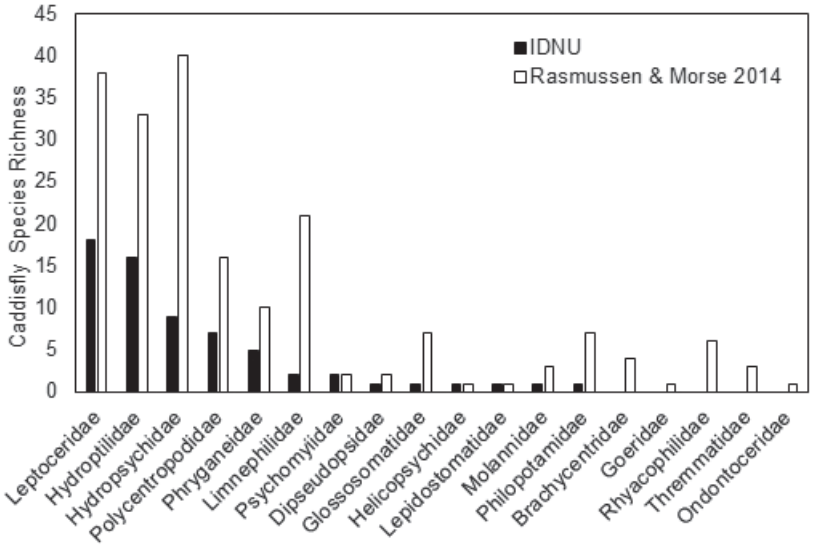

Figure 2. Comparison of caddisfly species richness within families at Indiana Dunes National Lakeshore versus Indiana records published by Rasmussen and Morse (2014).

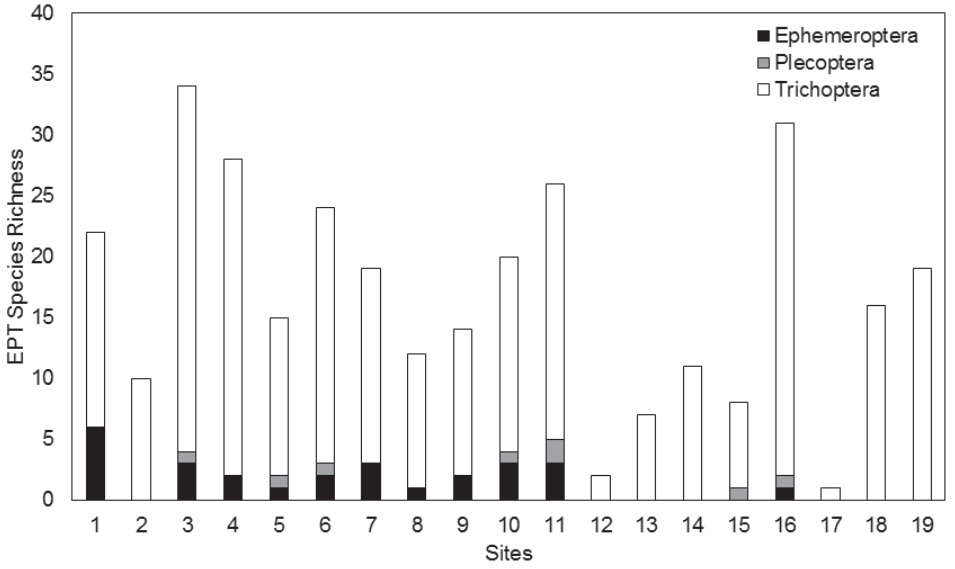

Figure 3. EPT richness found at each of 19 locations in Indiana Dunes National Lakeshore. Refer to Table 1 for specific site information.

(R = 0.55, p = 0.06, df = 16). Small streams of less than 2 m wetted width rarely produced more than 10 species, while larger streams averaged 20 or more species. One seep, densely vegetated by skunk cabbage, *Symplocarpus foetidus* (L.) Salisb. ex Barton,

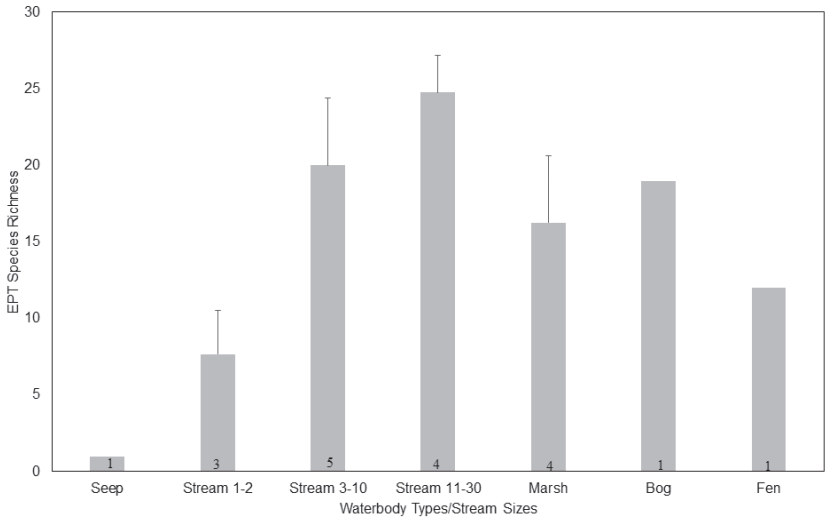

Figure 4. Mean ± SE of EPT richness by stream size and waterbody type within Indiana Dunes National Lakeshore and Indiana Dune State Park. Number in bar indicates sample size.

produced only the empty, coarse sand cases of the caddisfly *Lepidostoma* sp. This population probably died during an extensive drought of the previous year, though their cases remained. Cowles Bog, actually a fen, produced one mayfly and 11 caddisfly species. Pinhook Bog, the only acid bog among the sampling sites, produced 19 caddisfly species. Marshes produced an average of 16.5 EPT species, 89% of species captured there being caddisflies. Marshes, the fen, and bog supported a similar caddisfly fauna, exhibiting little in the way of uniqueness.

Are there any species of conservation significance inhabiting INDU? We collected several rare species and seven that were new records for Indiana. In addition, one potentially undescribed species of caddisfly was collected. A discussion of these records follows.

Ephemeroptera

Baetidae – Small Minnow Mayflies

Callibaetis pallidus Banks. This is a new state record. Randolph and McCafferty (1998) did not report the species from Indiana. However, Check (1982), in an unpublished master's thesis, listed Indiana as part of the distribution of the species. This is the first published record of the species in Indiana. Two females were taken from Beverly Dr. Marsh (Site 4).

Trichoptera

Polycentropodidae – Fingernet Caddisflies

Cernotina calcea Ross. This is a new state record. Ross (1938) described this species from the nearby Kankakee River, Illinois. It has not been reported from Indiana (Waltz and McCafferty 1983), Michigan (Leonard and Leonard 1949a, b), Minne-

sota (Houghton 2012), Ohio (Armitage et al. 2011), or Wisconsin (Longridge and Hilsenhoff 1973). One male and two females were collected from the East Arm of the Little Calumet River (Site 16).

Plectrocnemia clinei Milne. This is a new state record. Waltz and McCafferty (1983) did not list this species from Indiana. It has only been reported from Ohio (Armitage et al. 2011) and Minnesota (Houghton 2012) in the region. Two males and one female were taken from Pinhook Bog (Site 19).

Plectrocnemia crassicornis (Walker). This species has rarely been collected in Indiana. We collected a single specimen of the distinctive female from Munson Ditch (Site 3). The only published Indiana record is a single female from a nearby locality: INHS-Trichoptera-54964, "Michigan City, Ind. [La Porte Co.] Trail Creek June 21, 1957 John Lowe" (Waltz and McCafferty 1983). A second unpublished record exists in the INHS Insect Collection: INHS-Trichoptera-54963, "Morgan-Monroe St. Forest 7 mi. S. of Martinsville IND. May 16, 1962 H. H. Ross & J. Kingsolver at light". It is the only male specimen that has been collected in the state. The species has been reported from all states in the region (Armitage and Hamilton 1990, Armitage et al. 2011, Houghton 2012, Leonard and Leonard 1949b, Longridge and Hilsenhoff 1973, Ross 1944).

Polycentropus confusus Hagen. This species, too, is rarely collected in Indiana, its only published record is from Jefferson County in Clifty Falls State Park (Waltz and McCafferty 1983). It is known from all other neighboring states except Illinois (Armitage and Hamilton 1990). Three males and one female were collected from two locations on the East Arm Little Calumet River (Sites 10 & 11).

Hydroptilidae – Microcaddisflies

Hydroptila albicornis Hagen. This is the first northern Indiana record. Waltz and McCafferty (1983) previously reported it from the town of Shoals along the East Fork of the White River. A single female specimen was taken along Munson Ditch (Site 3). The species is known from all neighboring states except Michigan and Kentucky (Blickle 1979).

Oxyethira forcipata Mosely. This new state record is represented by a single male collected from Munson Ditch (Site 3). The species is known from all neighboring states except Kentucky (Blickle 1979) and has been recently demonstrated to occur in high incidence across Ohio, especially in the Erie-Ontario Lake Plains and the Western Allegheny Plateau (Armitage et al. 2011).

Oxyethira serrata Ross. This species is rare in Indiana, its only other record being from Lake Maxinkuckee in Marshall County (Waltz and McCafferty 1983). Four females were collected from Beverly Dr. Marsh (Site 4). The species in known from neighboring Illinois and Michigan (Blickle 1979).

Molannidae – Hoodcase Case Caddisflies

Molanna tryphena Betten. This is a new state record. The species is represented by three males and one female from Munson Ditch and Dunes Creek in IDSP and in the East Arm of the Little Calumet River at Heron Rookery (Sites 3, 5, 11). The species is known from Michigan (Leonard and Leonard 1949b), Minnesota (Houghton 2012), and Wisconsin (Longridge and Hilsenhoff 1973) within the Midwest, Great Lakes region. This is now the fourth *Molanna* known from Indiana (Waltz and McCafferty 1983).

Leptoceridae – Longhorn Caddisflies

Ceraclea punctata (Banks). This is a new state record. Five males and 33 females were collected from two locations on the East Arm of the Little Calumet River and from Dunes Creek (Sites 11, 15, 16). The species is known regionally from Illinois (Ross 1944), Michigan (Leonard and Leonard 1949b), Ohio (Armitage et al. 2011), and Wisconsin (Longridge and Hilsenhoff 1973).

Nectopsyche pavida (Hagen). This species is rarely collected in Indiana and is known only from Harrison (far south) and LaGrange (northeast corner) counties (Waltz and McCafferty 1983). A single female was taken from Beverly Dr. Marsh (Site 4). Though this species has been rarely collected in surrounding states (Leonard and Leonard 1949b, Longridge and Hilsenhoff 1973, Ross 1944), recent work has provided 30 locality records scattered across Ohio (Armitage et al. 2011).

Oecetis ochracea (Curtis). This is tentatively a new state record. A single female from Kintzele Ditch (Site 6) was collected. In the region, it is known from Ohio (Armitage et al. 2011) and Wisconsin (Longridge and Hilsenhoff 1973).

O. inconspicua (Walker) complex. One male and one female from Kintzele Ditch were recovered that superficially resemble *O. inconspicua*. The male specimen displays an elongate and dorsally directed appendage at the base of the inferior appendage (clasper), whereas in *O. inconspicua* figured by Ross (1944), this projection is small and squat. Some small differences are also apparent in the female. Description of this new species must be conducted as part of a revision of the complex, using both morphological characters and gene sequence data.

Triaenodes aba Milne. This species is known from Indiana by a single record from the Tippecanoe River in Kosciusko County (Waltz and McCafferty 1983). We collected over 400 females from the following sites: 1, 3, 4, 8, 9, 18, 19. Approximately 99.5% of these specimens were from marsh, bog, or fen habitat. It is likely to be abundant in such habitats elsewhere in Indiana, as has been the case in Ohio (Armitage et al. 2011). The species is known from all states that border Indiana (Glover 1996).

Discussion

A total of 78 EPT species was recovered from samples within INDU and IDSP. Included among these were seven new state records consisting of one mayfly and six caddisflies. Additionally, there is the potential for one caddisfly species new to science in the *O. inconspicua* complex (Floyd 1995, Zhou et al. 2010). While caddisflies were dominant in both numbers of individuals and species richness, mayfly and stonefly richness and abundance were remarkably low, perhaps because of the sluggish nature of streams in the region. With the six new state records, the number of caddisflies known from Indiana has increased to at least 201 species. An updated list is not presented here due to the low number of additions, but the lead author will provide a list upon request.

We do not know how many EPT species reside in INDU, but the fact that 31 species were found at only one of 19 sites strongly suggests that more species will be found. Species estimation at this point is not possible given that the number of singletons (species from a single site or sample) is greater than half of the number of sample units, a prerequisite for using several species richness estimators (Colwell 2013). We would have to double the number of light trap units taken in this study to model richness, a level of sampling not feasible with the resources at hand.

Four sites were comparatively rich in EPT species. A segment of Munson Ditch (Site 3) supported 34 species. Beverly Drive Marsh (Site 4) supported 28 EPT species. The East Arm of the Little Calumet River at Heron Rookery (Site 11) supported 26 species and was the only site to harbor more than one stonefly species. Further investigation of this site is in order, especially since it has yielded some coolwater species such as *Maccaffertium vicarium* (Walker). The East Arm Little Calumet River (Site 16) was also relatively rich with 31 species. Habitats similar to these four will likely yield additional taxa.

DeWalt and South (2015) conducted a similar inventory of EPT on Isle Royale National Park (ISRO) during 2013. They found that the EPT richness of ISRO (73 species) was comparable to INDU, but much lower than found on the mainland surrounding Lake Superior. They also reported that the size of stonefly species inhabiting the island was significantly smaller than that on the mainland—large species being excluded by some factor, presumably the distance (22-70 km from Minnesota or Michigan, respectively) for recolonization after glaciation. Caddisflies again provided over half of the species found, although their diversity was a much smaller proportion of the total EPT richness (57.5% ISRO vs. 82.1% INDU). A shift in family dominance was also evident with Limnephilidae providing the largest percentage of caddisfly richness (21.4%) for ISRO, while at IDNU Leptoceridae was the most species rich family (27.3%). Many of the species recovered from ISRO were cool- or coldwater species with low tolerance for organic enrichment. Conversely, INDU produced mostly warmwater species that were moderately tolerant of organic enrichment and/or low dissolved oxygen levels (see Barbour et al. 1999 for tolerances). Some species of EPT have probably been lost from INDU due to a

century of degradation and habitat modification. The lack of a diverse mayfly and stonefly fauna supports this contention.

National Parks and other public properties often protect large proportions of the regional biological community by providing intact habitat and by controlling commercial, industrial, and residential development within their boundaries. Some parks, such as Isle Royale, are isolated, providing considerable protection for communities. Indiana Dunes National Lakeshore is not isolated, its communities are subject to degradation because of the mosaic of public and private property around the park. Nearby there are industries, commerce, and relatively high population densities influencing water and air quality in the park. Still, INDU supports a moderately rich aquatic insect fauna, especially among caddisflies, a fact that would not be known if it were not for inventory work. No reliable baseline assessments for EPT species existed prior to our efforts.

In 2016 the National Park system of the United States will celebrate its 100th anniversary. Next year is also the 50th anniversary of Indiana Dunes National Lakeshore. The authors and volunteers who worked on this project are proud to provide valuable baseline data that will allow for better protection of INDU aquatic systems in the future.

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Supplementary material 1

Indiana Dunes EPT Specimen Data

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A new genus and species (*Cornucollis* gen. n. *masoalensis* sp. n.) of praying mantis from northern Madagascar (Mantodea, Iridopterygidae, Tropidomantinae)

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Abstract

An examination of Malagasy specimens accessed within the Muséum national d'Histoire naturelle, Paris, France, produced a praying mantis (Insecta: Mantodea) of an undescribed genus and species. An investigation of the internal and external morphology, in addition to its collection locality, revealed that this specimen belongs to the Iridopterygidae subfamily Tropidomantinae. Furthermore, the specimen's unique combination of characters justified the creation of a new genus. Geographic distributional records and external morphological character evidence are presented for *Cornucollis* **gen. n.** *masoalensis* **sp. n.** We provide a dichotomous key of the Tropidomantinae and Nilomantinae genera distributed within Madagascar. High-resolution images, illustrations of morphological characters, natural history information, and measurement data are presented.

Keywords

Taxonomy, new species, Madagascar, *Cornucollis masoalensis*, Afrotropical

Introduction

An undetermined Malagasy praying mantis (Insecta: Mantodea) specimen was found in the material of the Muséum national d'Histoire naturelle, Paris, France. The specimen exhibits the diagnostic characters of the family Iridopterygidae (*sensu* Ehrmann 2002), and so we considered those iridopterygid genera with an Afrotropical, Indomalayan, and Australasian geographic distribution that feature an overall morphological similarity to the undescribed specimen. We compared the undescribed specimen to the genera that met our diagnostic criteria; these genera belong to the subfamilies Tropidomantinae (Stål 1877, Westwood 1889, Giglio-Tos 1915, Hebard 1920, Kaltenbach 1998, Ehrmann 2002, Svenson and Roy 2011, Roy and Svenson 2011), Nilomantinae (Werner 1907, Giglio-Tos 1915, Paulian 1957, Ehrmann 2002), and Nanomantinae (Hebard 1920 and Beier 1933). Those genera with an overall gross morphology that is markedly distinct from the undescribed specimen were excluded in our generic-level comparisons (*e.g.*, very small, dark brown and gray mantises with darkly colored wings). The undescribed specimen features sufficient distinctive characteristics that do not correspond to standing generic descriptions and thus justified the creation of a new genus and species. As this specimen features 4 posteroventral forefemoral spines, 3 discoidal forefemoral spines, and a distinct, elevated medial keel that traverses the pronotum, which are diagnostic characters for the Iridopterygidae subfamily Tropidomantinae (Giglio-Tos 1915), we place this genus with the subfamily.

Materials and methods

Taxonomic sampling

Specimens were gathered for comparison from the Muséum national d'Histoire naturelle, Paris, France (MNHN), the California Academy of the Sciences (CAS), the National Museum of Natural History (USNM), and the research collection of praying mantises at the Cleveland Museum of Natural History (CMNH). Specimen records indicate that these mantises are most often collected with mercury vapor light traps and canopy beating. Specimens were preserved on insect pins and kept in climate-controlled cabinets or in vials of 95% ethanol.

Descriptive conventions and morphological characters

The generic- and species-level descriptions include diagnosis, taxonomic history, repository, and morphological character description. The morphological nomenclature followed Snodgrass (1935, 1937), La Greca (1954), Klass (1997), Wieland (2006, 2013), and Svenson (2014). Genitalic structures and other external diagnostic characters are

indicated on figure illustrations and images. External morphology was compared directly with gathered Tropidomantinae, Nilomantinae, and Nanomantinae specimens and descriptions in the primary literature.

To isolate the genitalia from relaxed specimens, the abdominalia was excised at tergite seven using iris scissors and placed in an individual vial of 10% KOH that was heated in a 40 °C water bath for five minutes to clear the structures. Structures were cleaned of excess tissues with fine ocular forceps and a 000 insect pin secured within a pin vise. The male genitalia was dissected into three phallomeric lobes, which are described from a ventral and dorsal perspective.

For efficiency and ease of use, prothoracic femoral and tibial spine counts were expressed via a formula proposed by Rivera (2010) using the morphological nomenclature of Wieland (2013). The formula is separated into femoral and tibial sections, which detail the number and potential variability of discoidal (DS), anteroventral (AvS) and posteroventral (PvS) spines. As the foretibiae do not have discoidal spines, those are omitted from the latter half of the formula. Neither the femoral genicular spurs nor the tibial spur are included in the spine counts. Forefemoral spine size arrangement is represented using the letter "I, i"; majuscule (*i.e.*, "I") represents relatively large spines, whereas the minuscule (*i.e.* "i") represents relatively smaller spines.

Measurements. Eighteen measurements were obtained using a Leica M165C stereomicroscope and an IC80 HD coaxial video camera using the live measurements module of the Leica Application Suite (LAS). All measurements are presented in millimeters.

1.) *Body Length* = From central ocellus to distal terminus of body or wing (whichever is longer); 2. *Forewing Length* = From convergence of vannal veins to apex of forewings; 3.) *Hindwing Length* = From convergence of vannal veins to apex of hindwings; 4.) *Pronotum Length* = From anteromedial margin of pronotum to posteromedial margin; 5.) *Prozone Length* = From anteromedial margin of pronotum to supracoxal sulcus; 6.) *Pronotum Maximum Width* = From lateral edge of pronotum to opposing edge, across widest region; 7.) *Pronotum Maximum Width* = From lateral edge of pronotum to opposing edge, across narrowest region posterior to supracoxal sulcus; 8.) *Head Width* = From lateral edge of compound eye to opposing edge of contralateral eye, perpendicular to central axis of the head, across widest point; 9.) *Head Vertex to Clypeus* = From center of the cranial vertex to base of clypeus; 10.) *Lower Frons Width* = From lateral margin of lower frons at widest point to opposing outer margin; 11.) *Lower Frons Height* = From lower margin of unpaired, median ocellus to middle of epistomal suture; 12.) *Prothoracic Femur Length* = From most proximal margin abutting the trochanter to distal apex of genicular lobe; 13.) *Mesothoracic Femur Length* = From most proximal margin abutting the trochanter to distal terminus; 14.) *Mesothoracic Tibia Length* = From proximal bend of the tibia to distal terminus, at a point medially positioned between apical spur and cuticular outgrowth of the tibia; 15.) *Mesothoracic Tarsus Length* = From most-proximal margin of basitarsus to distal terminus of the segment before the ungues; 16.) *Metathoracic Femur Length* = From most proximal margin abutting the trochanter to distal terminus; 17.) *Metathoracic*

Tibia Length = From proximal bend of the tibia to distal terminus, at a point medially positioned between apical spur and cuticular outgrowth of the tibia; 18.) *Metathoracic Tarsus Length* = From most-proximal margin of basitarsus to distal terminus of the segment before the ungues.

Habitus images and illustrations. High resolution images of the specimen and genitalia were captured using a Passport Storm© system (Visionary Digital™ 2012), which includes a Stackshot z-stepper, a Canon 5D SLR, macro lenses (50mm, 100mm, and MP-E 65mm), three Speedlight 580EX II flash units, and an associated computer running Canon utility and Adobe Lightroom 3.6 software. The z-stepper was controlled through Zerene Stacker 1.04 and images were processed using the P-Max protocol. Habitus and genitalia images were captured over an 18% grey card background for white balance standards. Images were processed in Adobe Photoshop CS6 Extended to adjust levels, contrast, exposure, sharpness, and to add scale bars. Minor adjustments were made using the stamp tool to correct background aberrations and to remove distracting debris. Plates were constructed using Adobe Illustrator CS6 and Adobe Photoshop CS6. Dorsal and ventral habitus images of the types, in addition to the original specimen labels, can be viewed online at http://specimens.mantodearesearch.com. Illustrations of key morphological structures were digitized in Adobe Illustrator CS5. All illustrations were produced by Rebecca Konte of the Cleveland Institute of Art.

Results

The undescribed specimen (Fig. 1) features a unique combination of external morphological characters variously present in the Iridopterygidae subfamilies Tropidomantinae, Nilomantinae, and Nanomantinae. These features include: distinctly conical compound eyes; a concave vertex with slight juxtaocular bulges; a slightly curved ventral cervical sclerite; lateral cervical sclerite with blunted, horn-like mediolateral projection directed laterad; pronotum broad, supracoxal bulge not distinctly pronounced, lateral margins narrowly tapered in the posterior half of the metazone; pronotum with slight lateral cuticular expansions, the margins of which feature socketed setae; a distinctly elevated medial keel traversing the entire length of the pronotum; male wings opaque; foretibial posteroventral spines procumbent and approximately 15 in number. Furthermore, the male genital characters include a processo apical (**paa**) that is relatively smooth; lobo membranoso (**loa**) with sclerotized region of crenulation on the posterior margin; ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) without granulation, features a distinct lateral outgrowth on both the dextral and sinistral margins, the posterior margin tapering into a narrow distal process (**pda**); right phallomere (**R1**) features a right arm (**bm**) with a sclerotized, acuminate outgrowth. An examination of the literature as well as specimens belonging to the Afrotropical genera within each subfamily was performed to determine which genus, if any, the unidentified specimen fit within.

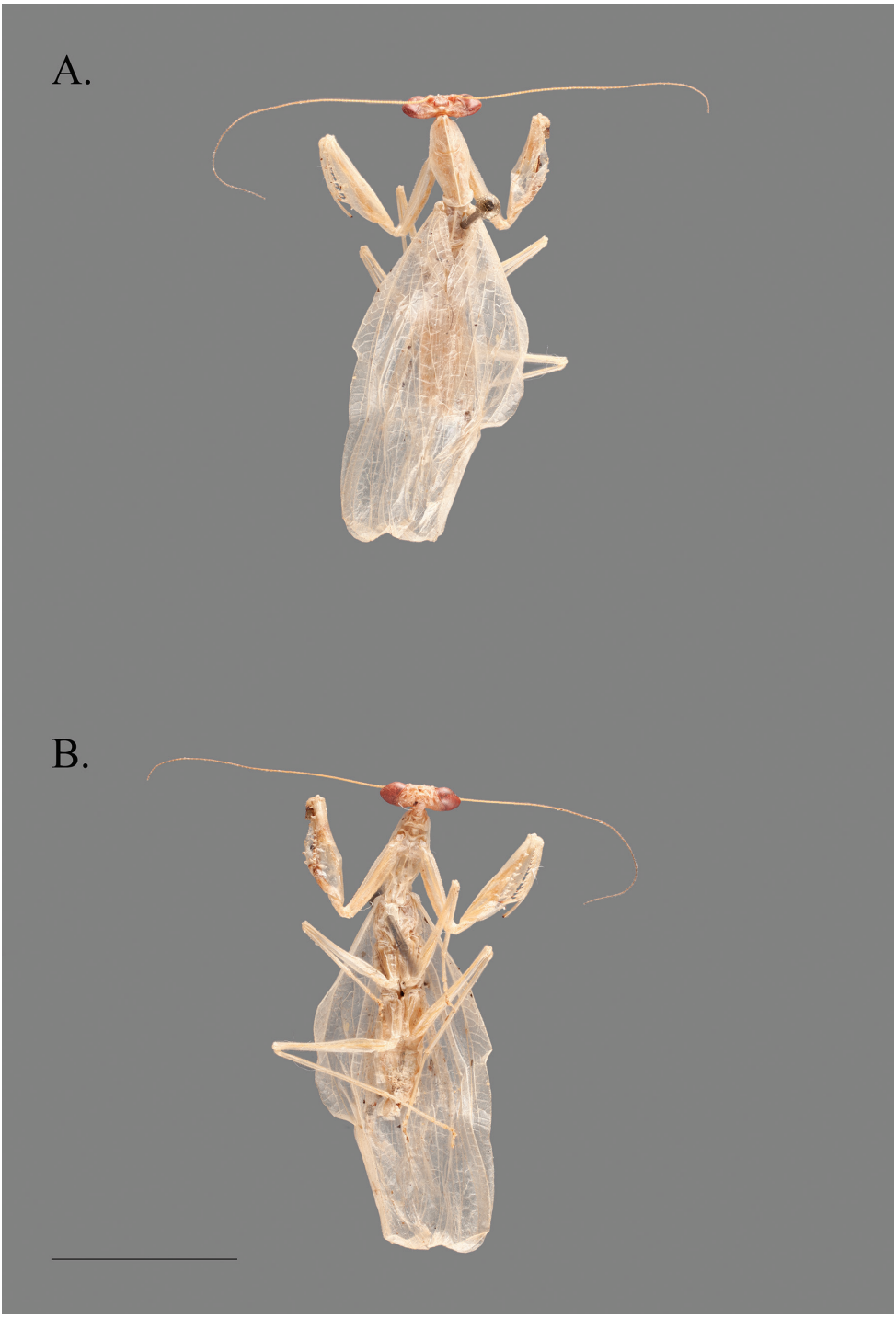

Figure 1. *Cornucollis masoalensis* gen.n., sp. n., male (scale bar = 10 mm). **A** dorsal habitus **B** ventral habitus.

Tropidomantinae

The genera belonging to the subfamily Tropidomantinae include *Tropidomantis* Stål, 1877, *Enicophlebia* Westwood, 1889, *Platycalymma* Westwood, 1889, *Hyalomantis* Giglio-Tos, 1915, *Negromantis* Giglio-Tos, 1915, *Melomantis* Giglio-Tos, 1915, *Neomantis* Giglio-Tos, 1915, *Xanthomantis* Giglio-Tos, 1915, *Kongobatha* Hebard, 1920, and *Chloromantis* Kaltenbach, 1998. While *Miromantis* Giglio-Tos, 1927 and *Oxymantis* Werner, 1931 belong to Tropidomantinae, their overall gross morphology is markedly distinct from the undescribed specimen in question and is therefore not considered here.

Tropidomantis differs in the following ways: compound eyes rounded; ventral cervical sclerite absent; pronotum anteriorly narrow with a distinct expansion at the supracoxal sulcus; pronotal lateral margins without distinct tapering in the posterior half of the metazone; foretibia with 8–10 posteroventral spines with sometimes the sixth spine extended; foretibial posteroventral spines relatively erect, slanted; male wings hyaline.

Enicophlebia differs in the following ways: compound eyes rounded; lateral cervical sclerite without mediolateral projection; pronotum with denticulate carina; foretibial spines relatively erect, slanted; forewings exceptionally broad at the base and distinctly creased proximal to the region of the pronounced pterostigma.

Platycalymma differs in the following ways: compound eyes rounded; cranial vertex does not retain an elevation in the shape of a truncated pyramid; lateral margins of the pronotum are smooth; medial keel of the pronotum does not traverse the length of the structure; male wings hyaline; male genital structure processo apical (**paa**) is variably granulated; male genital structure ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) features variable granulation, without smooth lateral outgrowths, and does not retain a narrow distal process (**pda**); male genital structure right phallomere (**R1**) features a simple right arm (**bm**) without outgrowths.

Hyalomantis differs in the following ways: compound eyes rounded; cranial vertical margin either straight or slightly concave medially that becomes laterally convex towards the circumocular margin; pronotum anterior without laterally expanded cuticular margins; lateral margin of the pronotum is smooth, slightly expanded in the metazone; foretibial posteroventral spines relatively erect, angled; male genital structure ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) without smooth lateral outgrowths and without a tapering, narrow distal process (pda); male genital structure right phallomere (**R1**) features a simple right arm (**bm**) without outgrowths.

Negromantis differs in the following ways: compound eyes rounded; cranial vertical margin straight or slightly higher than the compound eyes; juxtaocular bulges not retained; pronotum slender; pronotal medial keel not significantly pronounced; foretibiae thin, tubular, with 8–9 posteroventral spines.

Melomantis differs in the following ways: compound eyes rounded; cranial vertical margin straight with slight juxtaocular bulges; pronotum short and depressed; forewings significantly wider than the length of the pronotum, with arcuate margins.

Neomantis differs in the following ways: compound eyes rounded; cranial vertex higher than compound eyes; juxtaocular bulges protruding; pronotum broad with distinct expansion at the supracoxal sulcus; forewings significantly wide, wider than the length of the pronotum; foretibiae with 9–11 external spines; male forewings sub-hyaline.

Xanthomantis differs in the following ways: compound eyes rounded; cranial vertical margin straight or weakly concave, slightly higher than the compound eyes; pronotum relatively narrow, approximately as long as the forecoxae; supracoxal bulge distinct; metazone twice as long as the prozone; pronotal medial keel fine, extends just into the prozone; foretibial posteroventral spines of variable number and distribution.

Kongobatha differs in the following ways: head slightly wider than long; compound eyes rounded; cranial vertex higher than the compound eyes; juxtaocular tubercles angulate, blunted, and projecting; pronotum slender and relatively elongate, longer than the forecoxae; metazone almost twice as long as the prozone; supracoxal bulge present but not pronounced; pronotal medial keel fine; foretibiae with 9 erect, slanted posteroventral spines, the second and fourth spines proximal to the body relatively elongate; male forewings hyaline.

Chloromantisdiffers in the following ways: compound eyes rounded; cranial vertex straight, slightly higher than the compound eyes; juxtaocular bulges rounded and slightly projecting; pronotum short, distinctly rhombic; forewings significantly wider than the length of the pronotum; foretibiae with 8 erect, slanted posteroventral spines.

Nilomantinae

The genera included within the subfamily Nilomantinae include *Ilomantis* Saussure 1899, *Nilomantis* Werner, 1907, *Epsomantis* Giglio-Tos, 1915, and *Mimomantis* Giglio-Tos, 1915. Additionally, we will compare Ilomantis (Saussure, 1899), which is presently the junior synonym of *Nilomantis*, for a more thorough interpretation as *Nilomantis* and *Ilomantis* have an unstable taxonomic history. *Papugalepsus* Werner, 1928 belongs to Nilomantinae but the overall gross morphology of the genus is greatly distinct from the undescribed specimen in question and is therefore not considered here.

Ilomantis differs in the following ways: cranial vertical margin with pronounced bulges interior to the juxtaocular bulges, which are more elevated than the juxtaocular bulges themselves; pronotum narrow with a lateral margin that is very slightly extended around the perimeter; lateral cervical sclerites do not retain a horn-like marginal projection; ventral cervical sclerite not present; anteroventral tibial spines relatively erect, slanted; male wings hyaline; male genital structure lobo membranoso (**loa**) is smooth; male genital structure ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) features variable granulation, without

a sinistral lateral outgrowth; male genital structure right phallomere (**R1**) features a simple right arm (**bm**) without outgrowths.

Nilomantis differs in the following ways: cranial vertical margin straight; pronotum long and narrow with a lateral margin that is very slightly extended around the perimeter; lateral cervical sclerites do not retain a horn-like marginal projection; ventral cervical sclerite not present; anteroventral tibial spines relatively erect, slanted; male wings hyaline; male genital structure ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) terminates posteriorly into two lobes; male genital structure right phallomere (**R1**) features a simple right arm (**bm**) without outgrowths.

Epsomantis differs in the following ways: head not particularly wide; compound eyes rounded, slightly bulging; pronotal medial keel slight; forefemora with 5 posteroventral spines and 4 discoidal spines; forewings broad, costal area very broad at the base.

Mimomantis differs in the following ways: compound eyes rounded; cranial vertical margin straight with three tubercles on the vertex; pronotum long and narrow; pronotal medial keel does not traverse the prozone; forefemora with either 4–5 posteroventral spines (the posteroventral spine count variability is due to conflicting descriptions by Giglio-Tos (1915), Paulian (1957), and Ehrmann (2002)); foretibiae with 8–9 posteroventral spines, which are divergent basally; forewings hyaline, narrow, subparallel.

Nanomantinae

The genera included within the subfamily Nanomantinae include *Sceptuchus* Hebard, 1920 and *Sinomantis* Beier, 1933. While *Nanomantis* Saussure, 1871, *Fulcinia* Stål, 1877, *Tylomantis* Westwood,1889, *Calofulcinia* Giglio-Tos, 1915, *Fulciniella* Giglio-Tos, 1915, *Fulciniola* Giglio-Tos, 1915, *Pilomantis* Giglio-Tos, 1915, *Ima* Tindale, 1924, *Hedigerella* Werner, 1933, *Nannofulcinia* Beier, 1965, *Machairima* Beier, 1965, and *Parananomantis* Mukherjee, 1995 belong to Nanomantinae, the overall gross morphology of these genera are greatly distinct from the undescribed specimen in question and are therefore not considered here.

Sceptuchus differs in the following ways: compound eyes rounded, cranial vertical margin straight, juxtaocular bulges fully rounded, not projecting; pronotum slender and relatively elongate; supracoxal bulge distinct but slight; pronotal medial keel slight, not elevated; foretibia with 7 erect, slanted posteroventral spines; male forewings narrow, hyaline.

Sinomantis differs in the following ways: medium-sized; compound eyes rounded; juxtaocular bulges rounded and strongly protruding; pronotum narrow and relatively long, a denticulate elevated ridge traverses the metazone between the medial keel and each lateral pronotal margin; forecoxae with denticulaton; foretibiae with 9 erect, slanted posteroventral spines; forewings sub-hyaline.

The results of these generic-level diagnostic comparisons have lead us to conclude that the combination of characters observed on the undescribed specimen is unique and does not fit any of the diagnoses of previously described Iridopterygidae genera. Subsequently, we create a new genus to place this undescribed specimen.

***Cornucollis* gen. n.**
http://zoobank.org/EFDDB230-86BA-40FE-A684-21D43C0131DF

Etymology. We name the genus for the horn-like projections that extend from the lateral cervical sclerites of the cervical region.

Diagnosis. Compound eyes conical; cranial vertex concave with slight juxtaocular bulges. Ventral cervical sclerite present, arcuate; lateral cervical sclerites with blunted, horn-like mediolateral projection directed laterad. Pronotum relatively broad anteriorly but narrowly tapered in the posterior half of the metazone; pronotum with slight lateral cuticular expansions; pronotal medial keel distinctly elevated, traversing the entire length of the pronotum. Forefemora with 4 posteroventral spines and 3 discoidal spines; foretibial posteroventral spines procumbent.

Type species. *Cornucollis masoalensis* sp. n. here described.

***Cornucollis masoalensis* sp. n.**
http://zoobank.org/53024945-5633-4B20-AA94-2407DC74F0F1

Type. Holotype ♂ – Madagascar, Masoala, Tampolo battage canopée, 3–XI–2001, H. Barrios & D. Randriamasimanana (Muséum national d'Histoire naturelle, Paris, France).

Diagnosis. Small and relatively slender with dorsoventrally compressed cranium and likewise compressed, conical compound eyes. Pronotum length more than twice the width, relatively broad, with a slightly expanded lateral margin and deep tapering in the posterior half of the metazone; pronotal medial keel distinctly elevated, traversing the length of the pronotum. Cervical region with ventral sclerite; lateral cervical sclerite with a slightly blunted, horn-like mediolateral projection directed laterad. Anteroventral femoral spines with spineless region between distal penultimate and ultimate spine. Foretibial posteroventral spines procumbent. Forefemora = 3DS/10AvS/4PvS; Foretibiae = 12AvS/15PvS. Wings well-developed. Male genital complex with processo apical (**paa**) relatively smooth; lobo membranoso (**loa**) with sclerotized region of crenulation on the posterior margin; ventral sclerotization of the left phallomere complex (*i.e.* the ventral phallomere) (**L4A**) without granulation, with a distinct lateral outgrowth on both the dextral and sinistral margins, the posterior margin tapering into a narrow distal process (**pda**); right phallomere (**R1**) features a right arm (**bm**) with a sclerotized, acuminate outgrowth.

Description. ***Male.*** *Holotype.* Body length 24.22 mm; pronotum length 4.87; prozone length 1.98; pronotum width 2.18; pronotum narrow width 1.38; head width 4.22; head vertex to clypeus 1.61; frons width 1.4; frons height 0.31; prothoracic femur length 5.94; mesothoracic femur length 5.7; mesothoracic tibia length 3.38; mesothoracic tarsus length 3.022; metathoracic femur length 6.07; metathoracic tibia length 5.82; metathoracic tarsus length 4.61.

Head (Fig. 2). Patch of darkly colored speckles present on either side of the parietal sutures, near the vertical margin. Hypognathous. Juxtaocular bulges present, highlighted by parietal sutures. Head dorsoventrally compressed with likewise compressed, laterally conical compound eyes with blunted posterolateral margins. Cranial vertical margin margin is variably ciliated and cosinusoidal, the medial region strongly concave. Four gently sloping carinal ridges on the vertex (two of which originate from the mid-vertex, the other two originate from the mid-ocular region) converge into an elevation on the posteromedial vertex in the shape of a truncated pyramid, which is slightly bisected apically by the coronal suture. Vertex slightly concave posterior to the lateral, paired ocelli. Ocelli are situated atop an ocellar hill (*i.e.*, an elevated region of cuticle). Lateral, paired ocelli are larger in size, amber in color, and relatively more oblong than the unpaired, median ocellus which is relatively smaller, yellow, and approximately spherical. Lower frons transverse, the anterior margins of the structure closely abutting the posterior half of the circumantennal sclerites and the posterior half of the unpaired, median ocellus. Clypeus broad. Labrum approximately rounded along the anterior margin. Maxillary and labial palpi pale. Compound eye pigmentation darker than cuticle of the cranium. Antennae long and filiform, lightly ciliated, tapered distally.

Thorax. Pronotum broad (Fig. 3); socketed setae project from perimeter. Lateral margin of the pronotum (LMP) relatively expanded around the circumference of the prozone and anterior metazone; LMP distinctly tapered in the posterior region of the metazone. Pronotal medial keel, elevated, traversing the length of pronotum. Region of pronotal medial keel is elevated, sloping down to LMP. Prozone with bilaterally symmetric sculpting, which taper to just prior to LMP expansion. Anterior metazone features a slight indentation on either side of the medial keel. Metazone posterior margin elevated into a shelf which extends slightly over the anterior margin of the mesothorax. The cervix bears lateral cervical sclerites and intercervical sclerites; one ventral cervical sclerite is present, arcuate, traversing the space between the lateral cervical sclerites (Fig. 4). The anterior portions of the lateral cervical sclerites extend just past the anterior-most region of the prozone and are lightly ciliated; Lateral cervical sclerite mediolateral margin features a distinct, horn-like acumination (Fig. 4). A furcasternal tubercle projects medially at the base of the T-shaped sclerite, posterior to the prothoracic coxae; surfaced with sternal hairs. DK hearing organ present on metathoracic ventral surface (See Yager and Svenson 2008 for hearing organ description). Wings well-developed, extending beyond base of abdominalia, opaque; relatively long cilia project along anterior portion of costal margin and relatively short cilia densely surface both the dorsal and ventral wing surface.

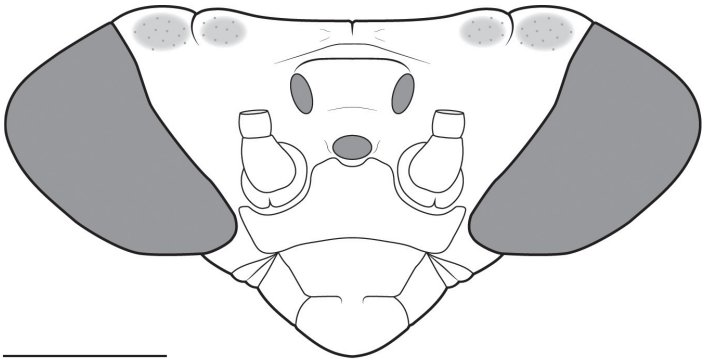

Figure 2. Illustration of anterior perspective of the cranium of *Cornucollis masoalensis* gen.n., sp. n., male (scale bar = 1 mm).

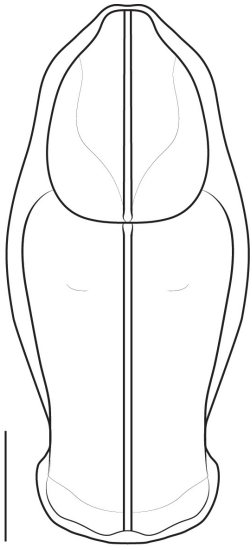

Figure 3. Illustration of dorsal perspective of the pronotum of *Cornucollis masoalensis* gen.n., sp. n., male (scale bar = 1 mm).

Prothoracic legs. Prothoracic legs are moderately surfaced with cilia and socketed setae. The forecoxae are long, extending past the base of the pronotum; postero- and anteroventral margins with socketed setae; apical lobes convergent with anterior lobe squared and posterior lobe rounded. Forefemora with a slightly arcuate dorsal margin that narrows distally. Posteroventral femoral spines robust and darkened at the apex, interspersed with cilia, socketed setae, and a row of crenulation along the posteroventral margin. Femoral genicular lobe with a moderately sized, slightly curved spine. Tibial spur groove deeply recessed, lying between first discoidal spine and the

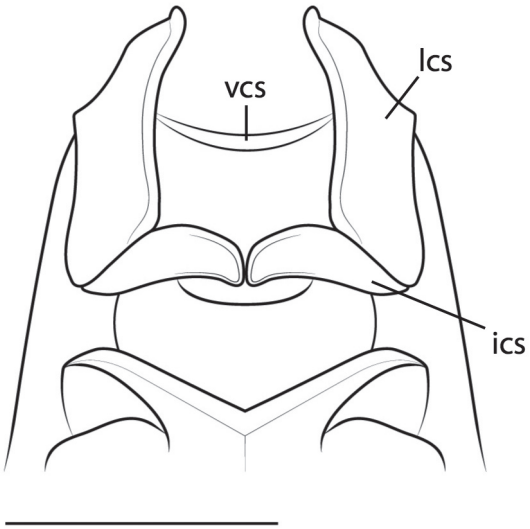

Figure 4. Illustration of the cervical sclerites of *Cornucollis masoalensis* gen.n., sp. n., male (scale bar = 1 mm). Abbreviations: **ics** = intercervical sclerites; **lcs** = lateral cervical sclerites; **vcs** = ventral cervical sclerite.

first anteroventral femoral spine. Anteroventral femoral spines alternate in size from medium to small in the following formation: IiIiIiIiII, with a spineless region between the distal penultimate and ultimate posteroventral femoral spines; spines darkened apically. The second discoidal spine is significantly longer than the first and third. Foretibiae moderately surfaced with cilia. Posteroventral tibial spines procumbent (Fig. 5); spines darkened apically; anteroventral tibial spines gradually elongate towards the tibial spur; spines darkened apically. Foretarsi unknown due to specimen damage. F= 3DS/10AvS/4PvS; T= 12AvS/15PvS.

Meso- and metathoracic legs. Meso- and metathoracic legs densely ciliated across surface. Posteroventral carina on the margin of the meso- and metafemora. Genicular lobes of the femora lacking spines. Tibiae tubular, featuring an apical lobe and two apical spurs. Tarsi 5-segmented with an enlarged penultimate euplantulae; darkened ungues.

Abdomen. Smooth, tubular, surface densely ciliated. Supraanal plate triangular, extremely narrow, ciliated; cerci long, ciliated, compressed, tapering to a point; subgenital plate terminating into two divergent rounded lobes, each featuring a short, ciliated stylus.

Genitalia (Fig. 6). Dorsal sclerotization of the left phallomeric complex (*i.e.*, the left phallomere) is fairly narrow anteriorly, broadening towards the posterior margin; anterior process (**ap**) of **L4B** is compact, recurved anteriorly; **ap** anterior margin heavily sclerotized; Apical process (**paa**) of **L2** is strongly dilated on the anterior margin of its visible "base," recurved distally, narrow; **paa** with a rounded apical margin. Lobo membranoso (**loa**) relatively short, a heavily sclerotized region of crenulation projects

Figure 5. Arrow indicates procumbent posteroventral foretibial spine arrangement of *Cornucollis masoalensis* gen.n., sp. n., male (scale bar = 1 mm).

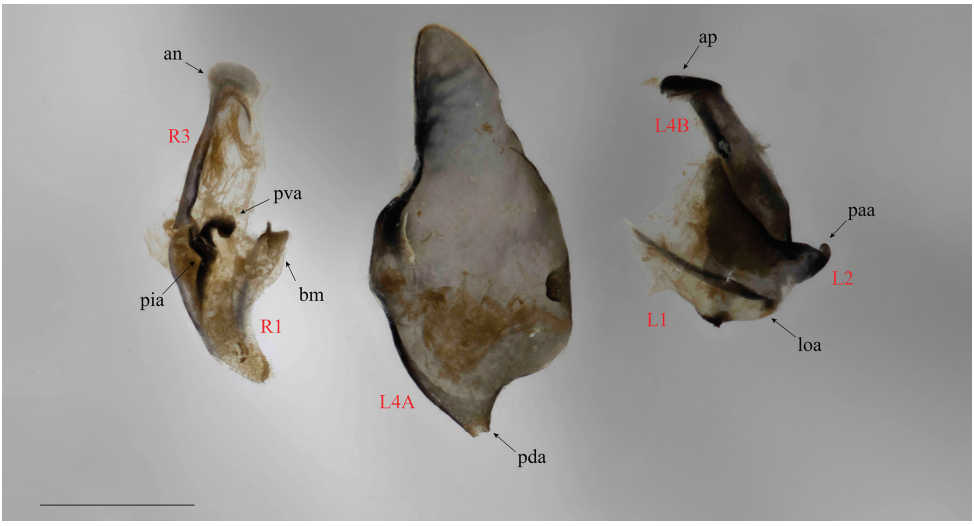

Figure 6. *Cornucollis masoalensis* gen.n., sp.n male genital complex. Right phallomeric lobe and dorsal sclerotization of the left phallomeric complex (*i.e.*, the left phallomere) are pictured in the ventral perspective; the ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) is shown in the dorsal perspective (scale bar = 1 mm). Abbreviations: **an** = anterior apodeme; **ap** = anterior process; **bm** = right arm; **L1, L2, L4B** = a sub-sclerite of the dorsal sclerotization of the left phallomeric complex; **L4A** = the ventral sclerotization of the left phallomeric complex; **loa** = lobo membranoso; **paa** = apical process; **pda** = distal process; **pia** = piastra ventrale; **pva** = processo ventrale sclerificato; **R1** = a sub-sclerite of the right phallomere; **R3** = a sub-sclerite of the right phallomere.

from the posteromedial margin. Ventral sclerotization of the left phallomere complex (*i.e.*, the ventral phallomere) (**L4A**) is narrow and rounded anteriorly, with a moderately sclerotized sinistral margin; **L4A** medial sinistral margin features a distinct, broad outgrowth; **L4A** posterior region tapers dextrally into a relatively narrow distal process (**pda**); **L4A** posterodextral margin is broad; **L4A** dextral margin moderately sclerotized with a relatively small outgrowth. Anterior apodeme (**an**) of **R1** is significantly rounded anteriorly with a moderately sclerotized sinistral margin; processo ventrale sclerificato (**pva**) is strongly curved and slightly tumescent, the structure is heavily sclerotized along the posterior margin; piastra ventrale (**pia**) is relatively linear in shape with a slightly slanted anterior margin. **R1** posterior region is narrow, lightly ciliated with a tapered, rounded posterior margin; the right arm (**bm**) with a distinct anterior sclerotization that features an acuminate projection.

Etymology. This species is named for the Masoala peninsula of Madagascar, the region where the specimen was collected.

Natural history. Specimen was collected in June in Tampolo, Masoala, Madagascar by beating the canopy of an unknown tree.

Key to the Malagasy Tropidomantinae and Nilomantinae Genera

1 Compound eyes conical in shape, dorsoventrally compressed **2**

– Compound eyes rounded..... **3**

2 Cranial vertex cosinusoidal with slight juxtaocular bulges; enlarged protuberances interior to the parietal suture present; ventral cervical sclerite absent.... ..... ***Ilomantis*** **(Saussure, 1899)**

– Cranial vertex concave with juxtaocular bulges; protuberances interior to the parietal suture not retained; ventral cervical sclerite present..... ***Cornucollis*** **gen. n.**

3 Wings well-developed with pronounced pterostigma; forewings with distinct crease around pterostigmatic region ..... ***Enicophlebia*** **Westwood, 1889**

– Wings well-developed without pronounced pterostigma; forewings without crease around pterostigmatic region **4**

4 Cranial vertex with juxtaocular bulges; pronotum generally broad in size ... **5**

– Cranial vertex without juxtaocular bulges; pronotum generally narrow in size..... **6**

5 Forecoxae equal to or less than the length of the pronotum; forewing costal region relatively narrow; the subcostal vein lies near the radial vein in the proximal half, diverging distally; female abdomen is relatively widened without lateral expansions of the tergites; supraanal plate approximately as long as wide, triangular in shape but blunted apically; darkened color patches may be present on the lower frons, foretibiae, pronotum, and forewings .... ***Hyalomantis*** **Giglio-Tos, 1915**

– Forecoxae significantly longer than the metazone of the pronotum; forewing with broadened costal region, which is a more pronounced feature in females; the subcostal vein lies near the radial vein; female abdomen is relatively wid-

ened with lateral, acuminate expansions of the tergites; supraanal plate elongate, triangular; darkened color patches not present..... ..... ***Platycalymma*** **Westwood, 1889**

6 Forewings narrow, margins approximately parallel..... ..... ***Mimomantis*** **Giglio-Tos, 1915**

– Forewings narrow with anterior margin slightly rounded..... ..... ***Negromantis*** **Giglio-Tos, 1915**

Conclusion

An undescribed praying mantis specimen from Madagascar was observed in the entomological collection of the Muséum national d'Histoire naturelle, Paris, France. As the specimen features the following external morphological traits (small overall body size, well-developed wings, a cranial vertex with juxtaocular tubercles, and lobeless meso- and metathoracic legs), the specimen was able to be placed among other members within the family Iridopterygidae. Due to the specimen's external morphological characters and Afrotropical distribution, we investigated genera within the subfamilies Tropidomantinae, Nilomantinae, and Nanomantinae to determine its generic-level placement. However, further study of this insect revealed a unique combination of external and internal morphological features that are not featured in present genera. These characters include a concave cranial vertex, the presence of a ventral cervical sclerite, lateral cervical sclerites with blunted, horn-like outgrowths, procumbent posteroventral tibial spines, among others. Therefore, the new genus *Cornucollis* gen. n. was created for this undescribed species *C. masoalensis* sp. n. Further field work to uncover the undescribed female conspecific, nymphs, and oothecae, will complement the description of this new genus and species.

Acknowledgments

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RESEARCH ARTICLE

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Records of *Hedotettix* and *Teredorus* in Thailand with the description of three new species (Orthoptera, Tetrigidae)

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Abstract

We are studying the fungi associated with insects in northern Thailand and as a result several rarely collected insect species have been uncovered. The genera *Hedotettix* with one new species and *Teredorus* with two new species are reported from Thailand. *Hedotettix triangularis* Zha & Hyde, **sp. n.**, *Teredorus chiangraiensis* Zha & Hyde, **sp. n.** and *Teredorus combfemorus* Zha & Hyde, **sp. n.** are introduced, described and photographed and compared with other species. Keys to species of *Hedotettix* and *Teredorus* from Thailand are provided.

Keywords

Tetriginae, taxonomy, pygmy grasshopper, newly recorded genus, biology, Chiang Rai

Introduction

The genera *Hedotettix* and *Teredorus* belong to Tetriginae, Tetrigidae of Orthoptera. *Hedotettix* includes 46 species (Ou et al. 2014, Zheng 2014a, 2014b, Eades et al. 2015), and has a worldwide distribution; only one species, *Hedotettix gracilis* (De Haan, 1843)

is known from Thailand (Ingrisch 2001, Zheng 2005, 2014a). *Teredorus* includes 29 species; although they mainly occur in South America, China, India and Nepal (Deng et al. 2014), there are no records of this genus in Thailand.

The aim of this paper is to report two species of *Hedotettix* and two of *Teredorus* from Thailand. *Hedotettix triangularis* Zha & Hyde, sp. n., *Teredorus chiangraiensis* Zha & Hyde, sp. n. and *Teredorus combfemorus* Zha & Hyde, sp. n. are described and illustrated as new to science and compared with other similar species. Keys to species of both *Hedotettix* and *Teredorus* in Thailand are provided.

Material and methods

Specimens were examined and photographed using a stereo microscope (Olympus Corporation, SZX16, Tokyo, Japan). Morphological terminology and measurements follow those of Vickery and Kevan (1983) and Zheng (2005). Measurements are given in millimeters (mm). Holotypes are deposited in the herbarium of Mae Fah Luang University (MFLU), Chiang Rai, Thailand, paratypes and research specimens in both MFLU and the Specimen Room of the School of Life Sciences, Huaibei Normal University (HNU), Huaibei, Anhui, China.

Taxonomy

Hedotettix Bolivar, 1887 in Thailand

Key to species of *Hedotettix* Bolivar, 1887 in Thailand

1 Anterior margin of pronotum slightly obtusely protruding; apex of posterior angle of lateral lobe of pronotum rounded; hind process reaching middle of hind tibia; upper valvula of female ovipositor narrow and elongate, 3.5 times as long as wide ..... ***Hedotettix gracilis* (De Haan, 1843)**

– Anterior margin of pronotum truncate; apex of posterior angle of lateral lobe of pronotum acutely angled or very short truncate; hind process reaching one third of hind tibia; upper valvula of female ovipositor broad and short, only 2.5 times as long as wide..... ***Hedotettix triangularis* sp. n.**

Hedotettix gracilis (De Haan, 1843)

Specimens examined. 1 female (No. 15-0624, MFLU) and 2 female (HNU), Thailand, Chiang Rai, 31 Oct. 2014, collected by ZHA Ling-Sheng.

Distribution. Thailand (Chiang Rai).

***Hedotettix triangularis* Zha & Hyde, sp. n.**
http://zoobank.org/76583B54-E7B9-43D6-8D4E-D8FF4529AA77
Figs 1–2

Diagnosis. *Hedotettix triangularis* sp. n. is similar to *H. gracilis* (De Haan, 1843) (Zheng 2005), the former differs from the latter by: 1) anterior margin of pronotum truncate (Fig. 2B); 2) apex of posterior angle of lateral lobe of pronotum acutely angled or very short truncate, not rounded; 3) hind process short, reaching one third of hind tibia (Fig. 1B, C); 4) upper valvula of female ovipositor distinctly short, only 2.5 times as long as wide (Fig. 2E).

Description. Female. Body size medium.

Head. Head not protruding over level of pronotal surface, vertex 1.1 times as wide as one eye; anterior margin of vertex arcuate, protruding forward and slightly surpassing beyond anterior margins of eyes, lateral margin distinctly folded upwards; median carina protruding forward and surpassing beyond anterior margin of vertex, conspicuous in anterior half while obscure or disappearing in posterior half, both sides of median carina distinctly concave (Fig. 2B); vertex together with frontal ridge rounded, which is visible before eyes in profile, not concave between lateral ocelli (Fig. 2D); longitudinal furrow decidedly narrower than width of first segment of antenna (0.7–0.8 times), and nearly parallel below level of antennae (Fig. 2A); antenna filiform and short, 16-segmented, length of a segment in middle about 4 times its width, inserted slightly above level of lower margins of eyes (Fig. 2A); eyes globose, lateral ocellus situated slightly above middle of inner margin of eye (Fig. 2A).

Thorax. Anterior margin of pronotum truncate, midkeel of pronotum complete and distinct (Figs 1B, 2B); pronotal disc smooth, with numerous fine granules, pronotum slightly tectiform in anterior half and long cone-shaped in posterior half (Fig. 1A, B); in profile upper margin of pronotum arcuate in anterior half (the highest point located between transverse sulcus) while straight in posterior half (Fig. 1A); lateral keels of prozona conspicious and parallel; shoulders broad, then gradually constricted backward; abbreviated carinae elongate or shortened, and present, obscure or absent between shoulders; humeral angle obtusely angled; length of distal part of hind process which surpass beyond apex of hind femur 1.5–2.0 mm, reaching one third of hind tibia (Fig. 1B); posterior angle of lateral lobe of pronotum extending downwards, nearly triangulate, apex acutely angled or very short truncate backwards, posterior margin of each lateral lobe with two concavities; visible part of tegmina ovate, 2.5–2.6 times as long as wide (Fig. 1A); length of distal part of hind wing which surpass beyond apex of hind process of pronotum 1.3–1.8 mm, and reaching about two thirds of hind tibia (Fig. 1A, B); fore femur slender and cylindrical, upper and lower margins straight; upper margin of mid femur slightly undulate, lower margin undulate; middle femur flat, distinctly narrower than width of visible part of tegmen (Fig. 1A); upper and lower margins of mid and hind femora finely dentate, hind femur about 3.0 times as long as wide; antegenicular denticles nearly right angled, genicular denticles fingered extending backward and apex triangulate (Fig. 1A); outer side of hind tibia with 9–11 spines,

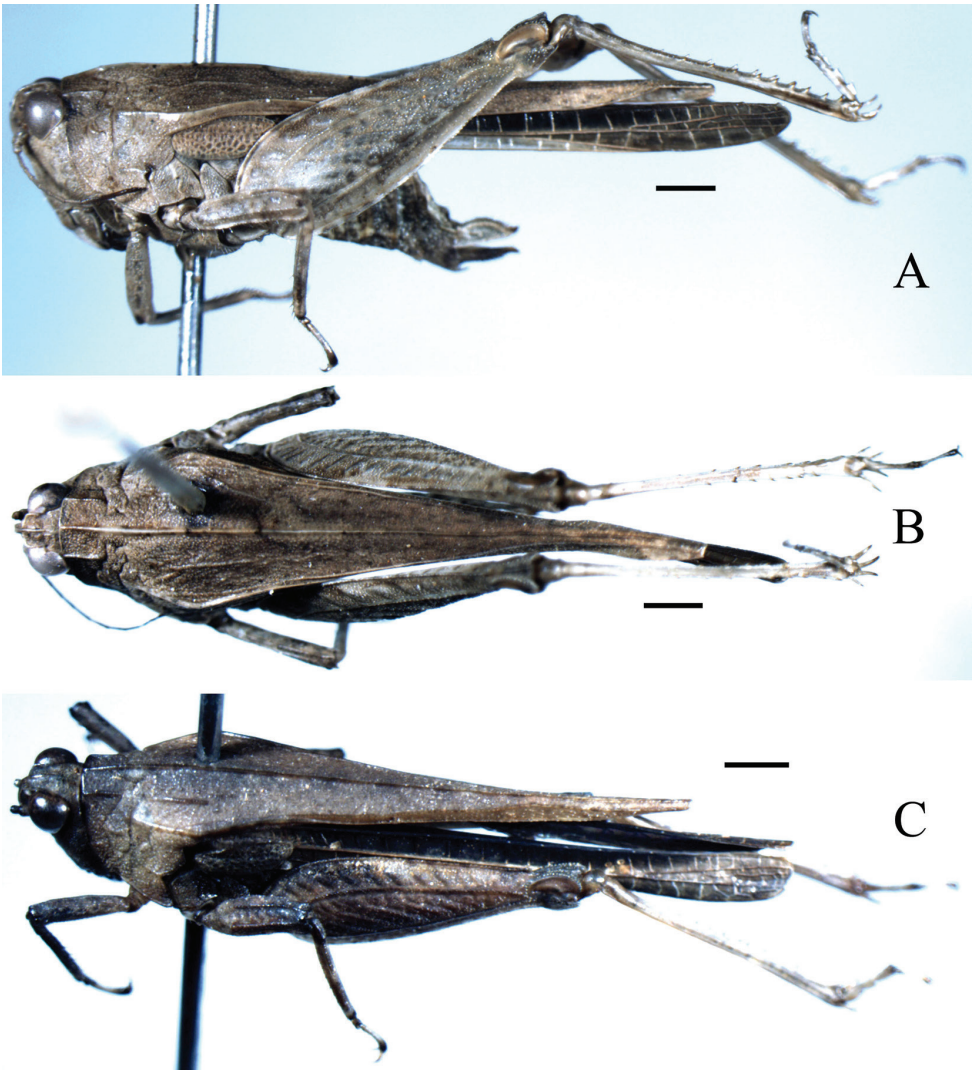

Figure 1. *Hedotettix triangularis* sp. n.: **A** lateral view of female **B** dorsal view of female **C** oblique view of male. Scale bars: 1.0 mm.

inner side with 6–9 spines; first hind tarsal segment about 2 times third in length, third pulvillus longer than first and second, apices of first and second pulvilli sharp, apex of third pulvillus nearly right angled.

Abdomen. Ovipositor: upper valvula about 2.5 times as long as wide, outer margins of upper and lower valvulae with small saw-like teeth (Fig. 2E); posterior margin of subgenital plate truncate, in the middle acutely triangularly protruding, which is slightly folded inward (Fig. 2C).

Coloration. Body yellowish brown. Antenna yellowish brown and distal segments dark brown; hind wings dark brown; for and mid tibiae with 3 obscure dark brown

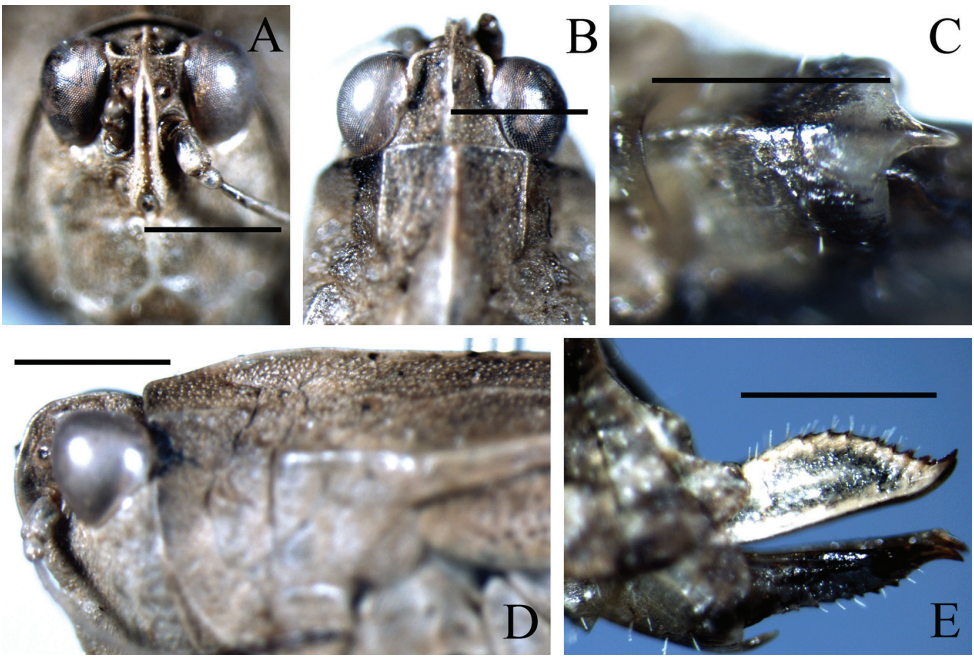

Figure 2. Female of *Hedotettix triangularis* sp. n.: **A** frontal view of head **B** dorsal view of head and anterior pronotum **C** ventral view of subgenital plate **D** lateral view of head and anterior pronotum **E** lateral view of ovipositor. Scale bars: **A–B, D–E**:1.0 mm, **C**: 0.5 mm.

bands (basal and middle bands small while distal band big) respectively; hind tibia light yellowish brown, distal part obscure dark brown.

Male. Body size slightly smaller and slender than female (Fig. 1C). Antenna 15-segmented; middle femur: slightly narrowing from basal to distal side, basal part slightly thicker than distal part, upper margin slightly arcuate and lower margin nearly straight, slightly wider than visible part of tegmen; subgenital plate: cone-shaped, apex notched and not bidentate. Other characters same as female.

Measurements. Length of body ♂7.0–8.0 mm, ♀9.0–10.5mm; length of pronotum ♂9.3–9.8 mm, ♀10.8–11.5 mm; length of hind femur ♂4.5–5.0 mm, ♀5.5–6.0 mm.

Type material. Holotype female (Nos. 15-0625, MFLU), Thailand, Chiang Rai, N20°16'17", E99°48'13", 1076.4 m alt, 30 Sep. 2014, collected by Ling-Sheng ZHA. Paratypes: 2 males and 1 female (Nos. 15-0626, 15-0627, 15-0628, MFLU) and 1 male (HNU), same data as holotype; 2 males and 2 females (HNU), Thailand, Chiang Rai, N20°9'16", E99°37'21", 1504.2 m alt, 22 Oct. 2014, collected by Ling-Sheng ZHA.

Biology and ecology. *Hedotettix triangularis* sp. n. inhabits open meadow in tropical regions. Color of margin of pronotum green when alive which is just like color of the meadow where they inhabit. From collecting time we infer they overwinter as adults.

Etymology. This new species' name derives from Latin *triangular*, which means posterior angles of lateral lobes of pronotum triangulate.

Distribution. Thailand (Chiang Rai).

Teredorus Hancock, 1907

Type species. *Teredorus stenofrons* Hancock, 1907, southern America, by original designation.

Note. *Teredorus* Hancock, 1907, is newly recorded genus for Thailand.

Key to species of *Teredorus* Hancock, 1907 in Thailand

1 Lateral keels of prozona normal, slightly shorter than width between them; hind process of pronotum short, never reaching two thirds of hind tibia; lower margins of fore and mid femora normal, not comb-shaped; lower outer side of hind femur distinctly black ..... ***Teredorus chiangraiensis* sp. n.**

– Lateral keels of prozona short, only 0.5 time as long as width between them; hind process of pronotum elongate, reaching three quarters of hind tibia; lower margins of fore and mid femora comb-shaped; lower outer side of hind femur partially dark brown ..... ***Teredorus combfemorus* sp. n.**

Teredorus chiangraiensis Zha & Hyde, sp. n.

http://zoobank.org/BC3DACC8-22A7-4507-917D-6BA32729B6FF

Figs 3–4

Diagnosis. *Teredorus chiangraiensis* sp. n. is similar to *T. combfemorus* sp. n., the former differs from the latter mainly by: 1) lateral keels of prozona slightly shorter than width between them (Fig. 4A), while only 0.5 time occurs in the later (Fig. 6D); 2) hind process of pronotum short, never reaching two thirds of hind tibia (Fig. 3A, C); 3) lower margins of fore and mid femora normal, not comb-shaped; 4) lower outer side of hind femur distinctly black (Fig. 3A, C) (also see in Table 1).

Description. Female. Body size small and slender, length of body (from vertex to apex of hind process) about 3.3 times its width (between posterior angles of lateral lobes of pronotum) (Fig. 3B).

Head. Head distinctly protruding over level of pronotal surface (Fig. 4D); in dorsal view, vertex strongly contracted forward, two eyes nearly connected with each other on anterior margin of vertex, vertex not protruding beyond anterior margins of eyes; lateral margins folded upward and up to same height as anterior part of median carina; median carina conspicuous and protruding in anterior half, while obscure in posterior half (Fig. 4A); vertex a little visible before eyes in lateral view, vertex together with frontal ridge right angled, frontal ridge straight and not concave between lateral ocelli, slightly arc-protruding between antennae (Fig. 4D), longitudinal furrow narrower than first segment of antenna in width; antenna filiform, 16-segmented, inserted below lower margin of eyes (Fig. 4B), mid segment 5–6 times as long as wide; eyes globose, erected above level of pronotal surface, lateral ocellus situated on one fifth of lower inner margin of eye (Fig. 4B, D).

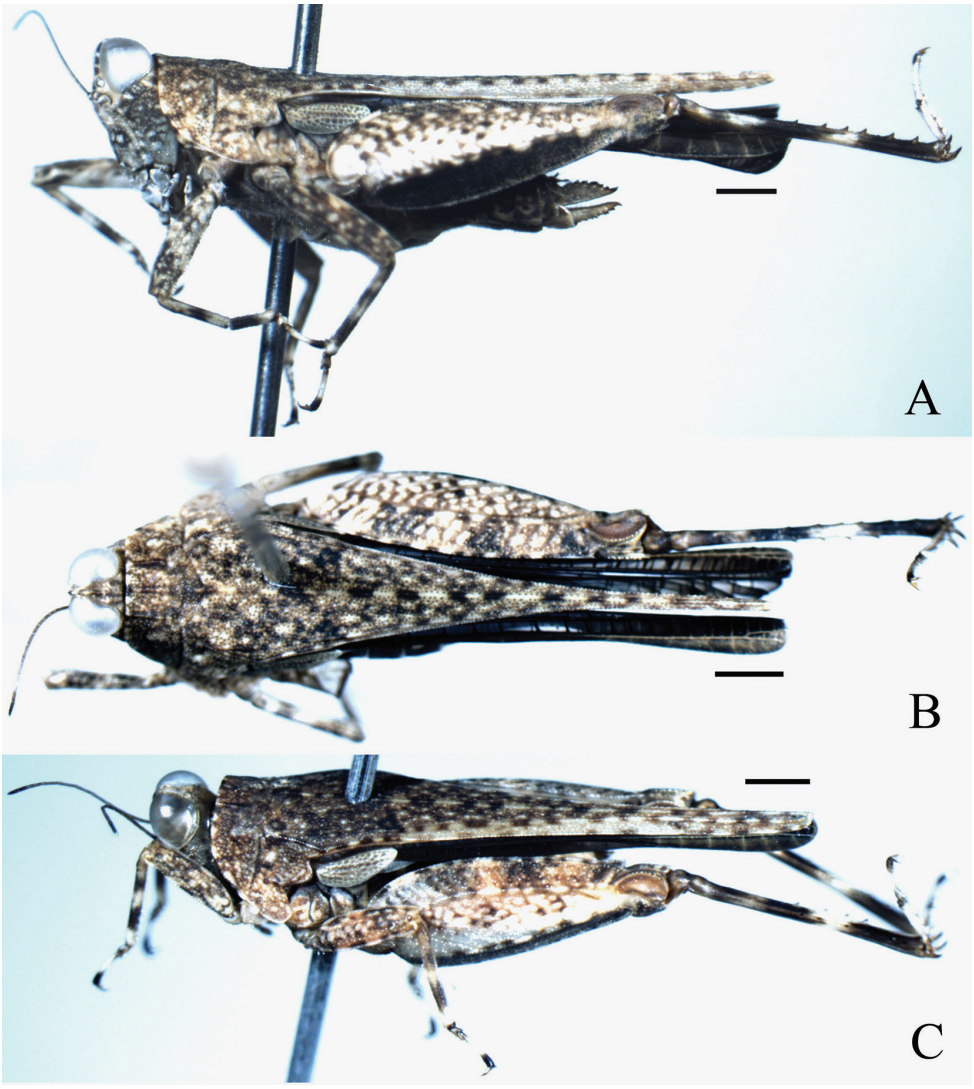

Figure 3. *Teredorus chiangraiensis* sp. n.: **A** lateral view of female **B** dorsal view of female **C** oblique view of male. Scale bars: 1.0 mm.

Thorax. Disc of pronotum smooth, with numerous small granules, midkeel of pronotum complete; in profile upper margin of pronotum straight, only a little protruding before shoulders (Fig. 3A, B); anterior margin of pronotum truncate, lateral keels of prozona conspicuous and parallel (Fig. 4A), humeral angle obtusely angled, abbreviated carinae absent between shoulders; hind process of pronotum narrow, long cone-shaped, surpassing beyond apex of hind femur and not reaching or slightly surpassing beyond middle of hind tibia (length of distal part which surpass beyond apex of hind femur variable between 1.5 and 2.5 mm, pronotum 4.0–5.7 times as long as the distal part)

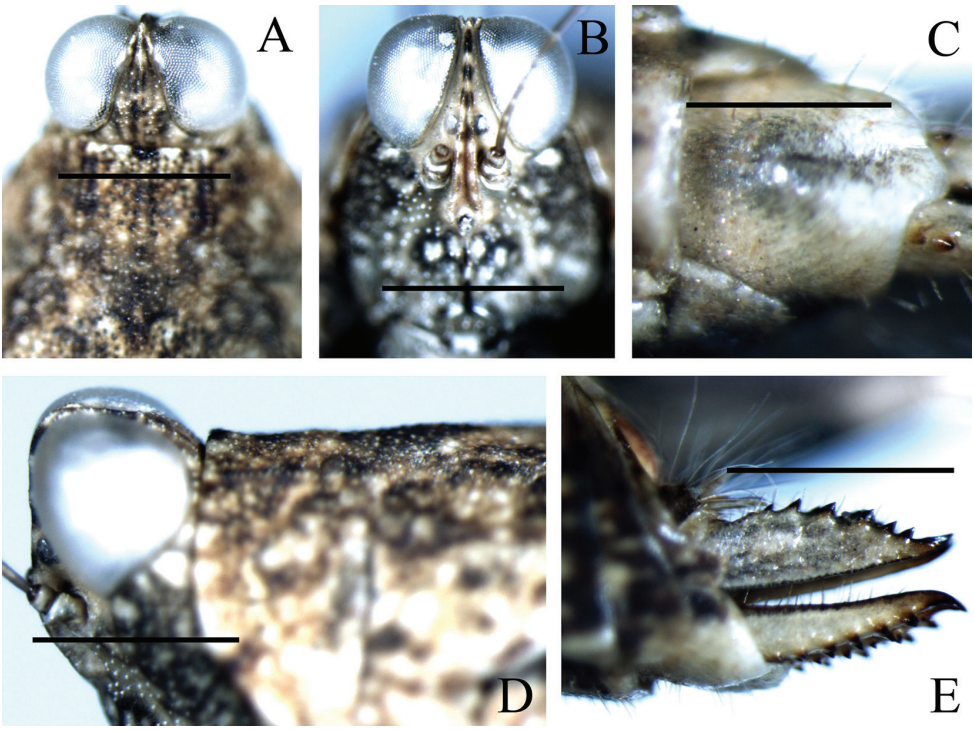

Figure 4. Female of *Teredorus chiangraiensis* sp. n.: **A** dorsal view of head and anterior pronotum **B** frontal view of head **C** ventral view of subgenital plate **D** lateral view of head and anterior pronotum **E** lateral view of ovipositor. Scale bars **A–B, D–E**: 1.0 mm, **C**: 0.5 mm.

Table 1. Main differences among *Teredorus chiangraiensis* sp. n., *T. combfemorus* sp. n. and *T. choui* Zheng, Ou & Lin, 2012.

Characters	*T. chiangraiensis*	*T. combfemorus*	*T. choui*
Lateral ocellus situated on inner margin of eye	Lower 1/5	Lower 1/4	Nearly in the middle
Width of longitudinal furrow than width of 1st segment of antenna	Narrower	Equal	Wider
Lateral keel of prozona	Normal (slightly shorter than width between them)	Short, 0.5 time the width between them	Short
Distal part of hind process which surpass apex of hind femur	1.5–2.5 mm	3.3 mm (♀)	♂3.5–4.0 mm, ♀ 2.8–3.0 mm
Apex of posterior angle of lateral lobe of pronotum	Nearly truncate	Nearly truncate	Rounded
Lower margins of fore and mid femora	Normal	Comb-shaped	Normal
Color of lower outer side of hind femur	Black	Partially dark brown	The same color as body
Upper valvulae of female	3.0 times its width	3.0 times its width	2.0 times its width

(Fig. 3B); posterior angle of lateral lobe of pronotum extending downwards, apex nearly truncate, posterior margin of each lateral lobe with two concavities; visible part of tegmina ovate, apex narrowly rounded, 2.8 times as long as wide; hind wings developed, reaching or slightly surpassing beyond apex of hind process of pronotum (Fig. 3A, B); upper and lower margins of all femora finely dentate; upper margin of fore femur slightly arcuate, distal part of lower margin slightly concave; upper margin of mid femur nearly straight, lower margin slightly undulate; mid femur slightly wider than visible part of tegmen; hind femur about 3.1 times as long as wide, antegenicular triangulate, genicular denticles fingered extending backward and apex triangulate; outer side of hind tibia with 6–7 spines, inner side with 4–5 spines; first segment of posterior tarsus equal to third in length, three pulvilli nearly equal in length, apices of all pulvilli obtuse.

Abdomen. Ovipositor: upper valvula about 3.0 times as long as wide, outer margins of upper and lower valvulae with small saw-like teeth (Fig. 4E); posterior margin of subgenital plate truncate and in the middle triangularly protruding which is folded inward (Fig. 4C).

Coloration. Body dark brown. Antenna brown, colour of distal segments deep; hind wings black; all femora with the same color as body; lower outer side of hind femur black, inner side of hind femur yellowish brown; all tibiae yellowish brown, with 3 black bands respectively (basal band small while middle and distal bands big).

Male. Slightly smaller than female (Fig. 3C). Antenna 15-segmented Hind femur slightly stubby, about 2.8 times as long as wide; subgenital plate briefly cone-shaped, apex notched and not bidentate. Other characters same as female.

Measurements. Length of body (from vertex to apex of abdomen) ♂6.5–7.0 mm, ♀8.0–8.5 mm; length of pronotum ♂8.5–10.0 mm, ♀9.3–10.0 mm; length of hind femur ♂4.7–5.0 mm, ♀5.2–5.5 mm.

Type material. Holotype female (Nos. 15-0629, MFLU), Thailand, Chiang Rai, N20°19'43", E 99°51'49", 404.4 m alt, 25 Nov. 2014, collected by Ling-Sheng ZHA. Paratypes: 2 males and 1 female (Nos. 15-0630, 15-0631, 15-0632, MFLU), 3 males and 2 females (HNU), same data as holotype.

Biology and ecology. *Teredorus chiangraiensis* Zha & Hyde, sp. n. inhabits stony place on border of a stream in tropical region. From collecting time we infer they overwinter as adults.

Etymology. This new species is named after Chiang Rai, its type locality.

Distribution. Thailand (Chiang Rai).

Teredorus combfemorus Zha & Hyde, sp. n.

http://zoobank.org/7E2D87D4-CBBE-47D3-A479-F4F0A6595E8A

Figs 5–6

Diagnosis. *Teredorus combfemorus* sp. n. is similar to *T. choui* Zheng, Ou & Lin, 2012, the former differs from the latter mainly by: 1) lateral ocellus situated on a quarter of lower inner margin of eye (Fig. 6A); 2) apex of posterior angle of lateral lobe

of pronotum nearly truncate (Fig. 5A, C), not rounded; 3) lower margins of fore and mid femora comb-shaped (Fig. 6F, G); 4) upper valvulae of female 3.0 times as long as wide (Fig. 6E) (also see in Table 1).

Description. Female. Body size small and slender, length of body (from vertex to apex of hind process) 3.5 times its width (between posterior angles of lateral lobes of pronotum) (Fig. 5B).

Head. Head distinctly protruding over level of pronotum; in dorsal view, vertex strongly contracted forward and two eyes nearly connected with each other on anterior margin of vertex, vertex not protruding beyond anterior margins of eyes; lateral margins folded upward and up to the same height as anterior median carina; median carina conspicuous and protruding in anterior half, while obscure in posterior half (Fig. 6D); vertex a little visible before eyes in lateral view, vertex together frontal ridge forming right angled, frontal ridge straight and not concave between lateral ocelli, slightly arc-protruding between antennae (Fig. 6C), longitudinal furrow nearly as wide as first segment of antenna; antenna filiform, 15-segmented, inserted below lower margins of eyes (Fig. 6A), mid segment 5–6 times as long as wide; eyes globose, erected above level of pronotal surface, lateral ocellus situated on a quarter of lower inner margin of eye (Fig. 6A, C).

Thorax. Disc of pronotum smooth, with numerous small granules, midkeel of pronotum complete; upper margin of pronotum with a very small protrusion before shoulders, in profile upper margin of pronotum slightly undulate (nearly straight) before shoulders and straight behind shoulders (Fig. 5A–C); anterior margin of pronotum truncate, lateral keels of prozona conspicuous and parallel, about 0.5 times as long as the width between them (Fig. 6D); humeral angle obtusely angled, abbreviated carinae absent between shoulders; hind process of pronotum narrow, long cone-shaped, reaching three quarters of hind tibia (length of distal part which surpass beyond apex of hind femur 3.3 mm, pronotum about 3.5 times as long as the distal part) (Fig. 5B); posterior angle of lateral lobe of pronotum extending downwards, apex nearly truncate, posterior margin of each lateral lobe with two concavities; visible part of tegmina ovate, apex narrowly rounded, 2.8 times as long as wide (Fig. 5A, C); hind wings developed, reaching or slightly surpassing beyond apex of hind process of pronotum; fore and mid femora flat, upper margins of all femora and lower margins of hind femora finely dentate, sawteeth of lower margins of fore and mid femora elongate, forming comb-shaped; upper margin of fore femur slightly arcuate, distal part of lower margin incomplete; upper margin of mid femur nearly straight, lower margin slightly undulate (Fig. 6F, G); width of mid femur distinctly wider than visible part of tegmen; hind femur about 2.9 times as long as wide, antegenicular triangulate, genicular denticles fingered extending backward and apex quadrangular (Fig. 5A); outer side of hind tibia with 7–8 spines, inner side with 4–5 spines; first segment of posterior tarsus equal to third in length, three pulvilli nearly equal in length, apices of all pulvilli obtuse.

Abdomen. Ovipositor: upper valvulae about 3.0 times as long as wide, outer margins of upper and lower valvulae with small saw-like teeth (Fig. 6E); posterior margin

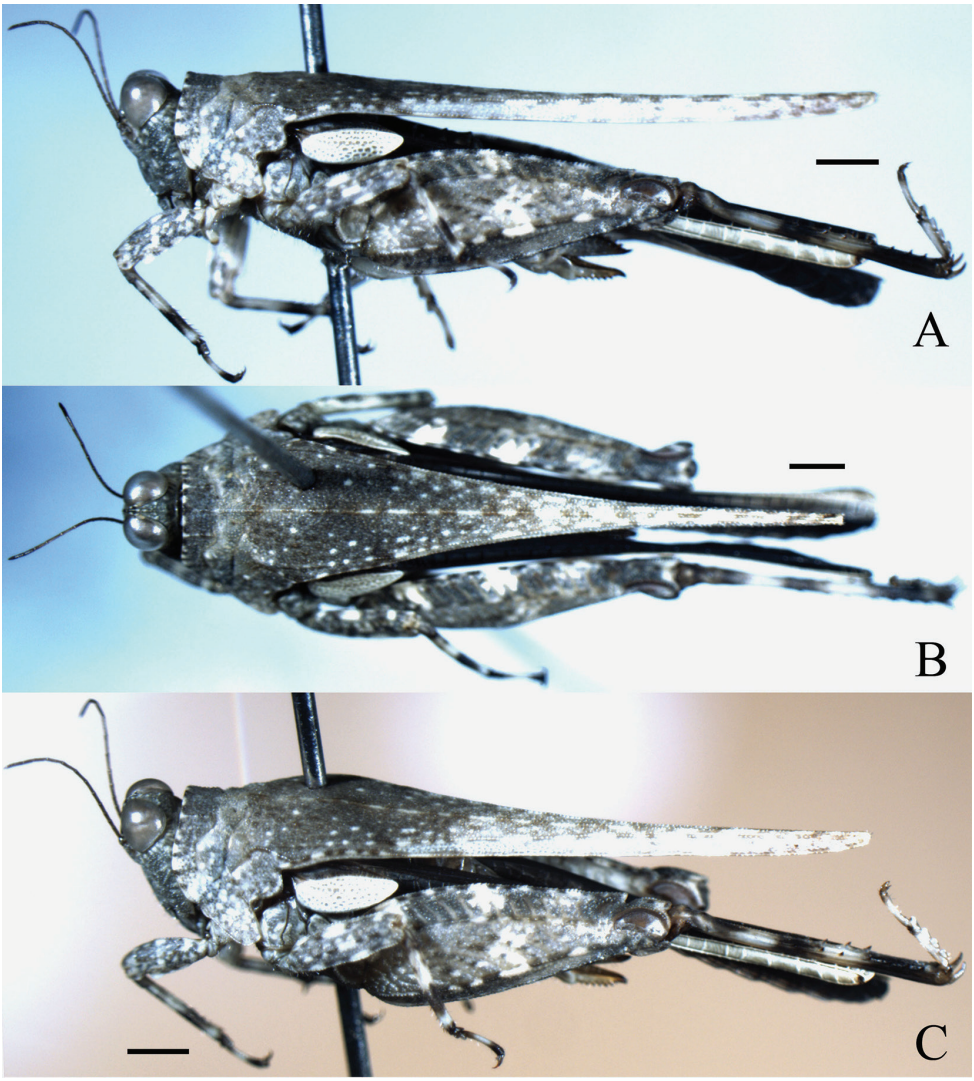

Figure 5. Female of *Teredorus combfemorus* sp. n.: **A** lateral view **B** dorsal view **C** oblique view. Scale bars: 1.0 mm.

of subgenital plate truncate and in the middle triangularly protruding which is folded inward (Fig. 6B).

Coloration. Body gray. Antenna brown, color of distal segments darker; hind wings black; all femora with the same color as body; lower outer side and inner side of hind femur partially dark brown; all tibiae yellowish brown, with three black bands (the distal band longest) respectively.

Male. Unknown.

Measurements. Length of body (from vertex to apex of abdomen) ♀8.5–9.0 mm; length of pronotum ♀11.5–12.0 mm; length of hind femur ♀5.5–6.0 mm.

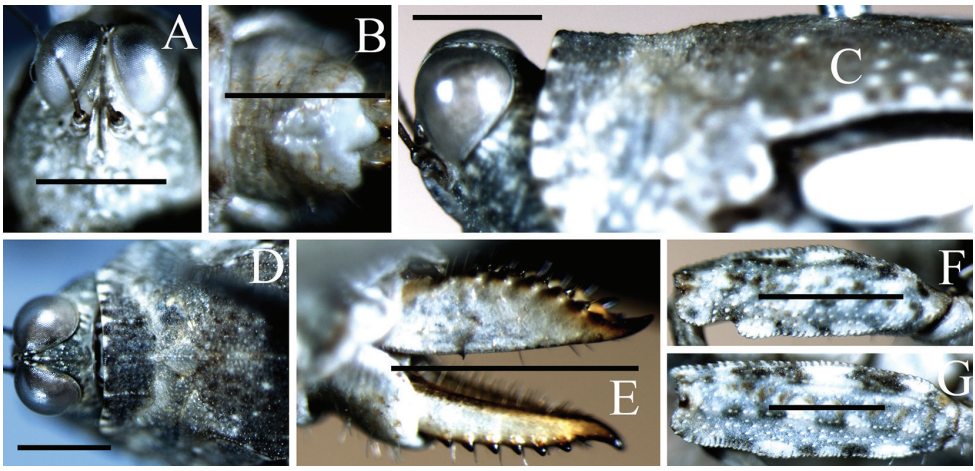

Figure 6. Female of *Teredorus combfemorus* sp. n.: **A** frontal view of head **B** ventral view of subgenital plate **C** lateral view of head and anterior pronotum **D** dorsal view of head and anterior pronotum **E** lateral view of ovipositor **F** lateral view of fore femur **G** lateral view of mid femur. Scale bars **A, C–G**: 1.0 mm, **B**: 0.5 mm.

Type material. Holotype female (Nos. 15-0633, MFLU), Thailand, Chiang Rai, Fathai, N20°2'58", E99°52'43", 425.5 m alt, 10 Dec. 2014, collected by Ling-Sheng ZHA. Paratypes: 2 females (HNU), same data as holotype.

Biology and ecology. *Teredorus combfemorus* Zha & Hyde, sp. n. inhabits stony place on border of a stream in tropical region. From collecting time we infer they overwinter as adults.

Etymology. This new species' name is derived from the Latin *comb* and *femora*, which means lower margins of fore and mid femora comb-shaped.

Distribution. Thailand (Chiang Rai).

Discussion

Species of *Hedotettix* generally inhabit open meadow in semi-humid subtropical or tropical regions. Partial body surfaces are often covered by bright green when alive which is just like color of the meadow where they inhabit, but the green will be faded gradually after their deaths or with the change of seasons. Together with their smooth body surface, we infer that most of life cycles they live on the ground instead of in soil, and maybe most of them cannot overwinter as adults.

Teredorus chiangraiensis sp. n. and *T. combfemorus* sp. n. are easily differed from other species of the genus by posterior angle of lateral lobe of pronotum nearly truncate (while rounded occur in all other species (Deng et al. 2014)). Based on molecular phylogeny using cytochrome c oxidase subunit I (CO I) gene (Fang et al. 2010) and morphological characteristics, Deng et al. (2014) thought *Teredorus* and *Systolederus* (Metrodorinae) can combine to the same genus, after all, they are mainly different by

shape of posterior angle of lateral lobe of pronotum. Truncate posterior angle of two new species from Thailand provides a new important support for this inference, also we infer Tetriginae are not monophyly in their phylogeny and evolution.

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Revision of the Australian species of the weevil genus *Trigonopterus* Fauvel

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Abstract

The Australian species of the genus *Trigonopterus* Fauvel are revised. Eight previously recognized species are redescribed and 24 additional new species are described: *T. allaetus* Riedel, **sp. n.**, *T. athertonensis* Riedel, **sp. n.**, *T. australinasutus* Riedel, **sp. n.**, *T. australis* Riedel, **sp. n.**, *T. bisignatus* Riedel, **sp. n.**, *T. bisinuatus* Riedel, **sp. n.**, *T. boolbunensis* Riedel, **sp. n.**, *T. cooktownensis* Riedel, **sp. n.**, *T. daintreensis* Riedel, **sp. n.**, *T. deplanatus* Riedel, **sp. n.**, *T. finniganensis* Riedel, **sp. n.**, *T. fraterculus* Riedel, **sp. n.**, *T. garradungensis* Riedel, **sp. n.**, *T. hasenpuschi* Riedel, **sp. n.**, *T. hartleyensis* Riedel, **sp. n.**, *T. kurandensis* Riedel, **sp. n.**, *T. lewisensis* Riedel, **sp. n.**, *T. montanus* Riedel, **sp. n.**, *T. monteithi* Riedel, **sp. n.**, *T. mossmanensis* Riedel, **sp. n.**, *T. oberprieleri* Riedel, **sp. n.**, *T. robertsi* Riedel, **sp. n.**, *T. terraereginae* Riedel, **sp. n.**, *T. yorkensis* Riedel, **sp. n.**. All new species are authored by the taxonomist-in-charge, Alexander Riedel. Lectotypes are designated for the following names: *Idotasia aequalis* Pascoe, *I. albidosparsa* Lea, *I. evanida* Pascoe, *I. laeta* Lea, *I. rostralis* Lea, *I. sculptirostris* Lea, *I. squamosa* Lea. A new combination of the name *Idotasia striatipennis* Lea is proposed: *Trigonopterus striatipennis* (Lea), **comb. n.**. A key to the species is provided. Australian *Trigonopterus* occur in coastal Queensland, narrowly crossing into New South Wales. The southern parts of the range are inhabited by species found on foliage. A rich fauna of 19 edaphic species inhabiting the leaf litter of tropical forests is reported for the first time from the Australian Wet Tropics.

Keywords

Australian Wet Tropics, Coleoptera, conservation, *cox1*, Curculionidae, Cryptorhynchinae, DNA barcoding, endemism, hyperdiverse, integrative taxonomy, morphology, weevils

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Introduction

Trigonopterus Fauvel is a genus of wingless weevils of the subfamily Cryptorhynchinae (Alonso-Zarazaga and Lyal 1999) and highly species-rich in the tropical forests of southeast Asia and Melanesia (Tänzler et al. 2012). New Guinea appears to be the center of its diversity, with more than 300 species recorded (Riedel 2010, Tänzler et al. 2012). *Trigonopterus* is currently the subject of studies on its ecology (Riedel et al. 2010, Tänzler et al. 2012), biogeography (Tänzler et al. 2014, Tänzler et al. 2016) and functional morphology (van de Kamp et al. 2011, van de Kamp et al. 2014, van de Kamp et al. 2015). The need for a stable taxonomy with valid names became urgent, and a fast-lane approach of taxonomy (Riedel et al. 2013a) was established to describe 200 new species from Indonesia and Papua New Guinea (Riedel et al. 2013b, 2014).

The number of Australian *Trigonopterus* species is relatively small. Nevertheless, from a biogeographical perspective this continental and presumably old fauna is of great interest. Eight species have been described from Queensland to date (Pullen et al. 2014). A study of museum collections and a limited amount of field work resulted in the discovery of a modest number of additional, undescribed species. Many of them were first collected by Geoff Monteith (QMBA), who also discovered an edaphic group of species by sifting leaf litter. All the previously known Australian species had been collected from vegetation.

Despite these advances there are problems remaining. Some Australian *Trigonopterus* are difficult to characterize using morphological characters alone: species of the *T. politus*-group (e.g., comprising the Australian *T. aequalis* Pascoe, *T. evanidus* Pascoe and *T. albidosparsus* (Lea)) and of the *T. squamosus*-group offer only few morphological characters, whereas molecular data indicate highly divergent lineages. Therefore we have to leave many museum specimens unidentified. Still, we believe that it is timely to present a first summary now, with the aims of 1) redescribing the known species based on their type material and 2) providing names for those new species that can be safely recognized based on morphological characters alone. Hopefully this study will instigate the additional field work needed to arrive at a more comprehensive understanding of the Australian *Trigonopterus* fauna.

Materials and methods

This study is based on 673 specimens, including 11 type specimens of old collections. Some of the material was collected specifically for this project from vegetation with the help of a beating sheet, or by sifting the litter of primary forests and subsequent extraction of specimens from it using Winkler eclectors (Besuchet et al. 1987). DNA sequences were obtained for 86 of the freshly collected specimens. Holotypes of new species were selected from these sequence vouchers whenever possible. DNA was extracted nondestructively as described by Riedel et al. (2010). Type and other old specimens from collections were treated in the same way, which has also proved to be the most conservative method for the extraction of genitalia and at the same time allows

saving the presumably more or less degraded DNA. Unfortunately all our trials of PCR using this old collection material failed, but it may be feasible in future with improved sequencing methods. The genitalia of most specimens did not require maceration after DNA extraction and could be directly stained in an alcoholic solution of chlorazol black and stored in glycerol in microvials attached to the pin of the specimens. Genitalia of specimens whose abdominal muscle tissue was not sufficiently digested after DNA extraction were macerated in a 10% KOH solution and rinsed in 3% acetic acid before staining. Illustrations of habitus and genitalia were prepared from holotypes. Finally, type series were supplemented with specimens stored in ethanol and older material from museum collections. Type depositories are cited using the following codens:

ANIC	Australian National Insect Collection, Canberra, Australia
BMNH	The Natural History Museum, London, UK
QMBA	Queensland Museum, Brisbane, Australia
SAMA	South Australian Museum, Adelaide, Australia
SMNK	Staatliches Museum für Naturkunde, Karlsruhe, Germany

The methods applied for DNA sequencing and sequence analysis are described by Riedel et al. (2010) and Tänzler et al. (2012). Morphological descriptions are limited to major diagnostic characters, as outlined by Riedel et al. (2013a, b). Negative character states (i. e. the absence of a character) are only mentioned explicitly where this appears appropriate. For example, some species of the *T. politus*-group have a weakly carinate dorsal margin of the eyes. In these cases the character is described, but for the majority of species, in which the eyes are dorsally simple and evenly rounded with the forehead, this condition is not mentioned. Common practice would require stating explicitly "eyes dorsally simple, rounded with forehead". Although formally accurate, in groups comprising hundreds of species this leads to inflated descriptions that distract the reader from the important information by enumerating the absence of rare character states.

Morphological terminology follows Beutel and Leschen (2005) and Leschen et al. (2009), i.e. the terms "mesoventrite" / "metaventrite" are used instead of "mesosternum" / "metasternum", and "mesanepisternum" / "metanepisternum" instead of "mesepisternum" / "metepisternum"; "penis" is used instead of "aedeagus" as the tegmen is usually without useful characters in *Trigonopterus* and therefore omitted from species descriptions. Descriptions were prepared using a Leica MZ16 dissecting microscope and a fluorescent-light desk lamp for illumination. Measurements were taken with the help of an ocular grid. The length of the body was measured in dorsal aspect from the elytral apex to the front of the pronotum. The width of the elytra was measured between the humeri at their greatest extent and across *both* elytra. Legs were described in an idealized laterally extended position; there is a dorsal / ventral and an anterior / posterior surface. Habitus illustrations were compiled using a DFC450 camera with L.A.S. 4.6.0 software adapted to a Z6 APO (all from Leica Microsystems, Heerbrugg, Switzerland). Photographic illustrations of genitalia were made using a

JVC KY70 camera (JVC Professional Products) adapted to an Axio Imager M2 microscope (Carl Zeiss Microscopy), with 5× or 10× A-Plan lenses; the resulting image stacks were combined using the Helicon Focus 6.2.2 software (Helicon Soft Ltd). For photography the genitalia were temporarily embedded in glycerol gelatin, as described by Riedel (2005), with their longitudinal axis somewhat lifted anteriorly to adequately illustrate structures of the down-curved apex. All photographs were enhanced using Adobe Photoshop CS2 and CS6, but care was taken not to obscure or alter any features of the specimens illustrated.

Sequence data were submitted to the European Molecular Biology Laboratory (EMBL), and the accession numbers are provided under each species e.g. as "(EMBL # LN888232)". Data on genetic material contained in this paper is published for non-commercial use only. Utilization for purposes other than non-commercial scientific research may infringe the conditions under which the genetic resources were originally accessed, and should not be undertaken without contacting the corresponding author of the paper and/or seeking permission from the original provider of the genetic material.

Taxonomy

Trigonopterus Fauvel, 1862

Type species. *Trigonopterus insignis* Fauvel, 1862, by monotypy.

Diagnosis. Fully apterous genus of Cryptorhynchinae. Length 1.5–6.0 mm (1.7–3.81 mm in Australian species). Rostrum in repose not reaching middle of mesocoxal length. Scutellar shield completely covered by elytra. Mesothoracic receptacle deep, posteriorly closed. Metanepisternum completely absent. Metathoracic spiracle externally on side of metaventrite. Elytra with 9 striae (sometimes superficially effaced). Tarsal claws minute. Body largely unclothed (densely squamose in *T. squamosus* Lea and *T. striatipennis* Lea). Metafemur in Australian species without stridulatory patch. For additional information, see van de Kamp et al. (2015) and http://species-id.net/wiki/Trigonopterus.

Descriptions of the species

1. *Trigonopterus aequalis* (Pascoe)

Idotasia aequalis Pascoe, 1872: 100.
Trigonopterus aequalis (Pascoe): Pullen et al. 2014: 271.

Diagnostic description. Lectotype (Fig. 1a). Length 3.50 mm. Color black, legs tending to deep ferruginous. Body subovate, almost without constriction between pronotum

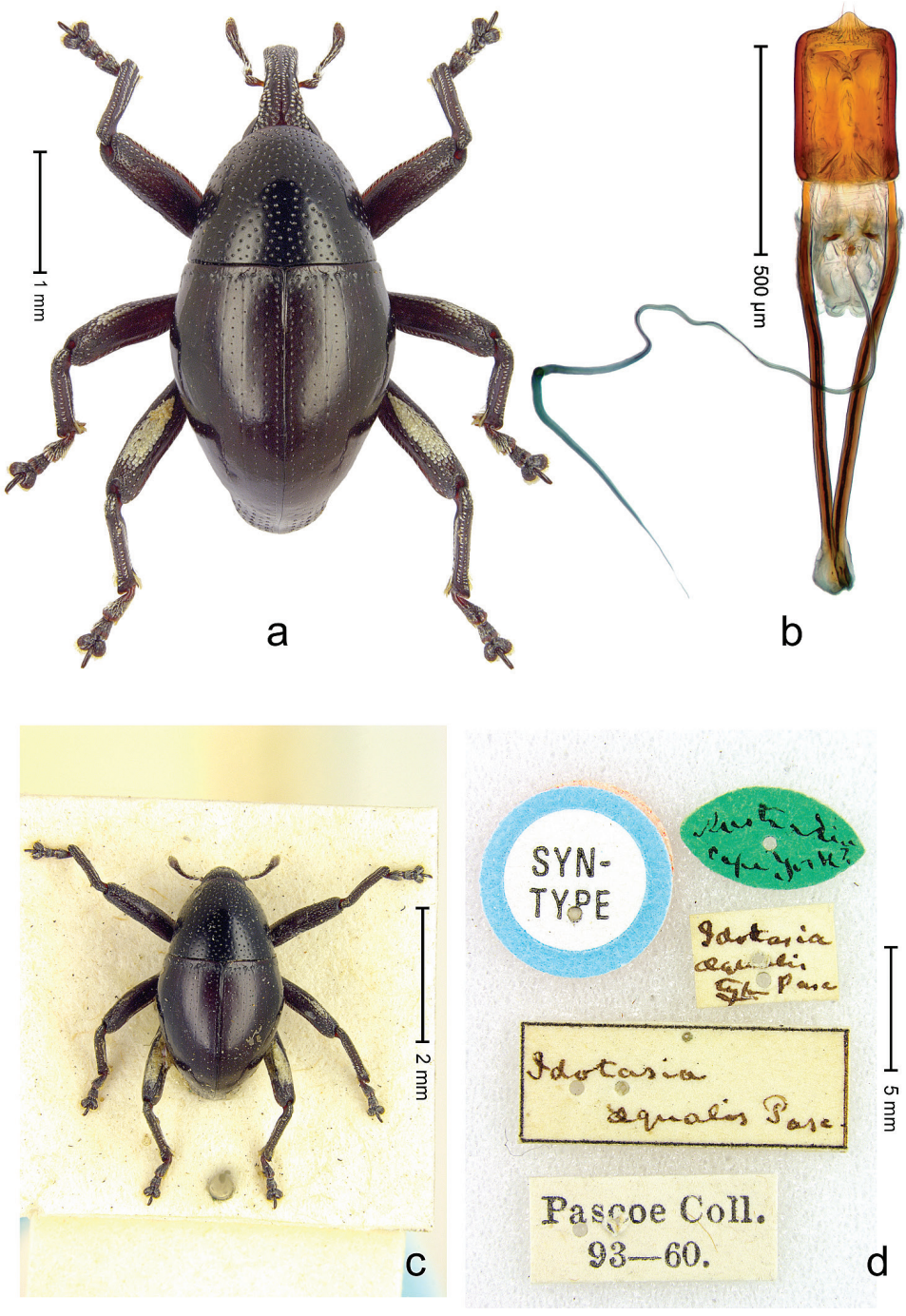

Figure 1. *Trigonopterus aequalis* (Pascoe), lectotype; **a** Habitus **b** Penis **c** as mounted originally **d** original labels.

and elytron; in profile evenly convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of silvery scales; apical 1/3 rugose-punctate. Eyes with dorsal margin weakly carinate, bordered by furrow. Forehead coarsely punctate. Pronotum with disk punctate; sides foveate; interspaces microreticulate; base medially hardly extended towards elytral suture. Elytra with striae marked by distinct rows of minute punctures, interspaces weakly microreticulate; along base and humeri with row of large punctures; apex densely punctate. Legs. Femora microreticulate, punctate. Metafemur dorsally with elongate patch of dense white scales; posterior surface with ventral edge rimmed by costa and row of scales, with longitudinal furrow containing row of scales parallel to indistinct dorsoposterior edge. Mesotibia apically with uncus and larger premucro approximate at base but not fused, widely diverging. Metatibia apically with uncus and small angular premucro. Abdominal ventrite 2 swollen, with posterior edge projecting, medially forming common cavity with ventrite 1; ventrite 5 dull, microreticulate, punctate, almost flat, with weak impression. Penis (Fig. 1b) with sides of body subparallel; apex with median triangular extension somewhat confluent with outline of apex; transfer apparatus short, dentiform, bordered by indistinct sclerites; ductus ejaculatorius without bulbus.

Material examined. Type specimens. Male, lectotype by present designation (Fig. 1) (BMNH): Queensland, Cape York ? (labels Fig. 1d), ARC4079 (PCR failed). Other specimens (ANIC): 1 ex, Warrah [S Tamworth, leg. W.W. Froggatt].

Distribution. New South Wales: Tamworth.

Notes. Pascoe (1872) did not designate a holotype nor specify the number of specimens examined but gave two localities, "Cape York" and "Rockhampton". Only the syntype from the first locality could be located in the BMNH. Presumably the missing syntype from Rockhampton represents a different species. A lectotype is designated here to achieve stability of nomenclature.

The question mark behind the name of the type locality ("Cape York ?") suggests that there was doubt about its validity already in Pascoe's times. This is supported by the fact that we could only examine one additional specimen, identified by Lea, from the village of Warrah, south of Tamworth in New South Wales. Additional field work should verify the occurrence of the species in this area.

2. *Trigonopterus albidosparsus* (Lea)

Idotasia albidosparsa Lea, 1913: 611.
Trigonopterus albidosparsa (Lea), incorrect subsequent spelling: Zimmerman 1992: 376.
Trigonopterus albidosparsus (Lea): Pullen et al. 2014: 271.

Diagnostic description. Male (ARC3695; Fig. 2e). Length 2.73 mm. Color black. Body subovate, almost without constriction between pronotum and elytron; in profile evenly convex. Rostrum with median costa and pair of submedian costae; intervening furrows with rows of partly abraded scales; apical 1/3 rugose-punctate. Eyes

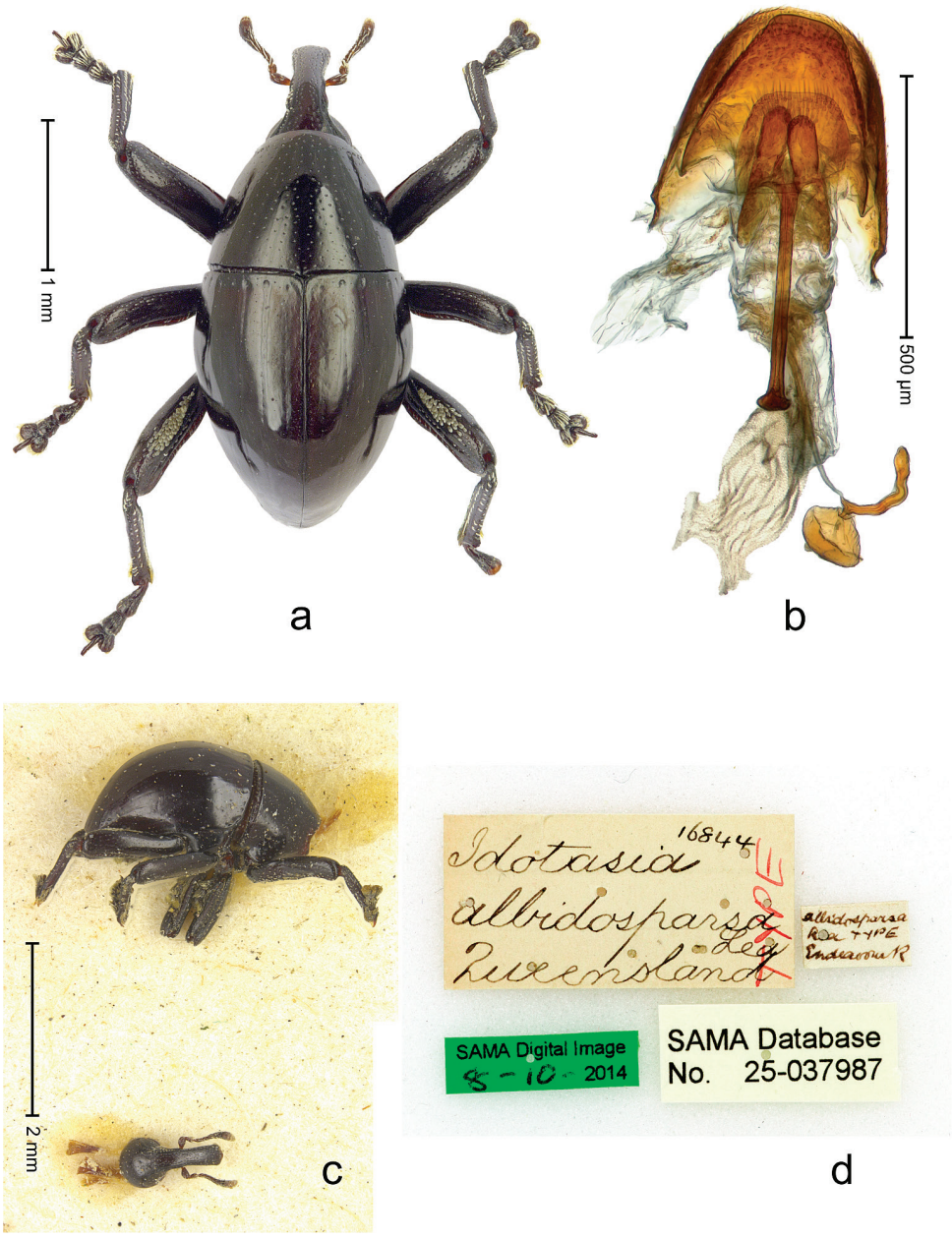

Figure 2 a–d. *Trigonopterus albidosparsus* (Lea), female lectotype; **a** Habitus **b** Terminalia **c** as mounted originally **d** original labels.

with dorsal margin bordered by furrow. Forehead sparsely punctate. Pronotum with disk subglabrous, with minute punctures; sides foveate; interspaces not microreticulate; base medially hardly extended towards elytral suture. Elytra subglabrous, striae

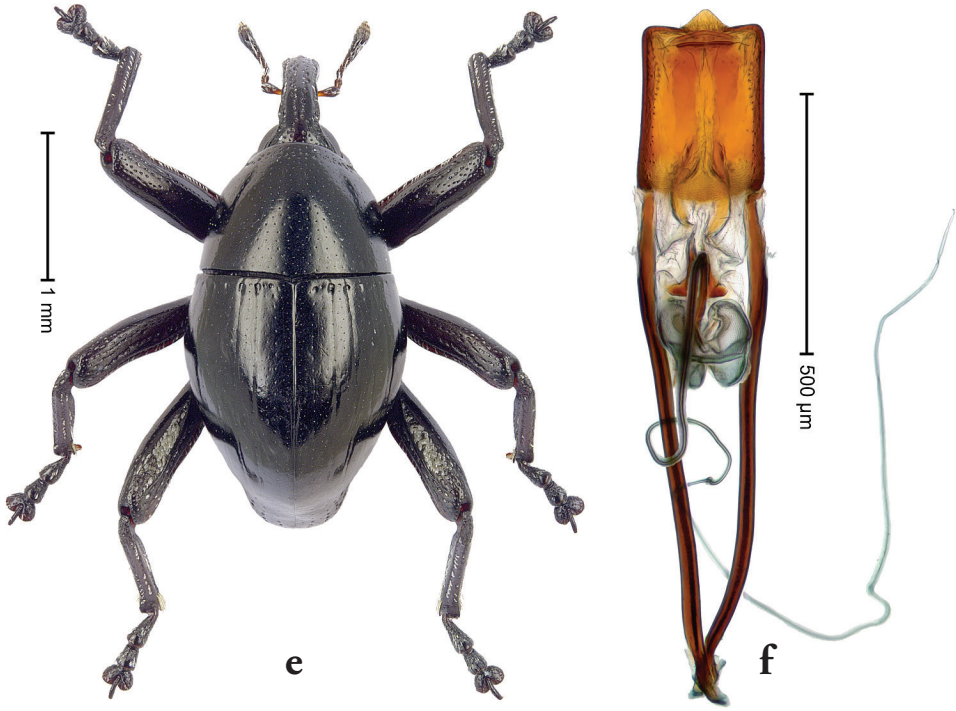

Figure 2 e–f. *Trigonopterus albidosparsus* (Lea), male; **e** Habitus **f** penis.

marked by very shallow lines, without punctures; along base and humeri with row of large punctures; apex with scattered shallow punctures. Legs. Femora microreticulate, punctate. Metafemur dorsally with elongate patch of dense silvery scales; posterior surface with pair of longitudinal furrows containing rows of scales parallel to ventral and dorsal edge; dorsoposterior edge distinct. Mesotibia apically with widened uncus only, premucro absent. Metatibia apically with uncus only, premucro not visible in lateral aspect, possibly transformed into small process on posterior tibial face near tarsal insertion. Abdominal ventrite 2 swollen, posterior edge projecting and with submedian pair of denticles, medially forming shallow cavity with ventrite 1; ventrite 5 dull, microreticulate, punctate, with transversely ovate cavity. Penis (Fig. 2f) with sides of body subparallel; apex with distinct median triangular extension; transfer apparatus long, spiniform, apically bordered by pair of L-shaped sclerites; ductus ejaculatorius without bulbus. **Female lectotype** (Fig. 2a–d). As male except: length 2.63 mm. Rostrum dorsally subglabrous, densely punctate with small punctures. Abdominal ventrites 1 and 2 medially flat; posterior edge of ventrite 2 simple, without pair of denticles; abdominal ventrite 5 flat. **Intraspecific variation.** Length 2.26–2.73 mm. Mesotibia apically with large uncus and much smaller premucro.

Material examined. Type specimens. Female, lectotype by present designation (SAMA): Queensland, Endeavour River (labels Fig. 2d), ARC4033 (PCR failed).

Other specimens (ANIC, QMBA, SMNK): 36 exx, ARC3695 (EMBL # LN888180), ARC3696 (EMBL # LN888181), ARC3697 (EMBL # LN888182), Cooktown, Mt. Cook N.P., S15°28.648', E145°15.793', to S15°29.252', E145°15.992', 63-324 m, 24-IV-2014; 31 exx, Cooktown, Mt. Cook N.P., S15°28.648', E145°15.793', to S15°29.252', E145°15.992', 63–245 m, 23-IV-2014; 10 exx, Mt. Cook N.P., S15°29', E145°16', 11-12-X-1980; 1 ex, 1 km SE Mt. Cook, S15°30', E145°16', 13-X-1980.

Distribution. Queensland: Cooktown.

Biology. Beaten from foliage in rainforest.

Notes. Lea (1913) did not designate a holotype in the original description, which is based on three syntypes. One syntype labelled "type" could be examined and is here designated as lectotype. The species appears to be confined to the Cooktown area. Numerous specimens from other localities of coastal Queensland, including some identified as *T. albidosparsa* by Lea, belong to different, closely related species.

3. *Trigonopterus allaetus* Riedel, sp. n.

http://zoobank.org/9C9576E3-6866-4523-A726-5AF39807037B

Diagnostic description. Holotype (Fig. 3a). Length 2.34 mm. Color black, antenna ferruginous. Body elongate-ovate, with weak constriction between pronotum and elytron; in profile evenly convex. Rostrum with median costa and pair of fine submedian ridges; intervening furrows with rows of white erect scales. Eyes large, in dorsal position, medially approximate. Pronotum with disk subglabrous, densely punctate with minute punctures; sides more densely punctate with larger punctures. Elytra subglabrous, with sparse minute punctures; along base and humeri with row of larger punctures. Legs. Meso- and metafemur dorsally with narrow band of white scales; metafemur with distinct dorsoposterior edge. Tibial apex with uncus and minute premucro. Abdominal ventrites 1-2 and ventrite 5 medially concave. Abdominal venter medially subglabrous, laterally with sparse white scales. Penis (Fig. 3b) with sides of body subparallel; apex with median acute extension; transfer apparatus short, dentiform; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.16–2.68 mm. Female rostrum subglabrous, sparsely setose, with submedian rows of punctures; base squamose. Female abdominal ventrites 5 flat.

Material examined. Holotype (ANIC): ARC4240 (PCR failed), Queensland, 8 km E Mt. Tozer, S12°45', E143°17', 08-VII-1986. Paratypes (ANIC, SMNK): Queensland: 1 ex, 3 km ENE Mt. Tozer, S12°45', E143°14', swept from u´growth, 28-VI-04-VII-1986; 6 exx (ARC4241, PCR failed), 9 km ENE of Mt. Tozer, S12°43', E143°17', beating rainforest vegetation, 05-10-VII-1986; 3 exx, 11 km ENE of Mt. Tozer, S12°43', E143°18', 11-16-VII-1986.

Distribution. Queensland: Iron Range.

Biology. Swept and beaten from rainforest vegetation.

Etymology. This epithet is a combination of the Latin prefix *ad-* (next to; near) and the specific epithet of *T. laetus* (Lea), a closely related species.

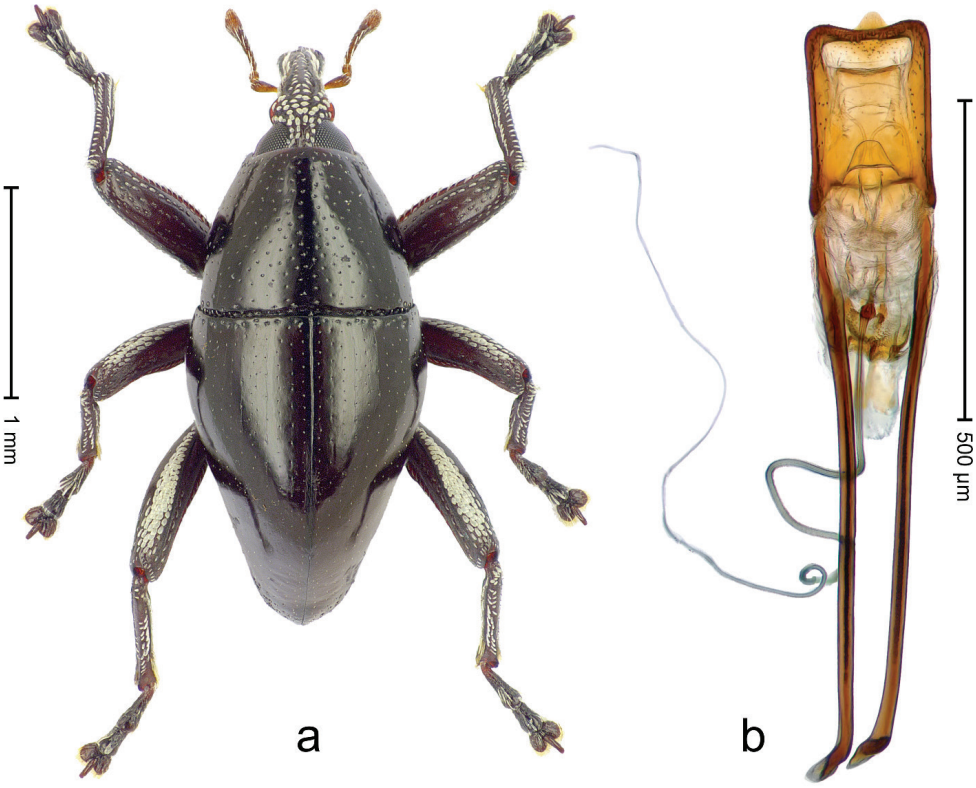

Figure 3. *Trigonopterus allaetus* sp. n., holotype; **a** Habitus **b** Penis.

4. *Trigonopterus athertonensis* Riedel, sp. n.
http://zoobank.org/DC95607E-F0F1-4532-A480-034564653309

Diagnostic description. Holotype (Fig. 4a). Length 2.45 mm. Color black; antenna and tarsi ferruginous. Body elongate, with distinct constriction between pronotum and elytron; in profile convex. Rostrum with median costa and pair of submedian costae ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed narrow seta; base dorsally protruding, projecting from profile subangularly; epistome posteriorly with transverse ridge. Forehead coarsely punctate-rugose. Pronotum with subapical constriction; disk coarsely punctate; with median costa; punctures each containing one seta, few with white scale. Elytra with striae deeply incised, containing few coarse punctures; intervals costate, sparsely punctate, in basal third partly transversely confluent; with indistinct transverse bands of sparse white scales; base markedly bisinuate. Legs. Femora densely punctate, with transverse band of sparse white scales. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia with supranucal denticle. Abdominal ventrites 1 medially concave; abdominal ventrite 2 swollen, especially laterally; ventrite

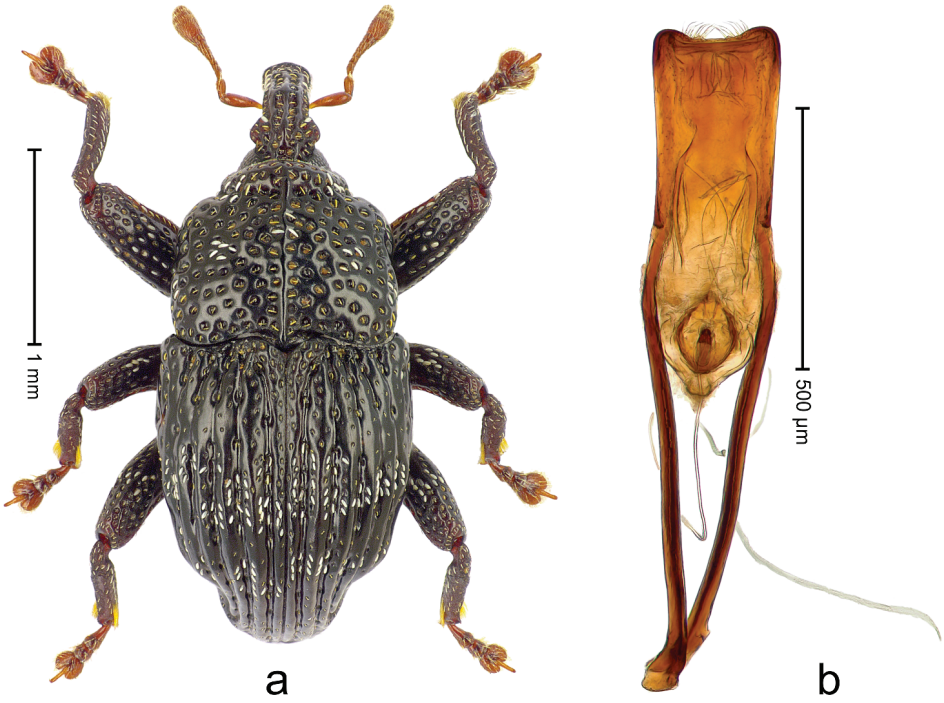

Figure 4. *Trigonopterus athertonensis* Riedel, sp. n., holotype; **a** Habitus **b** Penis.

5 in basal half concave, coarsely punctate. Penis (Fig. 4b) with sides of body weakly diverging to subtruncate apex; transfer apparatus compact, subrotund; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.45–2.68 mm.

Material examined. Holotype (ANIC): ARC4041 (PCR failed), Queensland, Mt. Fisher, 7 km SW Millaa Millaa, S17°34', E145°34', 1100 m, rainforest, litter, Q.M. Berlesate No. 409, 27-IV-1982. Paratypes (ANIC, QMBA, SMNK): Queensland: 1 ex, same data as holotype; 2 exx, Mt. Fisher, 7 km SW Millaa Millaa, S17°34', E145°34', 1050 m, rainforest, litter, Q.M. Berlesate No. 412, 27-IV-1982; 1 ex, Mt Fisher, summit, 17°34'S, 145°33'E, rainforest, 1360 m, sieved litter, Berlesate 991, 08-II-1999.

Distribution. Queensland: Mt. Fisher.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the Atherton Tablelands, where the species occurs.

5. *Trigonopterus australinasutus* Riedel, sp. n.

http://zoobank.org/77D735C6-FD14-48D5-BFB0-C5ACA3E7FA7D

Diagnostic description. Holotype (Fig. 5a). Length 3.28 mm. Color black; legs deep ferruginous to black; antenna lighter ferruginous. Body subovate; in dorsal aspect and

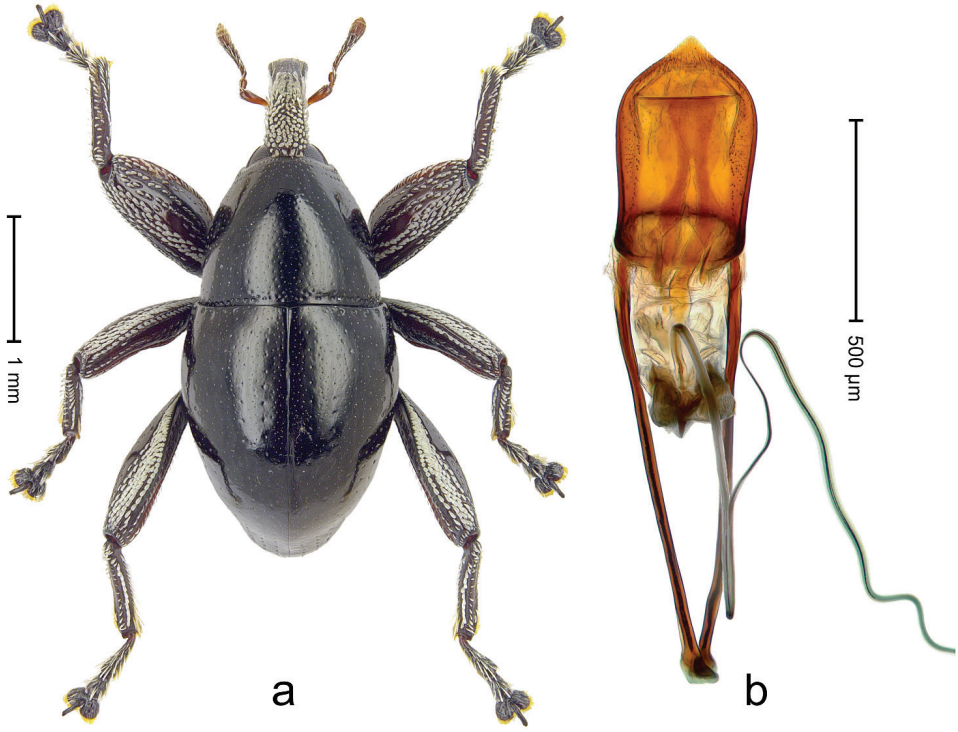

Figure 5. *Trigonopterus australinasutus* sp. n., holotype; **a** Habitus **b** Penis.

in profile with weak constriction between pronotum and elytron. Rostrum in basal half dorsally markedly swollen, punctate-reticulate, densely squamose with white erect scales; subapical third subglabrous, weakly punctate, sparsely setose. Eyes medially approximate. Pronotum subglabrous, with minute punctures; laterally punctures somewhat larger; evenly rounded towards sides; in front of procoxa with acute process. Elytra subglabrous with minute punctures; striae indistinct; basal margin straight, towards sides bordered by row of moderately deep punctures. Femora with anteroventral ridge distinct, rounded basally; at middle with small tooth. Mesofemur and metafemur dorsally densely squamose with white scales; metafemur with distinct dorsoposterior edge. Abdominal ventrites 1-2 medially concave. Abdominal venter medially subglabrous, laterally with sparse white scales. Penis (Fig. 5b) apically subangulate, weakly pointed; transfer apparatus beak-shaped, pointed, directed basad; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.98–3.47 mm. Female rostrum in apical 2/3 dorsally flattened, subglabrous, sparsely punctate; basally swollen, with erect white scales.

Material examined. Holotype (ANIC): ARC4238 (PCR failed), Queensland, 11 km ENE of Mt. Tozer, S12°43', E143°18', 11-16-VII-1986. Paratypes (ANIC, QMBA, SMNK): Queensland: 2 exx, same data as holotype; 5 exx, ARC4239 (PCR failed), 3 km ENE Mt. Tozer, S12°44', E143°14', 28-VI-04-VII-1986; 1 ex, 8 km E by N of Mt. Tozer, S12°44', E143°17', beating rainforest vegetation, 07-VII-1986; 3

exx, 9 km ENE of Mt. Tozer, S12°43', E143°17', 05-10-VII-1986; 1 ex, Claudie R., nr. Iron Rg., under bark, rotten logs, 19-25-VII-1978; Gordon Creek area, Claudie Riv. District, 23-I-1982.

Distribution. Queensland: Iron Range.

Biology. Swept and beaten from rainforest vegetation.

Etymology. This epithet is a combination of the Latin adjective *australis* (southern) and the specific epithet of *T. nasutus* (Pascoe), also an adjective.

Notes. This species is closely related to *T. nasutus* (Pascoe) and *T. gibbirostris* (Faust) from New Guinea. From the former it can be distinguished by a longer and spiniform transfer apparatus, from the latter by its medially pointed apex of the penis.

6. *Trigonopterus australis* Riedel, sp. n.

http://zoobank.org/535F820A-1CB9-4649-BE2E-303DC40908D2

Diagnostic description. Holotype (Fig. 6a). Length 2.78 mm. Color black; antenna and legs ferruginous. Body subovate, in dorsal aspect and in profile with marked constriction between pronotum and elytron. Rostrum punctate-scabrous, in basal third with median ridge and pair of submedian ridges; in front of antennal insertion with median bifid protrusion; punctures containing upcurved narrow scales; epistome posteriorly with curved ridge bearing 4 denticles. Forehead coarsely punctate-rugose. Pronotum with sides subparallel, anteriorly abruptly rounded to indistinct subapical constriction; irregularly foveate-reticulate; each fovea containing one inconspicuous seta; interspaces forming irregular, mainly longitudinal ridges. Elytra converging from humeri to apex; base bisinuate; striae deeply impressed, with coarse punctures; intervals carinate to costate; with sparse subrecumbent scales; sutural interval prominent, near base markedly swollen. Legs. Femora punctate-rugose, with sparse suberect scales. Tibiae subbasally with dorsal angulation; metatibia subapically with supprauncal angulation. Metaventrite subglabrous except deep median furrow. Abdominal ventrite 1 concave; abdominal ventrite 2 posteriorly transversely costate. Penis (Fig. 6b) with sides of body weakly converging from base to subtruncate apex; in profile ventrally with marked subapical swelling; transfer apparatus short, dentiform; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 1.92–3.34 mm. Body usually covered with more or less thick soil incrustations removed in holotype. Female body slender. Female rostrum dorsally somewhat flattened, without protrusion; in basal half with median costa and pair of submedian costae; epistome simple.

Material examined. Holotype (QMBA): ARC3895 (PCR failed), Queensland, West Claudie R., Iron Range, S12°45', E143°14', sieved litter, Berlesate No. 693, 50 m, 05-XII-1985. Paratypes (ANIC, SMNK): Queensland: 27 exx, 11 km ENE of Mt. Tozer, S12°43', E143°18', rainforest litter, Berlesate ANIC 1065, 11-16-VII-1986; 2 exx, 9 km ENE of Mt. Tozer, S12°43', E143°17', open forest litter, Berlesate ANIC 1061, 05-10-VII-1986; 1 ex, 3 km ENE of Mt. Tozer, S12°44', E143°14', flight intercept trap, rainforest, 28-VI-16-VII-1986; 1 ex, 3 km ENE of Mt. Tozer,

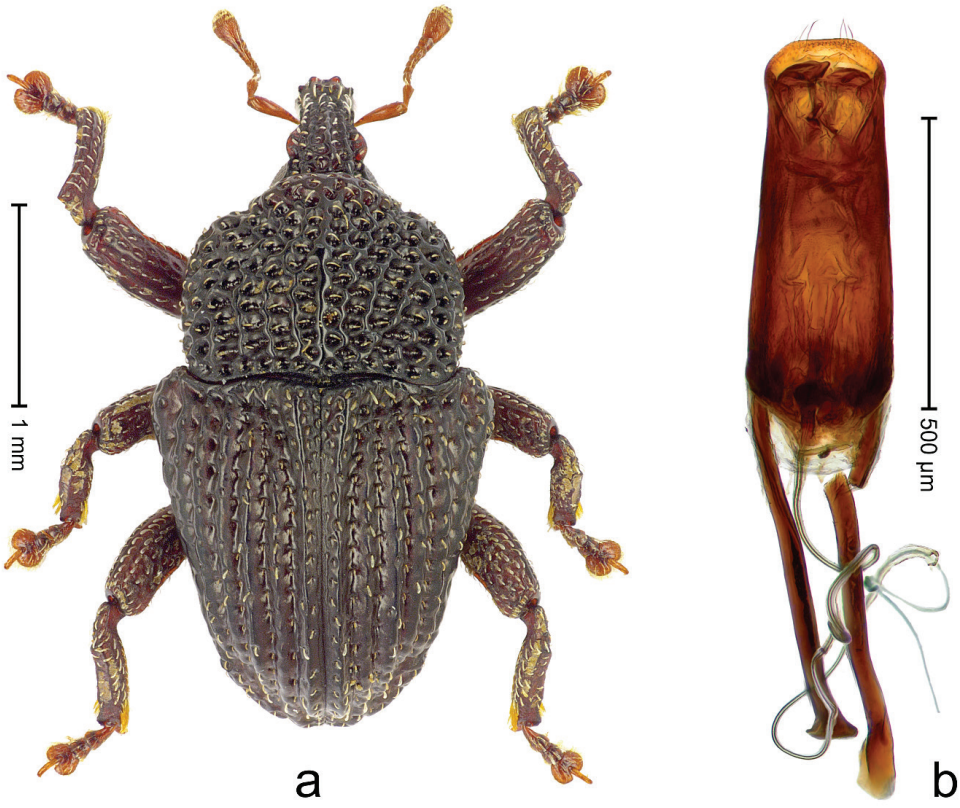

Figure 6. *Trigonopterus australis* sp. n., holotype; **a** Habitus **b** Penis.

S12°44', E143°14', Berlesate ANIC 1052 rainforest litter, 01-04- VII-1986; 3 exx, Claudie R. nr. Iron Rg., 19-25-VII-1978; 3 exx, Iron Ra., S12°45', E143°14', Berlesate ANIC 309, rainforest, 14-VI-1971; 1 ex, Iron Ra., S12°43', E143°48', Berlesate ANIC 308, rainforest, 15-VI-1971; 3 exx, ARC4042 (PCR failed), McIlwraith Range, 8km WbyN of Bald Hill, upper Leo creek site, S13°45', E143°22', berlesate ANIC 1117, leaf litter, closed forest, 500 m, 27-VI-12-VII-1989; 6 exx, McIlwraith Range, 8km WbyN of Bald Hill, mango tree site, S13°45', E143°22', berlesate ANIC 1118, leaf litter, closed forest, 500 m, 27-VI-12-VII-1989; 14 exx, McIlwraith Range, 11km WbyN of Bald Hill, search party campsite, S13°44', E143°20', berlesate ANIC 1107, leaf litter, closed forest, 520 m, 27-VI-12-VII-1989; 1 ex, McIlwraith Range, 15km WNW of Bald Hill, interface site, S13°43', E143°19', berlesate ANIC 1122, leaf litter, monsoon forest with *Casuarina* & *Acacia*, 500 m, 27-VI-12-VII-1989.

Distribution. Queensland: Mc Ilwraith Range, Iron Range.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is the Latin adjective *australis* (southern) and refers to the continent formerly known as "Terra Australis", i.e. Australia.

7. *Trigonopterus bisignatus* Riedel, sp. n.

http://zoobank.org/5A37941C-DBC6-4012-BBB7-F22D8B6C910D

Diagnostic description. Holotype (Fig. 7a). Length 2.73 mm. Color black; antenna and legs ferruginous. Body subovate, with shallow constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with curved ridge bearing 4 low denticles. Forehead coarsely punctate-rugose. Pronotum with indistinct subapical constriction; disk coarsely punctate-reticulate; with median costa; near middle with pair of very weak swellings, further laterad with clusters of yellow recumbent scales. Elytra with striae deeply incised; intervals costate, microreticulate, with shallow punctures and few scattered recumbent scales; base markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 punctate, flat. Penis (Fig. 7b) with sides of body weakly converging, at middle with constriction, widening to subtriangular apex; transfer apparatus flagelliform, ca. 1.5× longer than body of penis;

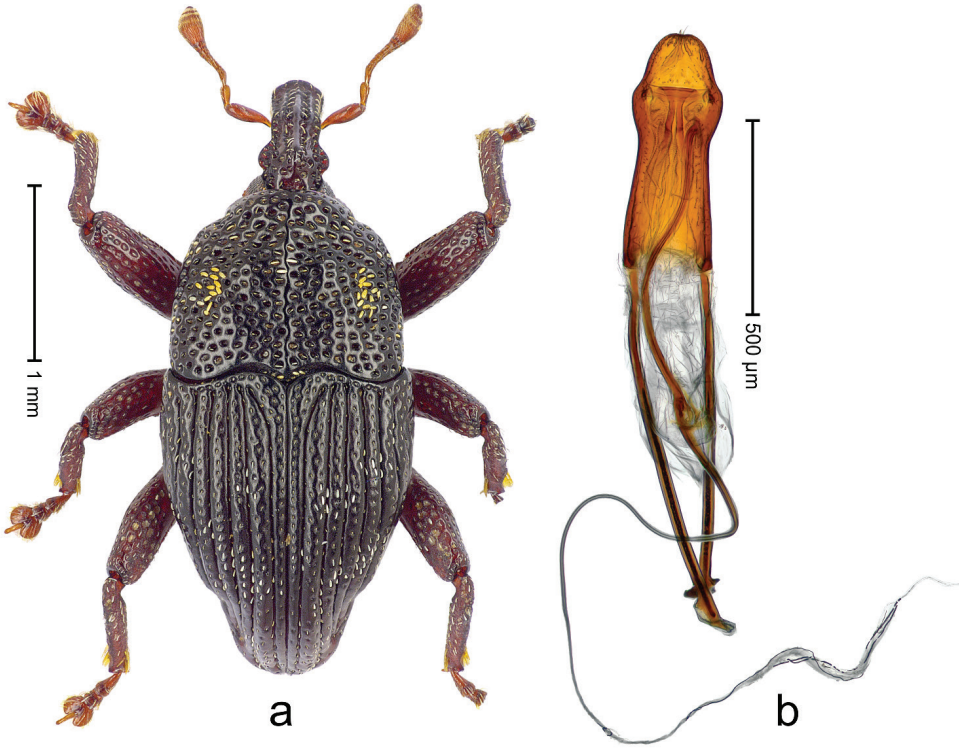

Figure 7. *Trigonopterus bisignatus* sp. n., holotype; **a** Habitus **b** Penis.

ductus ejaculatorius near insertion to transfer apparatus sclerotized, without bulbus. **Intraspecific variation.** Length 2.73–3.03 mm.

Material examined. Holotype (QMBA): ARC3752 (EMBL # LN888232), Queensland, Daintree N.P., NW Mossman, Manjal Jimalji (Devils Thumb) trail, S16°23.571', E145°19.058', sample 2, 377 m, 20-IV-2014. Paratypes (ANIC): Queensland: 1 ex, ARC4053 (PCR failed), Windsor Tableland, 35 km NW Mt. Carbine, 1050 m, rainforest, sieved litter, Berlesate No. 393, 16-IV-1982; 2 exx, ARC4050 (PCR failed), Mossman Gorge N.P., 6 km SW of Mossman, rainforest leaf litter, 50 m, 11-VII-1982.

Distribution. Queensland: Daintree N.P., Windsor Tableland.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is a combination of the Latin prefix *bi-* (two) and the participle *signatus* (marked) and refers to the pair of squamose patches on the pronotum.

Notes. *Trigonopterus bisignatus* Riedel, sp. n. was coded as "*Trigonopterus* sp. 560".

8. *Trigonopterus bisinuatus* Riedel, sp. n.

http://zoobank.org/CBB64820-13B8-41E4-A1D8-0541C087704C

Diagnostic description. Holotype (Fig. 8a). Length 2.88 mm. Color black; antenna and legs ferruginous. Body subovate, with shallow constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, projecting from profile subangularly; epistome posteriorly with 4 low denticles. Forehead coarsely punctate-rugose. Pronotum with subapical constriction; disk coarsely punctate-rugose; with median costa; submedially punctures confluent forming irregular longitudinal furrows and wrinkles, near middle sparing pair of weak swellings of irregular outline. Elytra with striae deeply incised; intervals costate, sparsely punctate, with few scattered recumbent white scales; base markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia subapically with supranucal denticle. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 punctate, weakly concave. Penis (Fig. 8b) with sides of body subparallel, apex rounded; behind ostium with pair of sclerites; endophallus with pair of elongate sclerites; transfer apparatus flagelliform, ca. 1.6× longer than body of penis; ductus ejaculatorius near insertion to transfer apparatus sclerotized, this portion longer and thicker than flagellum; without bulbus. **Intraspecific variation.** Length 2.60–2.90 mm. Female body more slender. Female rostrum dorsally somewhat flattened; median costa and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 coarsely punctate, basally swollen, apically flat.

Material examined. Holotype (QMBA): ARC3736 (EMBL # LN888218), Queensland, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.458', E146°01.227', sample 4, 82 m, 16-IV-2014. Paratypes (ANIC, QMBA, SMNK):

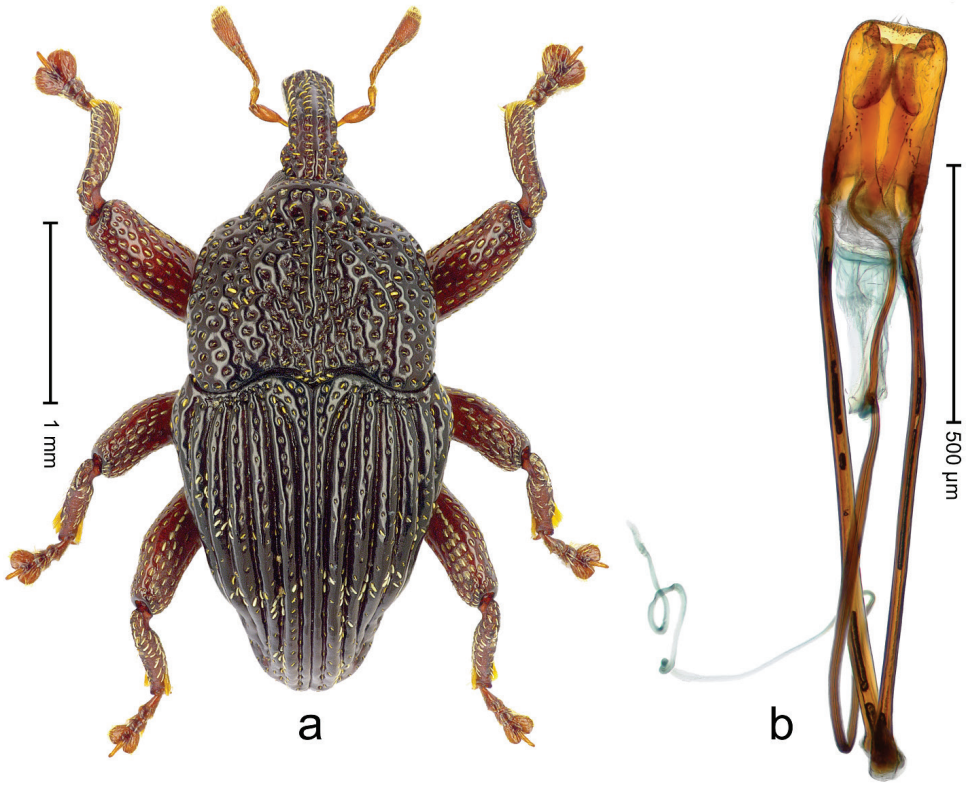

Figure 8. *Trigonopterus bisinuatus* sp. n., holotype; **a** Habitus **b** Penis.

Queensland: 3 exx, ARC3737 (EMBL # LN888219), ARC3738 (EMBL # LN888220), ARC3739 (EMBL # LN888221), same data as holotype; 7 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.388', E146°01.200', sample 1, 70 m, 16-IV-2014; 7 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.306', E146°01.214', sample 2, 103 m, 16-IV-2014; 3 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.252', E146°01.222', sample 3, 105 m, 16-IV-2014; 22 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.458', E146°01.227', sample 4, 82 m, 16-IV-2014; 1 ex Stone Ck (Hasenpusch), 01-XI-1995, 06-II-1996, 100 m, pitfall traps; 4 exx, ARC3719 (EMBL # LN888201), ARC3720 (EMBL # LN888202), ARC3721 (EMBL # LN888203), ARC3722 (EMBL # LN888204), Wooroonooran N.P., Palmerston Highway, K-tree-road, sample 3, 428 m, S17°36.510', E145°46.074', 04-IV-2014; 1 ex, ARC3718 (EMBL # LN888200), Danbulla N.P., Robson´s Creek, S17°07.14', E145°37.92', 700 m, 09-12-IV-2014, ex dung pitfall trap; 3 exx, Graham Range, 550 m, S17°17', E145°58', 01-XI-8-XII-1995, pitfall traps; 3 exx, Graham Range, 01-XI-1995, Berlesate 895, S17°17', E145°58', rainforest, 550 m; 1 ex, Graham Range, 08-XII-1995, Berlesate 901, S17°17', E145°58', rainforest, 550 m; 3 exx, North Bell Peak, 22-XI-

1990, Berlesate 845, S17°06', E145°52', rainforest, 600 m; 1 ex, Kauri Creek, 2 km E, S17°08', E145°37', 10-11-II-1999, 680 m, rainforest, dung pitfall, 2191; 1 ex, Mt. Murray Prior, 30-X-1995, Berlesate 894, S16°56', E145°51', rainforest, 770 m, sieved litter; 1 ex ARC4049 (PCR failed), 4 km E Lake Barrine, S17°16', E145°41', ANIC Berlesate 352, rainforest, 01-VII-1971; 1 ex, Eacham N.P., S17°18', E145°37', ANIC Berlesate 435, rainforest, 20-II-1973; 1 ex, Eacham N.P., S17°18', E145°37', 760 m, ANIC Berlesate 437, rainforest, 19-II-1973; 1 ex, Eacham N.P., S17°18', E145°37', 760 m, ANIC Berlesate 484, rainforest, 23-III-1973; 2 exx, 3.2 km SW Little Mulgrave, ANIC Berlesate 263, rainforest, 25-II-1970; 1 ex, Barrine N.P., S17°16', E145°38', ANIC Berlesate 486, 21-III-1975.

Distribution. Queensland: Atherton Tablelands, Danbulla N.P., Garradunga, Graham Range, Kauri Creek, Mt. Murray Prior, North Bell Peak, Wooroonooran N.P.

Biology. Sifted from leaf litter in primary forest; occasionally found in pitfall traps.

Etymology. This epithet is a combination of the Latin prefix *bi-* (two) and the participle *sinuatus* (curved) and refers to the outline of the elytral base.

Notes. *Trigonopterus bisinuatus* Riedel, sp. n. was coded as "*Trigonopterus* sp. 561".

9. *Trigonopterus boolbunensis* Riedel, sp. n.

http://zoobank.org/4FD5DC0C-580E-4F35-B729-7730A23089B4

Diagnostic description. Holotype (Fig. 9a). Length 2.10 mm. Color of head, legs, and sides of pronotum ferruginous; remainder black. Body subovate, with distinct constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of mesad directed setae; base dorsally protruding, projecting from profile; epistome posteriorly with transverse ridge. Forehead coarsely punctate-rugose. Pronotum subquadrate; sides subparallel; with distinct subapical constriction; coarsely punctate; each puncture containing one small seta, laterally each with one yellowish scale; with indistinct median ridge. Elytral striae weakly incised, with sparse rows of punctures; intervals costate, with small punctures containing small recumbent cream-colored scales; base bisinuate. Legs. Femora rugose-punctate; with scattered, narrow, cream-colored scales. Tibiae subbasally with dorsal angulation. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity, with coarse punctures; ventrite 5 punctate, weakly concave. Penis (Fig. 9b) with sides of body subparallel; apex subangulate; endophallus with anchor-shaped basal sclerite; transfer apparatus spiniform; ductus ejaculatorius without bulbus.

Material examined. Holotype (QMBA): ARC3894 (PCR failed), Queensland, Mt. Boolbun South, S15°57', E145°08', 850-1000 m, rainforest, leaf litter, Berlesate 896, 06-XI-1995.

Distribution. Queensland: Mt. Boolbun.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective and refers to the name of the type locality, Mt. Boolbun.

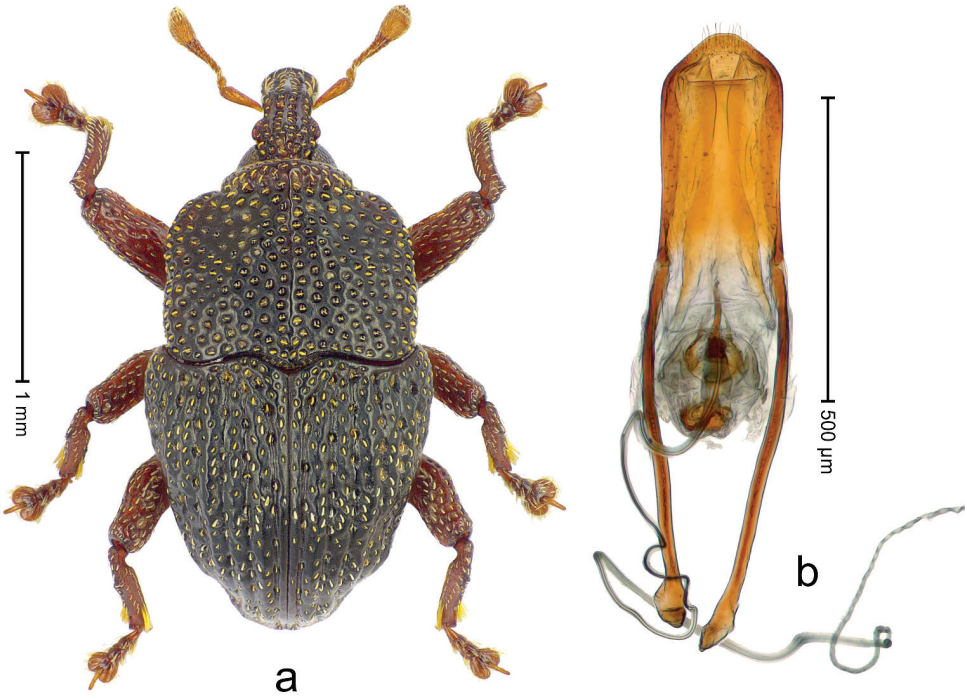

Figure 9. *Trigonopterus boolbunensis* sp. n., holotype; **a** Habitus **b** Penis.

10. *Trigonopterus cooktownensis* Riedel, sp. n.

http://zoobank.org/2728105D-13D1-41AC-856D-0B65DD4898A2

Diagnostic description. Holotype (Fig. 10a). Length 2.95 mm. Color black. Body subovate, almost without constriction between pronotum and elytron; in profile evenly convex. Rostrum with median costa and pair of submedian costae dorsally flattened; intervening furrows with rows of silvery scales; apical 1/3 rugose-punctate. Eyes with dorsal margin bordered by furrow. Forehead with sparse coarse punctures. Pronotum with disk punctate; sides with punctures slightly larger; interspaces not microreticulate; base slightly extended towards elytral suture. Elytra with striae marked by rows of minute punctures; along base and humeri with row of large punctures; apex with dense rows of small shallow punctures. Legs. Femora microreticulate, punctate. Metafemur dorsally with elongate patch of dense silvery scales; posterior surface with pair of longitudinal furrows containing rows of scales parallel to ventral and dorsal edge; dorsoposterior edge indistinct. Mesotibia apically with uncus and premucro largely fused, with shallow incision at apex. Metatibia apically with uncus and distinct premucro. Abdominal ventrite 2 swollen, with posterior edge projecting, medially forming common cavity with ventrite 1; ventrite 5 concave, dull, microreticulate, punctate. Penis (Fig. 9b) with sides of body subparallel, weakly converging; apex with median triangular extension confluent with outline of apex; transfer apparatus short, dentiform, apically bordered by pair of L-shaped sclerites; ductus ejaculatorius without bulbus.

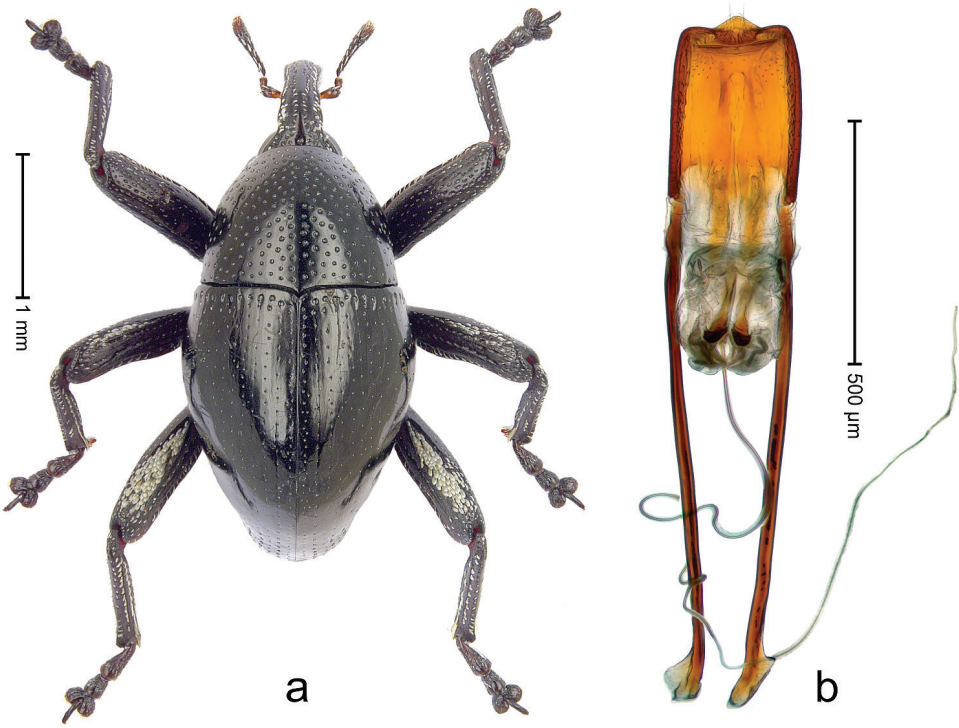

Figure 10. *Trigonopterus cooktownensis* sp. n., holotype; **a** Habitus **b** Penis.

Material examined. Holotype (QMBA): ARC3698 (EMBL # LN888183), Queensland, Cooktown, Mt. Cook N.P., S15°28.648', E145°15.793', to S15°29.252', E145°15.992', 63-245 m, 23-IV-2014. Paratypes (ANIC, SMNK): Queensland: 1 ex, Cooktown, Mt. Cook N.P., S15°29', E145°16', 11-12-X-1980; 1 ex, Cooktown, Mt. Cook N.P., S15°28.648', E145°15.793', to S15°29.252', E145°15.992', 63-324 m, 24-IV-2014.

Distribution. Queensland (Mt. Cook).

Biology. Beaten from foliage of *Acacia*-dominated forest.

Etymology. This epithet is an adjective based on the name of the type locality, Cooktown.

Notes. *Trigonopterus cooktownensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 566". It occurs syntopically with *T. albidosparsus* Lea.

11. *Trigonopterus daintreensis* Riedel, sp. n.

http://zoobank.org/96C266B2-62A1-4581-8551-97784D4A0279

Diagnostic description. Holotype (Fig. 11a). Length 2.80 mm. Color black; antenna and tarsi ferruginous. Body with marked constriction between pronotum and elytron; in profile convex. Rostrum with median costa and pair of submedian costae; interven-

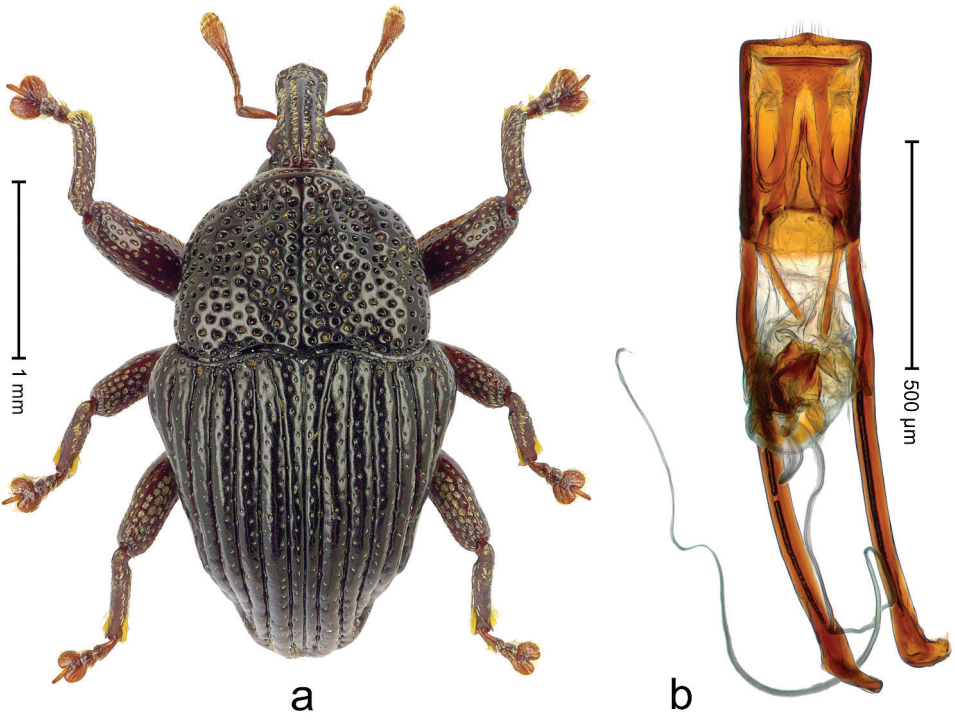

Figure 11. *Trigonopterus daintreensis* sp. n., holotype; **a** Habitus **b** Penis.

ing furrows with rows of coarse punctures each containing one mesad directed seta; in apical third punctate; base dorsally protruding, projecting from profile subangularly. Forehead coarsely punctate. Pronotum with sides weakly converging, rounded to distinct subapical constriction; disk coarsely punctate; along midline with row of ca. 16 punctures; interspaces microreticulate; with median costa. Elytra cuneiform; from humeri markedly converging to narrow apex; dorsally somewhat flattened; base bisinuate; striae deeply incised; intervals costate, with 1-2 rows of small punctures. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia subapically with suprauncal denticle. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 coarsely punctate, weakly concave. Penis (Fig. 10b) with sides of body diverging; apex subtruncate, with short median extension; endophallus with pair of elongate sclerites, from ostium almost reaching asymmetrical bell-shaped transfer apparatus; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.42–3.05 mm. Body of females subovate. Female rostrum dorsally somewhat flattened; median costa and pair of submedian costae subglabrous.

Material examined. Holotype (ANIC): ARC4047 (PCR failed), Queensland, Daintree N.P., Noah Beach, S16°09', E145°26', FIT N03F, 10 m, 15-III-07-V-1998. Paratypes (ANIC, SMNK): Queensland: 2 exx, same data as holotype; 1 ex, Noah

Beach, S16°09.07', E145°26.45', FIT=4, 10 m, 07-I-09-II-1998; 4 exx, ARC4048 (PCR failed), Noah Beach, S16°09', E145°26', FIT N04F, 10 m, 09-II-15-III-1998.

Distribution. Queensland: Daintree National Park.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the type locality, the Daintree National Park.

12. *Trigonopterus deplanatus* Riedel, sp. n.

http://zoobank.org/A0B05E4E-B897-4A78-941D-E0B9F4B48EB3

Diagnostic description. Holotype (Fig. 12a). Length 2.98 mm. Color black; antenna and legs ferruginous. Body with marked constriction between pronotum and elytron; in profile convex. Rostrum in basal half with median costa and pair of submedian costae, intervening furrows with rows of mesad directed setae; in apical third scabrous; epistome posteriorly with transverse ridge; base dorsally weakly protruding, weakly projecting from profile. Forehead coarsely punctate. Pronotum subquadrate, sides weakly converging, apex subtruncate; disk punctate-reticulate; interspaces between punctures narrow,

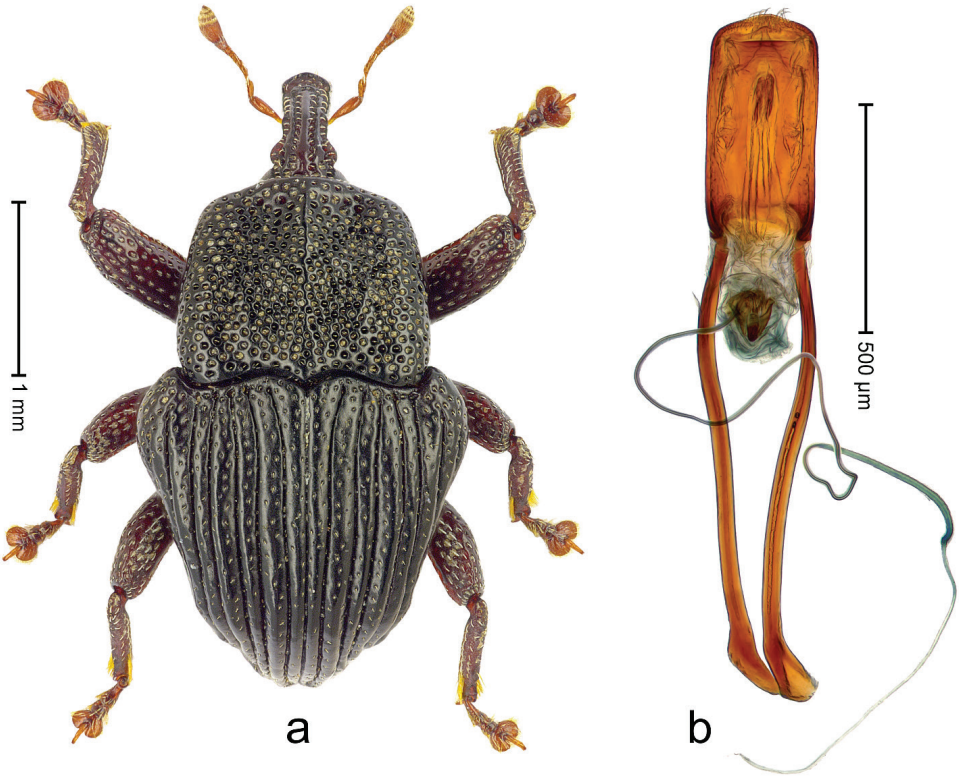

Figure 12. *Trigonopterus deplanatus* sp. n., holotype; **a** Habitus **b** Penis.

partly broken away; along midline with row of ca. 20-23 punctures; in anterior half with median ridge bordered by pair of shallow depressions. Elytra cuneiform; from humeri markedly converging to narrow apex; dorsally flattened; base bisinuate; striae deeply incised; intervals costate, punctate with small punctures. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation. Abdominal ventrites 1 laterally swollen, medially concave, with course punctures; abdominal ventrite 2 swollen; ventrite 5 densely punctate, weakly concave. Penis (Fig. 12b) with sides of body subparallel; apex subangulate; transfer apparatus funnel-shaped, with asymmetrical extension on one side; ductus ejaculatorius without bulbus.

Material examined. Holotype (QMBA): ARC3893 (PCR failed), Queensland, Cairns, Mt. Williams, S16°55', E145°40', 850 m, rainforest, sieved litter, Berlesate 868, 03-XII-1993.

Distribution. Queensland: Mt. Williams.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is based on the Latin participle *deplanatus* (levelled) and refers to the dorsally flattened body.

13. *Trigonopterus evanidus* (Pascoe)

Idotasia evanida Pascoe, 1872: 100.
Trigonopterus evanidus (Pascoe): Pullen et al. 2014: 271.

Diagnostic description. Male (ARC3662; Fig. 13e). Length 3.19 mm. Color black. Body subovate, almost without constriction between pronotum and elytron; in profile evenly convex. Rostrum with median costa and pair of submedian ridges; intervening furrows with rows of white scales; apical 1/3 rugose-punctate. Eyes with dorsal margin bordered by furrow. Forehead sparsely punctate. Pronotum with disk densely punctate with small punctures; interspaces not microreticulate; sides foveate; base medially weakly extended towards elytral suture. Elytra subglabrous, striae marked by very shallow lines; along base and humeri with row of large punctures; apex with dense rows of small shallow punctures. Legs. Femora microreticulate, punctate. Metafemur dorsally with elongate patch of dense white scales; posterior surface with ventral edge rimmed by costa and row of scales, with longitudinal furrow containing row of scales parallel to indistinct dorsoposterior edge. Mesotibia apically with uncus and larger premucro fused in basal half, diverging in apical half. Metatibia apically with uncus and small angular premucro. Abdominal ventrite 2 swollen, with posterior edge projecting, medially forming common cavity with ventrite 1; ventrite 5 concave, dull, microreticulate, punctate. Penis (Fig. 13f) with sides of body subparallel; apex with median triangular extension somewhat confluent with outline of apex; transfer apparatus short, dentiform, bordered by S-shaped sclerites; ductus ejaculatorius without bulbus. **Female lectotype** (Fig. 13a–d). As male except: length 2.56 mm. Rostrum punctate-rugose, with weak

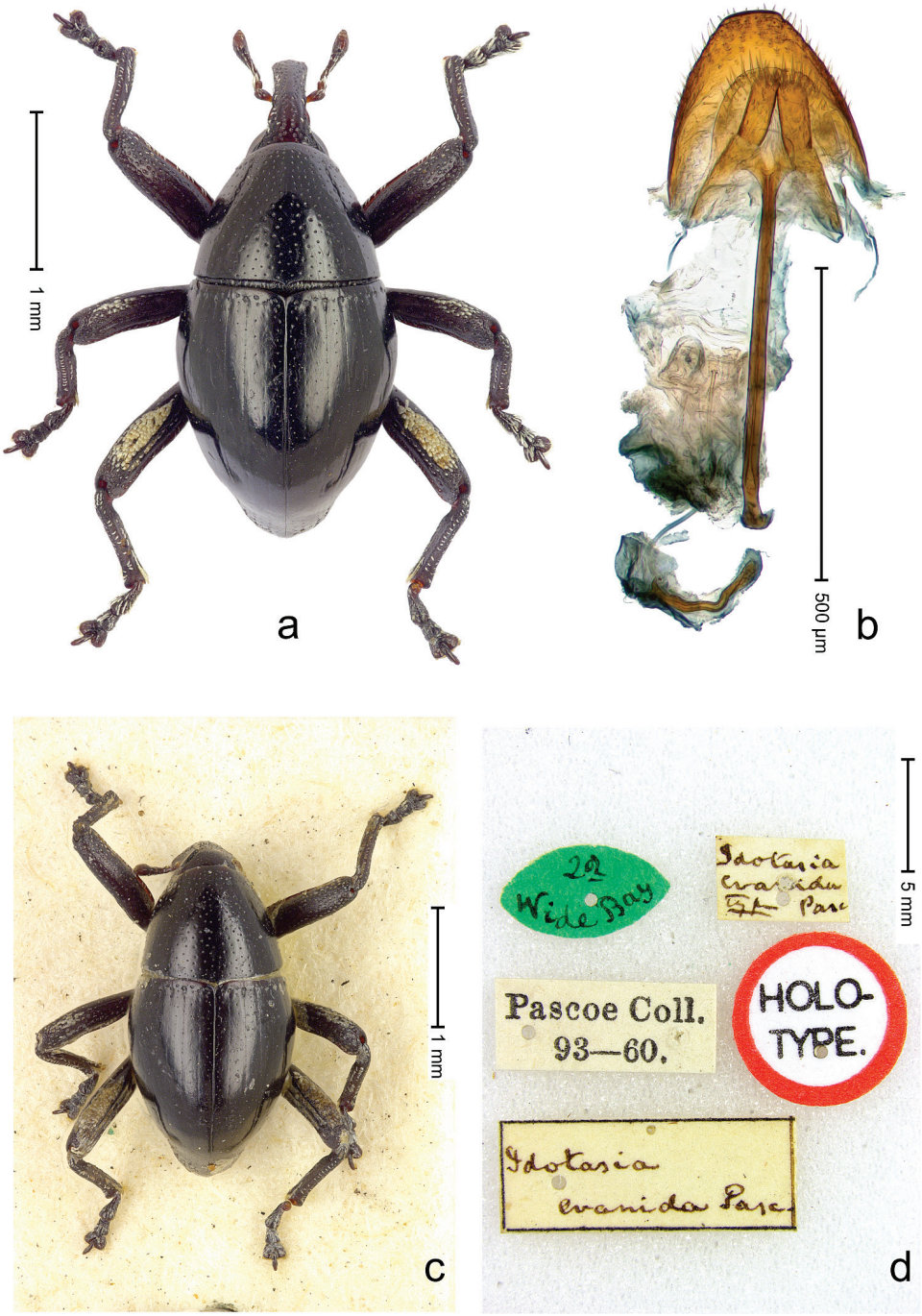

Figure 13 a–d. *Trigonopterus evanidus* (Pascoe), female lectotype; **a** Habitus **b** Terminalia **c** as mounted originally **d** original labels.

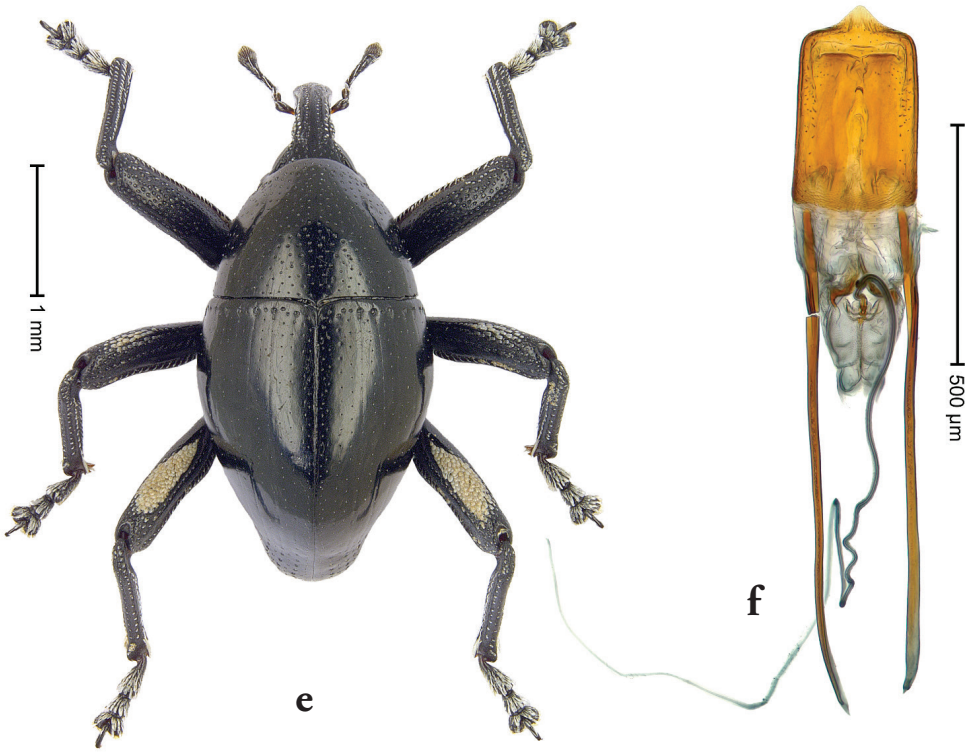

Figure 13 e–f. *Trigonopterus evanidus* (Pascoe), male; **e** Habitus **f** Penis.

median costa. Mesotibia apically with large uncus and much smaller premucro. Terminalia (Fig. 12b) with styli wide.

Material examined. Type specimens. Female, lectotype by present designation (BMNH): Queensland, Wide Bay (labels Fig. 12d), ARC4080 (PCR failed). Other specimens (QMBA, SMNK): Queensland: 1 ex, ARC3660 (EMBL # LN888164), Brisbane, St. Lucia, S27°30.033', E152°59.562', 27 m, hand-collected from *Mallotus* leaves, 20-XI-2013; 2 exx, ARC3661 (EMBL # LN888165), ARC3662 (EMBL # LN888166), Brisbane, St. Lucia, S27°30.033', E152°59.562', 27 m, hand-collected from *Mallotus* leaves, 23-XI-2013; 1 ex, ARC3862 (EMBL # LN888246), Ventnor Site 1, FIT trap, S24°53.58', E151°19.98', 475 m, 01-X-05-XII-2013.

Distribution. Queensland: Brisbane.

Biology. Collected from foliage in gardens and forests.

Notes. The lectotype here designated has a circular label reading "Holotype" fixed to its pin by staff of the BMNH, but Pascoe (1872) did not designate a holotype in the original description nor specify the number of specimens examined. As other syntypes may exist, we here designate the one in the BMNH as the lectotype to ensure stability of nomenclature in case additional syntypes are discovered that belong to different species.

14. *Trigonopterus finniganensis* Riedel, sp. n.
http://zoobank.org/52761014-3B8F-4562-9DE2-5A14026E5A62

Diagnostic description. Holotype (Fig. 14a). Length 2.98 mm. Color black, elytra orange-ferruginous. Body subovate, almost without constriction between pronotum and elytron; in profile evenly convex. Rostrum dorsally sparsely punctate, with pair of shallow sublateral furrows containing sparse rows of mesad-directed scales. Eyes with dorsal margin weakly carinate, bordered by furrow. Forehead with sparse minute punctures. Pronotum with disk subglabrous, with minute punctures; sides above coxa with scattered coarse punctures; base medially weakly extended towards elytral suture. Elytra subglabrous; along base and humeri with sparse row of large, shallow punctures; apex with scattered shallow punctures. Legs. Femora weakly microreticulate, with small punctures. Metafemur dorsally with elongate patch of dense silvery scales; posterior surface with pair of longitudinal furrows containing rows of indistinct scales parallel to ventral and dorsal edge; dorsoposterior edge indistinct. Mesotibia apically with uncus and larger premucro approximate at base, not fused, widely diverging. Metatibia apically with uncus and angular premucro. Abdominal ventrite 2 swollen, with posterior edge projecting, medially forming common cavity with ventrite 1; ventrite 5 weakly concave, subglabrous, dull, with sparse minute punctures. Penis (Fig. 14b)

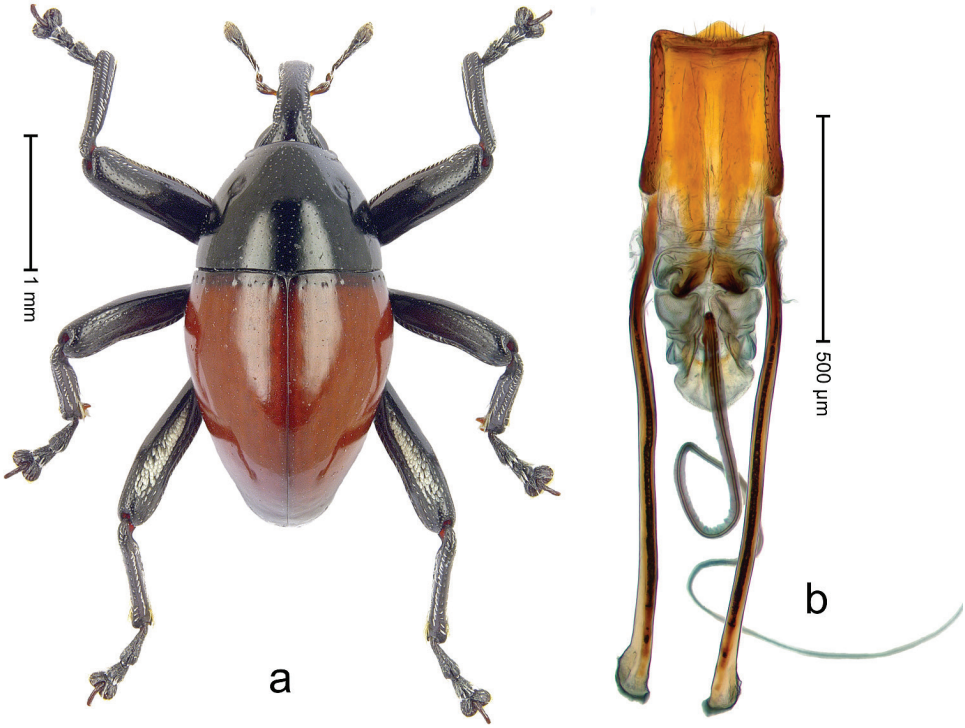

Figure 14. *Trigonopterus finniganensis* sp. n., holotype; **a** Habitus **b** Penis.

with sides of body subparallel, weakly concave; apex with median triangular extension confluent with outline of apex; transfer apparatus short, spiniform, apically bordered by pair of P-shaped sclerites; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.46–2.98 mm. Female rostrum dorsally subglabrous, densely punctate with small punctures. Mesotibia apically with large uncus and much smaller premucro. Female abdominal ventrites 1 and 2 medially flat; female abdominal ventrite 5 flat.

Material examined. Holotype (QMBA): ARC3702 (EMBL # LN888184), Queensland, Mt. Finnigan, ascent from Shiptons Flat, S15°49.043', E145°16.780', 1055 m, 28-IV-2014. Paratypes (QMBA, SMNK): 3 exx, ARC3703 (EMBL # LN888185), ARC3704 (EMBL # LN888186), ARC3705 (EMBL # LN888187), same data as holotype; 2 exx, 3.5 km NNE Mt. Spurgeon, 16°24', S 145°13', E, 16-X-1991, Pyrethrum, trees & rocks; 2 exx, Mt. Finnigan Summit, via Helenvale, 03-05-XII-1990, 1050 m.

Distribution. Queensland (Mt. Finnigan, Mt. Spurgeon).

Biology. Beaten from foliage of montane sclerophyll shrubland.

Etymology. This epithet is an adjective based on the name of the type locality, Mt. Finnigan.

Notes. *Trigonopterus finniganensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 565".

15. *Trigonopterus fraterculus* Riedel, sp. n.

http://zoobank.org/BAA81DE2-8A8D-438B-8CBF-6FA42DEC5513

Diagnostic description. Holotype (Fig. 15a). Length 1.92 mm. Color ferruginous; pronotum dark ferruginous, almost black. Body subovate, with marked constriction between pronotum and elytron; in profile weakly convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of coarse punctures each containing one mesad directed scale; epistome posteriorly with angulate ridge bearing 4 denticles. Forehead coarsely punctate-rugose. Pronotum with distinct subapical constriction; disk foveate-reticulate; each fovea containing one brown scales; sublaterally few scales widened and cream-colored; with irregular median costa. Elytra with striae deeply incised; intervals costate, subglabrous, with sparse recumbent scales; few scales almond-shaped, cream-colored; base weakly bisinuate. Legs. Femora punctate-rugose, with sparse recumbent scales. Tibiae subbasally with dorsal angulation; metatibia subapically with supprauncal denticle. Abdominal venter with coarse punctures containing upcurved clavate scales; ventrite 5 basally with transverse ridge. Penis (Fig. 15b) with sides of body weakly converging, pointed apex extended, curved ventrad; endophallus denticulate, with pair of lyriform sclerites; transfer apparatus long, spiniform; ductus ejaculatorius near insertion to transfer apparatus sclerotized, without bulbus. **Intraspecific variation.** Length 1.92–2.20 mm. Female body slender. Female rostrum dorsally somewhat flattened; with median costa and pair of submedian costae; epistome simple.

Material examined. Holotype (ANIC): ARC4043 (PCR failed), Queensland, 11 km ENE of Mt. Tozer, S12°43', E143°18', rainforest litter, Berlesate ANIC 1062, 11-

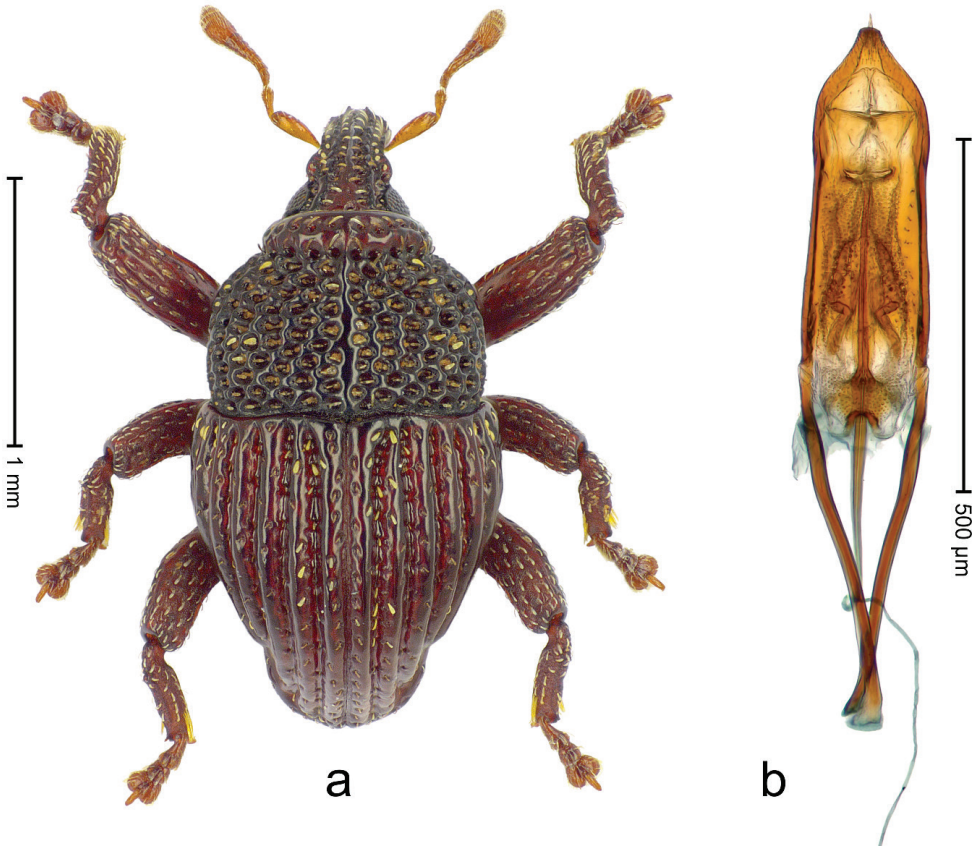

Figure 15. *Trigonopterus fraterculus* sp. n., holotype; **a** Habitus **b** Penis.

16-VII-1986. Paratypes (ANIC, SMNK): Queensland: 2 exx, same data as holotype; 1 ex, 9 km ENE of Mt. Tozer, S12°43', E143°17', open forest litter, Berlesate ANIC 1061, 05-10-VII-1986.

Distribution. Queensland: Iron Range.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is based on the Latin noun *fraterculus* (younger brother) and refers to its presumably close phylogenetic relationship to the larger species *T. australis* Riedel, sp. n..

16. *Trigonopterus garradungensis* Riedel, sp. n.

http://zoobank.org/8BC90C74-FC26-42F7-A7C6-88A7F7EA4ADC

Diagnostic description. Holotype (Fig. 16a). Length 3.28 mm. Color black; antenna and legs ferruginous. Body subovate, with marked constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges

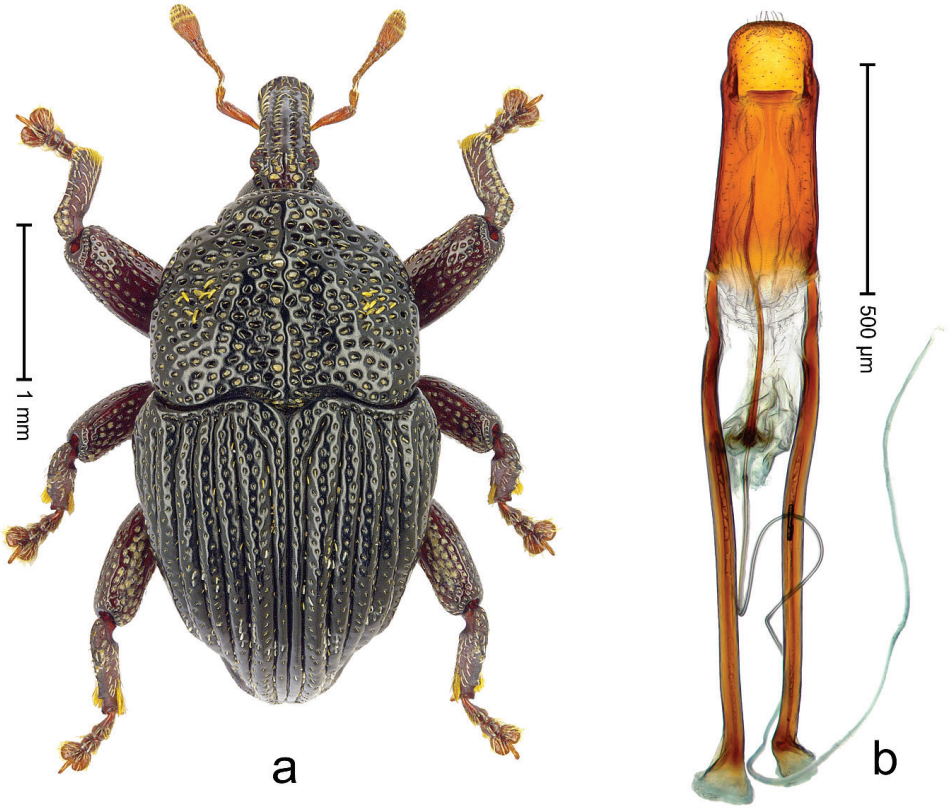

Figure 16. *Trigonopterus garradungensis* sp. n., holotype; **a** Habitus **b** Penis.

ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with angulate ridge bearing 4 denticles. Forehead coarsely punctate-rugose. Pronotum with subapical constriction; disk coarsely punctate-reticulate; with median costa; near middle with pair of weak swellings, further laterad with clusters of sparse yellow recumbent scales. Elytra with striae deeply incised; intervals costate, punctate, with few scattered recumbent scales; sutural interval narrow, below level of interval 2; base markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia in apical third with blunt suprauncal projection. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 punctate, weakly concave. Penis (Fig. 16b) with sides of body weakly converging, in apical third with constriction, apex rounded; transfer apparatus flagelliform, ca. 1.2× longer than body of penis; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.97–3.28 mm. Female rostrum dorsally somewhat flattened; median costa and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 coarsely punctate, basally swollen, apically flat.

Material examined. Holotype (QMBA): ARC3732 (EMBL # LN888214), Queensland, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.458', E146°01.227', sample 4, 82 m, 16-IV-2014. Paratypes (QMBA, SMNK): Queensland: 3 exx, ARC3733 (EMBL # LN888215), ARC3734 (EMBL # LN888216), ARC3735 (EMBL # LN888217), same data as holotype; 2 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.388', E146°01.200', sample 1, 70 m, 16-IV-2014; 3 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.306', E146°01.214', sample 2, 103 m, 16-IV-2014; 1 ex, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.458', E146°01.227', sample 4, 82 m, 16-IV-2014.

Distribution. Queensland: Garradunga.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the type locality, Garradunga.

Notes. *Trigonopterus garradungensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 559".

17. *Trigonopterus hasenpuschi* Riedel, sp. n.

http://zoobank.org/63796EB2-1187-4C40-8B57-75563B3BA9B8

Diagnostic description. Holotype (Fig. 17a). Length 3.22 mm. Color black; antenna and tarsi ferruginous. Body subrhomboid, with marked constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with subangulate ridge. Forehead coarsely punctate-rugose. Pronotum with sides converging to apex, almost without subapical constriction; foveate-reticulate; each fovea containing one inconspicuous seta; interspaces subglabrous. Elytra cuneiform, from broad rounded humeri markedly converging to narrow apex; base bisinuate; striae deeply incised; intervals costate, with 1-2 rows of small punctures; sutural interval subglabrous except few punctures near base; intervals 2-5 behind middle with inconspicuous transverse patches of narrow recumbent scales. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; pro- and metatibia subapically with suprauncal denticle. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 coarsely punctate, weakly concave. Penis (Fig. 17b) with sides of body subparallel; apex subtruncate; endophallus with pair of subtriangular sclerites; transfer apparatus flagelliform; ductus ejaculatorius with distinct bulbus. **Intraspecific variation.** Length 2.59–3.22 mm. Body in smaller specimens and females more slender. Female rostrum dorsally somewhat flattened; median ridge and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrite 5 flat.

Material examined. Holotype (QMBA): ARC3723 (EMBL # LN888205), Queensland, Mission Beach, Clump Mt. N.P., Bicton Hill, S17°50.499',

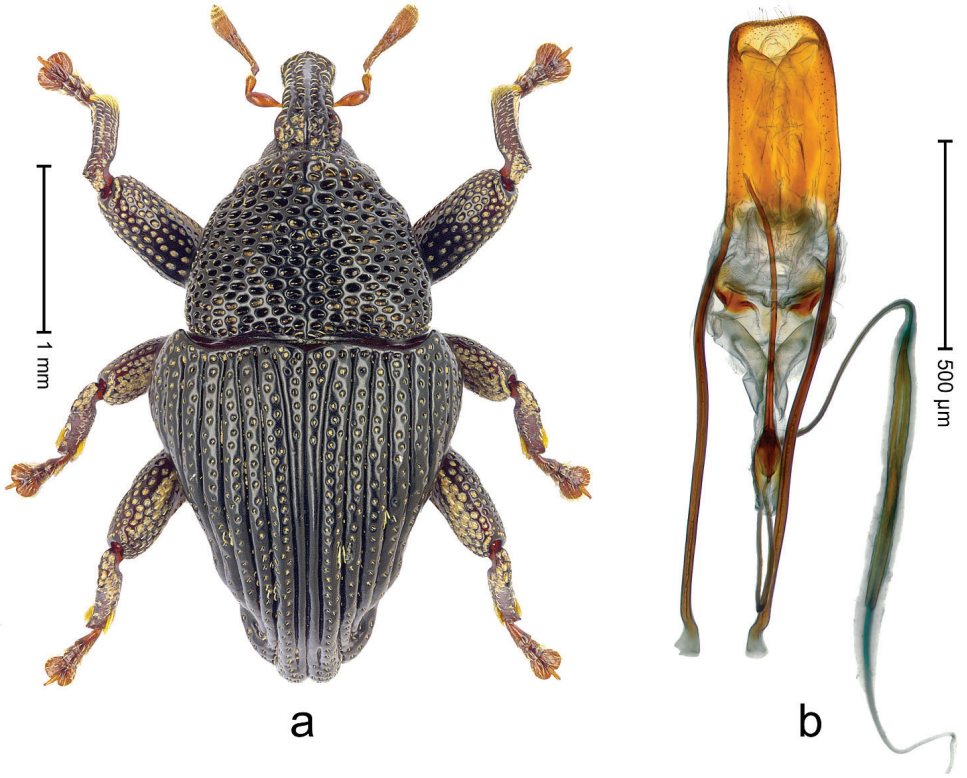

Figure 17. *Trigonopterus hasenpuschi* sp. n., holotype; **a** Habitus **b** Penis.

E146°05.905', sample 1, 150 m, 15-IV-2014. Paratypes (QMBA, SMNK): Queensland: 3 exx, ARC3724 (EMBL # LN888206), ARC3725 (EMBL # LN888207), ARC3726 (EMBL # LN888208), same data as holotype; 2 exx, ARC3740 (EMBL # LN888222), ARC3741 (EMBL # LN888223), Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.388', E146°01.200', sample 1, 70 m, 16-IV-2014; 1 ex, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.306', E146°01.214', sample 2, 103 m, 16-IV-2014; 2 exx, Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.252', E146°01.222', sample 3, 105 m, 16-IV-2014; 1 ex, ARC3731 (EMBL # LN888213), Garradunga, Polly Ck., N Innisfail, Hasenpusch property, S17°27.458', E146°01.227', sample 4, 82 m, 16-IV-2014; 3 exx, Stone Ck. (Hasenpusch), 01-XI-1995-06-II-1996, 100 m, pitfall traps, S17°28', E146°01'; 2 exx, Kirrama Range, 09-XII-1986, Berlesate 730, S18°10', E145°45', rainforest, 700 m, sieved litter; 1 ex, Cardwell range, Upper Broadwater Ck. Valley, 18-XII-1986-14-I-1987, 750 m, RF, Pitfall Traps.

Distribution. Queensland: Mission Beach, Cardwell Range, Kirrama Range, Garradunga.

Biology. Sifted from leaf litter in primary forest.

Etymology. This species is named in honor of Jack Hasenpusch (Garradunga), who preserves the habitat of this and other *Trigonopterus* species on his insect farm.

Notes. *Trigonopterus hasenpuschi* Riedel, sp. n. was coded as "*Trigonopterus* sp. 554".

18. *Trigonopterus hartleyensis* Riedel, sp. n.

http://zoobank.org/49E719CC-0A8C-4C07-AAE1-9BB31D846F98

Diagnostic description. Holotype (Fig. 18a). Length 2.14 mm. Color black; antenna and legs ferruginous. Body subglobose, with shallow constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of mesad directed setae; base dorsally protruding, markedly projecting from profile; epistome posteriorly with transverse ridge. Forehead coarsely punctate-rugose. Pronotum broad, with sides weakly converging to apex, with distinct subapical constriction; punctate-reticulate; with sparse, narrow, cream-colored scales; in anterior half with indistinct median ridge. Elytra with striae marked by isolated foveae; intervals costate; with sparse, recumbent, cream-colored scales; base bisinuate. Legs. Femora densely punctate. Tibiae subbasally with dorsal angulation. Abdominal ventrites 1-2 foveate; ventrite 1 concave; ventrite 2 swollen, transversely costate; ventrite 5 subbasally with shallow impression. Penis (Fig. 18b) with sides of body subparallel; apex rounded; endophallus with pair of elongate sclerites; transfer apparatus short, spiniform; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 1.90–2.40 mm. Female body subovate. Female rostrum dorsally somewhat flattened; in apical half with submedian rows of punctures; near base with median costa and pair of submedian costae; epistome simple.

Material examined. Holotype (QMBA): ARC3762 (EMBL # LN888239), Queensland, Cedar Bay N.P., road between Rossville and Bloomfield, S15°47.510', E145°18.141', sample 2-B, 322 m, 01-V-2014. Paratypes (ANIC, QMBA, SMNK): Queensland: 2 exx, ARC3763 (EMBL # LN888240), same data as holotype; 11 exx, ARC3764 (EMBL # LN888241), ARC3765 (EMBL # LN888242), ARC3766 (EMBL # LN888243), 2.5 km W Mt. Hartley, near Rossville – Bloomfield-road, S15°47.071', E145°18.701', sample 1, 649 m, 01-V-2014; 1 ex, Cedar Bay N.P., road between Rossville and Bloomfield, S15°47.510', E145°18.141', sample 2, 322 m, 29-IV-2014; 5 exx, 2.5 km W Mt. Hartley, near Rossville – Bloomfield-road, S15°47.393', E145°18.348', sample 3, 419 m, 01-V-2014; 1 ex, Big Tableland, 740 m, 20-XII-1990-08-I-1991, flight intercept trap, S15°43', E145°17'; 1 ex, 2.5 km S Mt. Hartley, 08-XII-1993-02-II-1994, pitfalls, S15°47', E145°19'; 7 exx, Mt Hartley, 30 km S Cooktown, 760 m, SBP62, rainforest litter, 03-VII-1982; 4 exx, Mt. Finnigan, 30 km S Cooktown, 400 m, litter and fungi, rainforest, 01-VII-1982; 2 exx, Mt. Finnigan, 30 km S Cooktown, 400 m, moist litter pockets rainforest, 03-VII-1982; 1 ex, Moses Ck, 4 km NbyE of Mt. Finnigan, Berlesate ANIC 696, sieved rainforest litter, 14-16-X-1980.

Distribution. Queensland: Surroundings of Mt. Hartley.

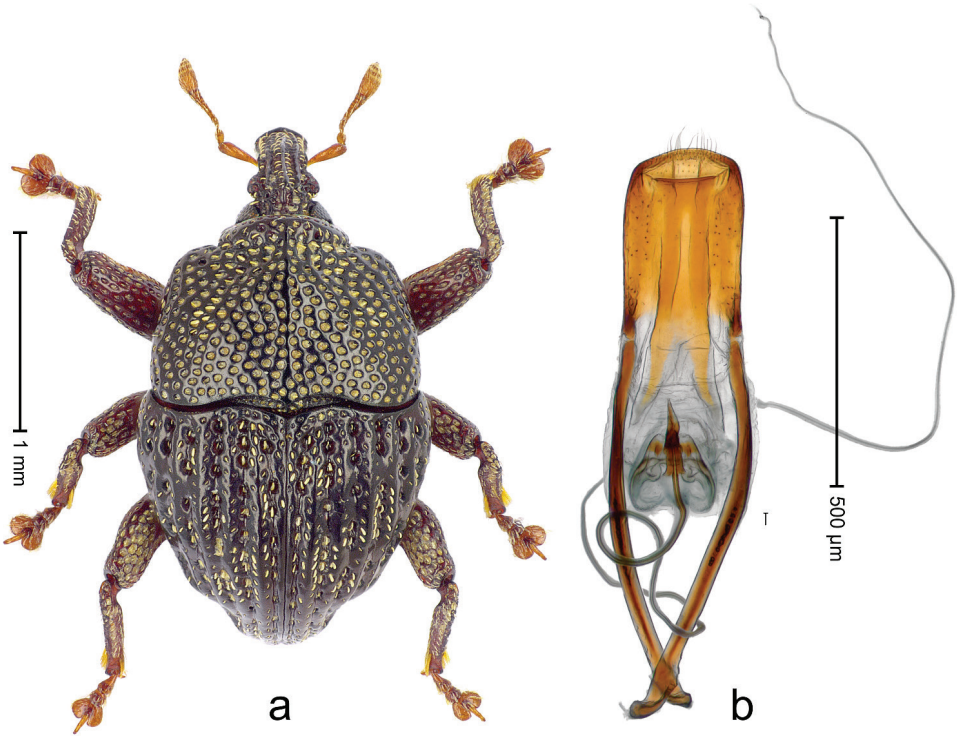

Figure 18. *Trigonopterus hartleyensis* sp. n., holotype; **a** Habitus **b** Penis.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the type locality, Mt. Hartley.

Notes. *Trigonopterus hartleyensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 555".

19. *Trigonopterus kurandensis* Riedel, sp. n.

http://zoobank.org/693B815E-07A2-4AC3-A8C4-7F2C2030D0E8

Diagnostic description. Holotype (Fig. 19a). Length 3.19 mm. Color black; antenna and legs ferruginous. Body subovate, with shallow constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with curved ridge bearing 4 denticles. Forehead coarsely punctate-rugose. Pronotum with subapical constriction; disk coarsely punctate-reticulate; with median costa; near middle with pair of weak swellings, further laterad with clusters of sparse yellow recumbent scales. Elytra with striae deeply incised; intervals costate, microreticulate, punctate, with few scattered recumbent scales; base

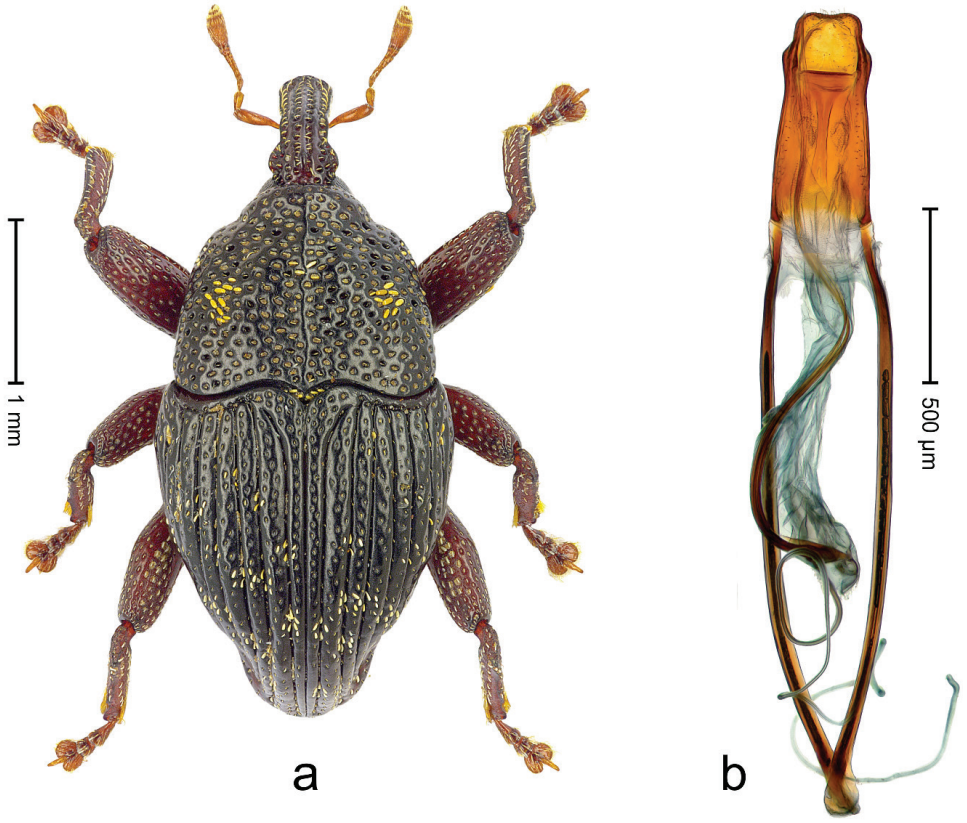

Figure 19. *Trigonopterus kurandensis* sp. n., holotype; **a** Habitus **b** Penis.

markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia in apical third with blunt supranucal projection. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 punctate, weakly concave. Penis (Fig. 19b) with sides of body weakly converging, in apical third with constriction, apex rounded; transfer apparatus flagelliform, ca. 3.0× longer than body of penis; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.97–3.19 mm. Female body more slender, surface more polished. Female rostrum dorsally somewhat flattened; median costa and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 coarsely punctate, basally swollen, apically flat.

Material examined. Holotype (QMBA): ARC3711 (EMBL # LN888193), Queensland, Kuranda N.P., Saddle Mountain Road, S16°49.094', E145°39.712', sample 2, 637 m, 31-III-2014. Paratypes (ANIC, QMBA, SMNK): Queensland: 10 exx, ARC3710 (EMBL # LN888192), ARC3712 (EMBL # LN888194), ARC3713 (EMBL # LN888195), same data as holotype; 2 exx, Kuranda N.P., Saddle Mountain Road, S16°49.106', E145°39.759', sample 1, 637 m, 31-III-2014; 1 ex, ARC4052

(PCR failed), Kuranda, Black Mt. Rd., S17°47', E145°39', rainforest, sieved litter, Q.M. Berlesate No. 223, 360 m, 09-VI-1980; 4 km W of Kuranda, S16°49', E145°36', ANIC Berlesate 340, 450 m, 27-VI-1971.

Distribution. Queensland: Kuranda.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of Kuranda, the type locality.

Notes. *Trigonopterus kurandensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 558".

20. *Trigonopterus laetus* (Lea)

Idotasia laeta Lea, 1913: 610.
Trigonopterus laetus (Lea): Pullen et al. 2014: 271.

Diagnostic description. Lectotype (Fig. 20a, c). Length 2.30 mm. Color black, legs and antenna dark ferruginous. Body subovate, with constriction between pronotum and elytron; in profile with shallow constriction. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of white scales; apical 1/3 rugose-punctate. Eyes large, in dorsal position. Pronotum with disk punctate; sides more densely punctate with slightly larger punctures. Elytra subglabrous; along base and humeri with row of large punctures; subapically with sparse small punctures. Legs. Meso- and metafemur dorsally with narrow band of white scales; anteroventral ridge of femora weakly crenulate, terminating 1/3 before apex with minute denticle. Tibial apex with uncus, without premucro. Abdominal ventrite 2 posteriorly forming edge; medially forming common cavity with ventrite 1; ventrite 5 weakly concave, almost flat, nude, microreticulate, sparsely punctate. Penis (Fig. 20b) with sides of body subparallel; apex broadly subangulate; body containing two pairs of lyriform sclerites; transfer apparatus short, dentiform; ductus ejaculatorius near insertion to transfer apparatus swollen, subapically with very indistinct bulbus. **Intraspecific variation.** Length 1.96–2.30 mm. Female rostrum subglabrous, with submedian rows of punctures. Female abdominal ventrites 1 and 2 convex, medially flat.

Material examined. Type specimens. Male, lectotype by present designation (Fig. 20) (SAMA): Queensland, Endeavour River (labels Fig. 20e), ARC4038 (PCR failed). Female, paralectotype (SAMA), same data as lectotype; 1 paralectotype (ANIC – permanent loan from Macleay Museum), Sue Island. Other specimens (ANIC, QMBA, SMNK): Queensland: 1 ex, 44 km N of Cairns, beating shrubs, 10-XII-1982; 3 exx, ARC1672 (EMBL # LN888161), ARC1673 (EMBL # LN888162), ARC1674 (EMBL # LN888163), Cooktown, Jensen´s Xing, Pyrethrum, trees & logs, RF, S15°26', E145°07', 20 m, 19-22-X-2008; 1 ex, ARC3692 (EMBL # LN888179), Cooktown, Mt. Cook N.P., S15°28.648', E145°15.793', to S15°29.252', E145°15.992', 63-324 m, 24-IV-2014; 2 exx, Cooktown, Mt. Cook N.P., S15°29', E145°16',11-12-X-1980;

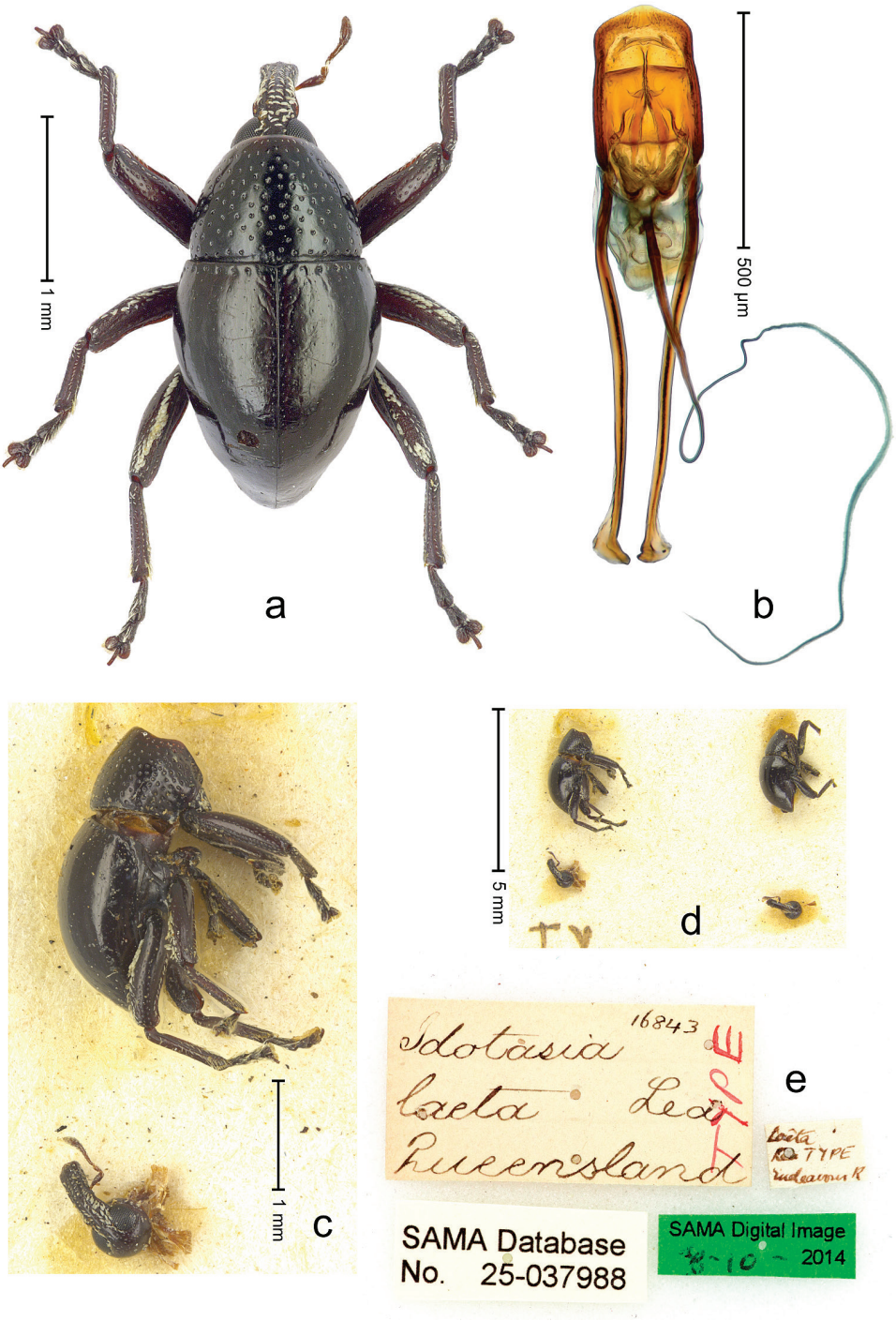

Figure 20. *Trigonopterus laetus* (Lea), male lectotype; **a** Habitus **b** Penis **c** as mounted originally **d** original labels.

1 ex, Mt. Webb N.P., S15°04', E145°07', ex malaise trap, 27-30-IV-1981; 1 ex, Mt. Webb N.P., S15°04', E145°07', 28-30-IX-1980; 2 exx, Mt. Webb N.P., S15°04', E145°07', 30-IX-1980; 3 exx, Mt. Webb N.P., S15°04', E145°07', 27-30-IV-1981; 3 exx, Mt. Webb N.P., S15°04', E145°07', 29-IX-1980; 3 exx, 11 km ENE of Mt. Tozer, S12°43', E143°18', beating rainforest vegetation, 11-16-VII-1986; 9 exx, 9 km ENE of Mt. Tozer, S12°43', E143°17', beating rainforest vegetation, 05-10-VII-1986; 4 exx, 3 km ENE of Mt. Tozer, S12°44', E143°14', beating, 11-16-VII-1986; 1 ex, 3 km ENE of Mt. Tozer, S12°44', E143°14', 01-04-VII-1986; 1 ex, 8 km E by N of Mt. Tozer, S12°44', E143°17', beating rainforest vegetation, 07-VII-1986; 1 ex, 15 km NE by E Heathlands, sweeping, S11°41', E142°42', 15-26-I-1992; 1 ex: West Claudie River, 4 km SW road junction, 12°44', S 143°15', E, 11-XII-1986, malaise; 1 ex, 3 km E Lockerbie, Cape York, Pyrethrum on logs, Rf, 19-23-III-1987; 2 exx, Bamaga, XII-1983.

Distribution. Queensland: Cooktown, Mt. Webb N.P., Heathlands N.P., Iron Range N.P., Lockerbie Scrub.

Biology. Beaten from foliage in rainforest.

Notes. Lea (1913) did not designate a holotype in the original description nor specify the number of specimens examined. The original description is based on more than one specimen. One pair with the male marked "TY" and one syntype from Sue Island could be examined, but other specimens may exist. The male is here designated as lectotype.

21. *Trigonopterus lewisensis* Riedel, sp. n.

http://zoobank.org/252B8FC8-CC37-4D95-9B9B-B38366B15055

Diagnostic description. Holotype (Fig. 21a). Length 3.03 mm. Color ferruginous. Body elongate-subovate, with distinct constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed narrow ochre scale; base dorsally protruding, projecting from profile subangularly; epistome posteriorly with indistinct irregular ridge. Forehead coarsely punctate-rugose. Pronotum with distinct subapical constriction; disk coarsely punctate-reticulate; with median costa; punctures each containing one narrow scale of ochre or white color. Elytra with striae deeply incised; intervals costate-carinate, with dense rows of punctures; punctures containing each one ochre or white narrow scale; base markedly bisinuate. Legs. Femora densely punctate, with sparse ochre scales, with transverse band of larger white scales. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia with supranuncal tooth. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity, with coarse punctures; ventrite 5 medially concave, laterally swollen and with ochre elongate scales. Penis (Fig. 21b) with sides of body subparallel, subapically converging to subtruncate apex; endophallus with large X-shaped sclerite; complex transfer apparatus compact; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.58–3.19 mm. Body of females shorter. Female rostrum basally with median costa

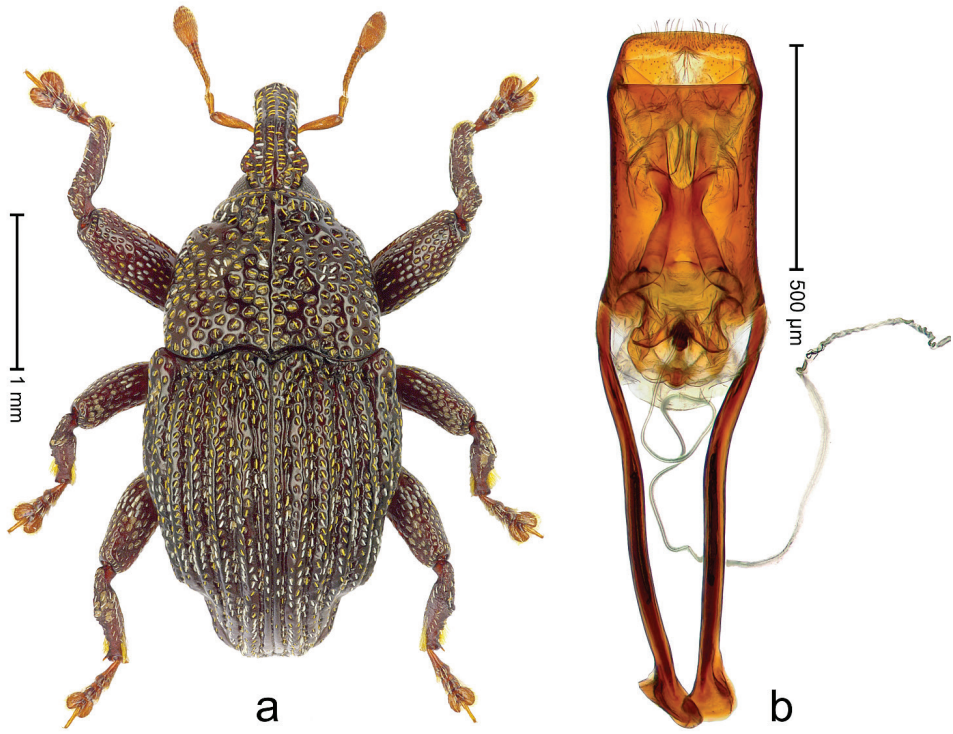

Figure 21. *Trigonopterus lewisensis* sp. n., holotype; **a** Habitus **b** Penis.

and pair of submedian costae; in apical half subglabrous, punctate; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 flat.

Material examined. Holotype (ANIC): ARC4045 (PCR failed), Queensland, Mt. Lewis Rd. via Julatten, 1000 m, rainforest, intercept trap, 11-XI-25-XII-1987. Paratypes (ANIC, SMNK): Queensland: 2 exx, same data as holotype; 1 ex, Mt. Lewis Rd. via Julatten, 1000 m, rainforest, intercept trap, 13-IX-10-X-1987; 1 ex, Mt. Lewis Rd. via Julatten, 1000 m, rainforest, intercept trap, 10-X-11-XI-1987; 1 ex, Mt. Lewis Rd. via Julatten, 01-XII-1975.

Distribution. Queensland: Mt. Lewis Road.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the type locality, Mt. Lewis.

22. *Trigonopterus montanus* Riedel, sp. n.

http://zoobank.org/4652D7C5-8B0E-45F4-BFF6-4832E9A94CB8

Diagnostic description. Holotype (Fig. 22a). Length 3.25 mm. Color ferruginous. Body elongate, with distinct constriction between pronotum and elytron; in profile

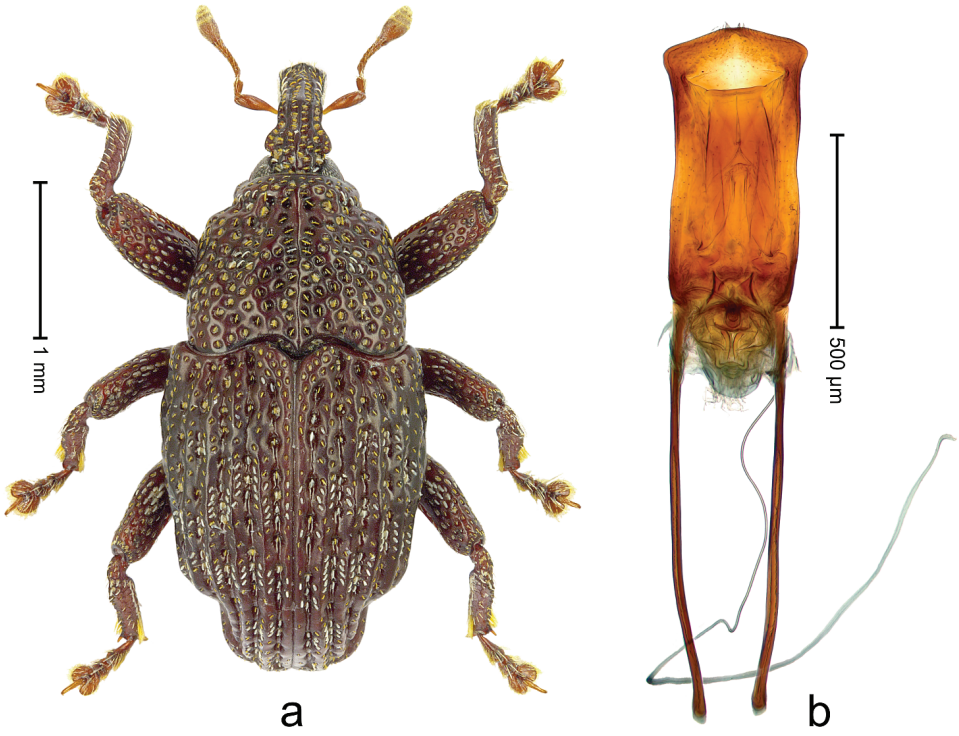

Figure 22. *Trigonopterus montanus* sp. n., holotype; **a** Habitus **b** Penis.

convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed narrow scale; base dorsally protruding, gently projecting from profile; epistome posteriorly with 4 denticles. Forehead coarsely punctate-rugose. Pronotum with distinct subapical constriction; disk coarsely punctate-reticulate; with median costa; uneven, near middle with pair of weak swellings; punctures each containing one narrow scale of ochre or white color. Elytra with striae deeply incised, containing coarse punctures; intervals costate, punctate, in basal half partly transversely confluent; punctures containing small ochre scales or larger white scales; base markedly bisinuate. Legs. Femora densely punctate, with sparse scales. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally denticulate; metatibia with suprauncal tooth. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity, with coarse punctures; ventrite 5 in basal half concave, coarsely punctate. Penis (Fig. 22b) with sides of body subparallel, widened to subangulate apex; transfer apparatus compact, with pair of triangular sclerites; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 3.16–3.25 mm. Color ferruginous (ht, 1 pt), or black except tarsi and antenna ferruginous (1 pt). Female rostrum basally with median costa and pair of submedian costae; in apical half subglabrous, punctate; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 flat.

Material examined. Holotype (ANIC): ARC4040 (PCR failed), Queensland, Bellenden Ker Range, Summit TV Stn., S17°16', E145°51', 1560 m, rainforest, litter, Q.M. Berlesate No. 565, 29-IV-02-V-1983. Paratypes (ANIC, SMNK): Queensland: 2 exx, same data as holotype.

Distribution. Queensland: Mt. Bellenden Ker.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is based on the adjective *montanus* (belonging to a mountain) and refers to the isolated occurrence of the species on the summit of Mt. Bellenden Ker.

23. *Trigonopterus monteithi* Riedel, sp. n.

http://zoobank.org/BF36E82F-CE3A-4310-934D-FCF8859275BA

Diagnostic description. Holotype (Fig. 23a). Length 3.22 mm. Color black; antenna and tarsi ferruginous. Body subrhomboid, with marked constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with transverse ridge. Forehead coarsely punctate-rugose. Pronotum with sides converging to apex, almost without subapical constriction; foveate-reticulate; each fovea containing one inconspicuous seta; interspaces subglabrous, weakly microreticulate. Elytra cuneiform, from broad rounded humeri markedly converging to narrow apex; base bisinuate; surface microreticulate; striae deeply incised, narrow; intervals flat to weakly costate, with 1-2 rows of small punctures; sutural interval subglabrous except few punctures near base; intervals 2-5 behind middle with inconspicuous transverse patches of narrow recumbent scales. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; pro- and metatibia subapically with supprauncal denticle. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity; ventrite 5 coarsely punctate, weakly concave. Penis (Fig. 23b) with sides of body subparallel; apex subtruncate; endophallus with pair of subtriangular sclerites; transfer apparatus long spiniform; ductus ejaculatorius with distinct bulbus. **Intraspecific variation.** Length 2.04–3.53 mm. Female rostrum dorsally somewhat flattened; median ridge and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrite 5 flat.

Material examined. Holotype (QMBA): ARC3717 (EMBL # LN888199), Queensland, Kuranda, Saddle Mountain Road, S16°48.836', E145°39.580', sample 3, 586 m, 31-III-2014. Paratypes (QMBA, SMNK): Queensland: 1 ex, ARC3716 (EMBL # LN888198), same data as holotype; 2 exx, ARC3714 (EMBL # LN888196), ARC3715 (EMBL # LN888197), Kuranda, Saddle Mountain Road, S16°49.094', E145°39.712', sample 2, 637 m, 31-III-2014; 1 ex, 30 km N Kuranda, Black Mt. Rd., rainforest, leafmold, ANIC Berlesate 165, 04-XI-1969; 1 ex, Kuranda, Black Mt. Rd., S16°44', E145°34', 350 m, rainforest, ANIC Berlesate 339, 27-VI-1971; 1 ex,

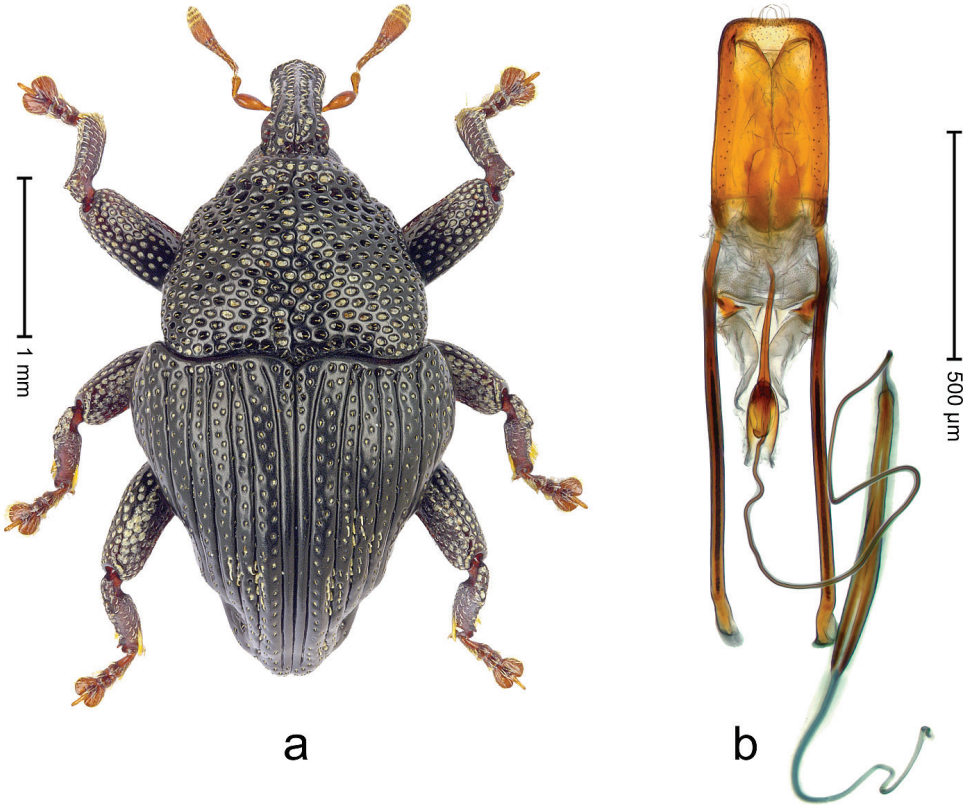

Figure 23. *Trigonopterus monteithi* sp. n., holotype; **a** Habitus **b** Penis.

Davies Ck road, 20 km ESE Mareeba, 04-13-XII-88, 750 m, flight intercept trap; 1 ex, 9.6 km S Redlynch, Crystal Cascades, leaf litter, ANIC Berlesate 277, 30-IV-1970; 1 ex, Mt. Formartine South, 24-XI-1990, Berlesate 848, E145°37', S16°43', rainforest, 700 m, sieved litter; 2 exx, ARC3750 (EMBL # LN888230), ARC3751 (EMBL # LN888231), Daintree N.P., NW Mossman, Manjal Jimalji (Devils Thumb) trail, S16°23.571', E145°19.058', sample 2, 377 m, 20-IV-2014; 2 exx, ARC3746 (EMBL # LN888228), Cape Tribulation, Mt. Sorrow track, S16°04.789', E145°27.948', sample 1, 150 m, 09-IV-2014; 2 exx, ARC3745 (EMBL # LN888227), Cape Tribulation, Mt. Sorrow track, S16°04.579', E145°27.081', sample 6, 283 m, 10-IV-2014; 2 exx, ARC3747 (EMBL # LN888229), Cape Tribulation, Mt. Sorrow track, S16°04.695', E145°27.690', sample 7, 234 m, 10-IV-2014; 1 ex, 1,5 km NW of Cape Tribulation, site 1, S16°05', E145°28', Berlesate 480, 0 m, rainforest, sieved litter, 02-X-1982; 1 ex, 1,5 km NW of Cape Tribulation, site 1, Berlesate 445, S16°05', E145°28', 0 m, rainforest, sieved litter, 03-X-1982; 3 exx, 2.0 km W of Cape Tribulation, site 4, S16°05', E145°28', 200 m, Berlesate 429, sieved litter, rainforest, 25-IX-1982; 1 ex, 3.0 km W of Cape Tribulation, site 6, S16°05', E145°27', 500 m, Berlesate 422, rainforest, sieved litter, 19-IX-1982; 1 ex, 1.5 km W of Cape Tribulation, site 3, 150

m, baited flight trap, RF, 19-IX-1982; 2 exx, 2.5 km W of Cape Tribulation, site 5, S16°05', E145°27', 180 m, Berlesate 533, rainforest, sieved litter, 21-IV-1983; 1 ex, 2.5 km W of Cape Tribulation, site 5, S16°05', E145°27', 180 m, Berlesate 502, rainforest, sieved litter, 02-I-1983; 4 exx, Cape Tribulation, 49 km N of Daintree, 10 m, rainforest leaf and log litter, SBP 75, 12-VII-1982; 1 ex, Cape Tribulation, 49 km N of Daintree, 200 m, rainforest leaf litter, SBP 77, 14-VII-1982; 2 exx, Cape Tribulation, 10 m, rainforest streamside flood litter, SBP 79, 14-VII-1982; 1 ex, Table Mtn 10 km S of Cape Tribulation, S16°09', E145°26', 320 m, rainforest, sieved litter, 24-IV-1983; 1 ex, 2.0 km W of Cape Tribulation, site 4, S16°05', E145°28', 200 m, rainforest, sieved litter, 25-IX-1982; 1 ex, Cape Tribulation Area, S16°03', to S16°05', E145°28', 200 m, Winkler ANIC 1234 leaf and log litter, 01-11-V-1992; 3 exx, Thornton Range, S16°15', E145°26', 150 m, Berlesate ANIC 327, rainforest, 23-VI-1971; 2 exx, Thornton Range, S16°14', E145°26', 100 m, Berlesate ANIC 325, rainforest, 23-VI-1971; 1 ex, Thornton Range, S16°14', E145°26', 100 m, Berlesate ANIC 333, rainforest, 24-VI-1971; 4 exx, Thorn Rd., 11-XII-1969; 2 exx, Cooper Ck. near Daintree, S16°11', E145°26', 50 m, ANIC Berlesate 334, 22-VI-1971; 1 ex, Mt. Finnigan, 400 m, rainforest, litter and fungi, SPB56, 01-VII-1982; 1 ex, Mt. Finnigan, 400 m, rainforest, moist litter pockets, SPB61, 03-VII-1982; 1 ex, Moses Ck., 4 km NbyE of Mt. Finnigan, S15°47', E145°17', sieved rainforest litter, Berlesate ANIC 696, 14-16-X-1980; 3 exx, Julatten, edge of rainforest along creek, ex intercept trap, 21-30-XI-1987; 1 ex, Buchanan Ck., S 16°15', E145°26', 140 m, FIT B06F, 11-II-12-III-1998; 3 exx, Buchanan Ck., S 16°15', E145°26', 140 m, FIT B06F, 12-III-08-V-1998; 2 exx, Noah Beach, S 16°09', E145°26', 10 m, FIT N08F, 15-III-07-V-1998; 2 exx, Noah Beach, S 16°09', E145°26', 10 m, FIT N08F, 09-II-15-III-1998; 1 ex, Noah Beach, S 16°09', E145°26', 10 m, FIT N09F, 09-II-15-III-1998; 2 exx, Noah Beach, S 16°09', E145°26', 10 m, FIT N09F, 15-III-07-V-1998; 1 ex, Daintree, Buchanan Creek, S 16°14.39', E145°25.54', 140 m, FIT#6, 15-I-11-II-1998; 2 exx, Daintree, Cooper Creek, S 16°09.10', E145°24.19', 140 m, FIT#9, 11-I-10-II-1998; 2 exx, Daintree, Cooper Creek, S 16°09', E145°24', 140 m, FIT C05F, 16-III-07-V-1998; 2 exx, Daintree, Thompson Creek, S 16°07', E145°25', 80 m, FIT T08F, 10-I-12-II-1998; 1 ex, Daintree, Thompson Creek, S 16°07', E145°25', 80 m, FIT T09F, 12-II-15-III-1998; 2 exx, Daintree, Thompson Creek, S 16°07', E145°25', 80 m, FIT T09F, 15-III-07-V-1998; 1 ex, Daintree, Thompson Creek, S 16°07', E145°25', 80 m, FIT T09F, 10-I-12-II-1998; 10 exx, Daintree, Pimm´s Block, S 16°11', E145°24', 100 m, FIT T07F, 13-III-08-V-1998; 1 ex, Daintree, Pimm´s Block, S 16°11.33', E145°24.30', 100 m, FIT =6, 08-I-09-II-1998; 1 ex, Hutchinson Ck., S 16°13', E145°24', 30 m, FIT H09F, 11-II-14-III-1998; 4 exx, Hutchinson Ck., S 16°13', E145°24', 30 m, FIT H09F, 14-III-08-V-1998; 2 exx, Donovan Ck., S 16°01', E145°27', 20 m, FIT D09F, 10-II-14-III-1998; 3 exx, Donovan Ck., S 16°01', E145°27', 20 m, FIT D07F, 14-III-06-V-1998; 1 ex, Fairy Ck., S 16°14', E145°25', 80 m, FIT F07F, 11-II-13-III-1998; 1 ex, Fairy Ck., S 16°14', E145°25', 80 m, FIT F07F, 12-I-11-II-1998; 1 ex, Fairy Ck., S 16°14', E145°25', 80 m, FIT F01F, 13-III-08-V-1998; 4 exx, ARC3759

(EMBL # LN888236), ARC3760 (EMBL # LN888237), ARC3761 (EMBL # LN888238), Cedar Bay N.P., road between Rossville and Bloomfield, S15°47.510', E145°18.141', sample 2, 322 m, 29-IV-2014; 4 exx, Cedar Bay N.P., road between Rossville and Bloomfield, S15°47.510', E145°18.141', sample 2-B, 322 m, 01-V-2014; 3 exx, Cedar Bay N.P., road between Rossville and Bloomfield, S15°48.274', E145°18.901', sample 4, 214 m, 29-IV-2014; 1 ex, 3 km NE Mt. Webb, S15°03', E145°09', 01-30-X-1980.

Distribution. Queensland: Cairns, Kuranda, Lamb Range, Mt. Formartine South, Cape Tribulation, Daintree N.P., Cedar Bay N.P., Mt. Webb.

Biology. Sifted from leaf litter in primary forest.

Etymology. This species is named in honor of Geoff Monteith (Brisbane), who collected the majority of the new Australian *Trigonopterus* species for the first time and whose help was essential for the success of this study.

Notes. *Trigonopterus monteithi* Riedel, sp. n. was coded as "*Trigonopterus* sp. 553".

24. *Trigonopterus mossmanensis* Riedel, sp. n.

http://zoobank.org/6B1EA8BB-66D3-437D-9F5B-F27F75DDD450

Diagnostic description. Holotype (Fig. 24a). Length 1.92 mm. Color ferruginous. Body subovate, with weak constriction between pronotum and elytron; in profile convex. Rostrum with 4 rows of coarse punctures each containing one mesad directed seta; without distinct ridges; base gently projecting from profile; epistome indistinct. Forehead coarsely punctate. Pronotum with indistinct subapical constriction; disk coarsely punctate; punctures each containing one inconspicuous seta, very few with yellow recumbent scales instead. Elytra with striae deeply incised; intervals costate, punctate, with scattered recumbent scales; sutural interval narrow and weakly convex, below level of interval 2; base markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; uncus of protibia slender, hook-shaped, basally continued with ventral tibial outline, markedly curved ventrad towards apex. Abdominal ventrites 1 laterally swollen, medially concave; abdominal ventrite 2 swollen; ventrite 5 microgranulate, weakly concave. Penis (Fig. 24b) with sides of body converging, apex subtruncate; transfer apparatus flagelliform, ca. 1.8× longer than body of penis; ductus ejaculatorius without bulbus.
Intraspecific variation. Length 1.92–2.11 mm. Color ferruginous or black with only legs and head ferruginous. Female rostrum dorsally somewhat flattened; with median costa and pair of submedian costae; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 coarsely punctate.

Material examined. Holotype (QMBA): ARC3896 (PCR failed), Queensland, Mossman Bluff Track, 5-10 km W Mossman, site 6, 860m, flt. Intercept, 16-30-XII-1988. Paratype (QMBA) 1 ex, Mossman Bluff Track, 5-10 km W Mossman, site 7, 1000 m, pitfall, 16-30-XII-1988.

Distribution. Queensland: Mossman Bluff.

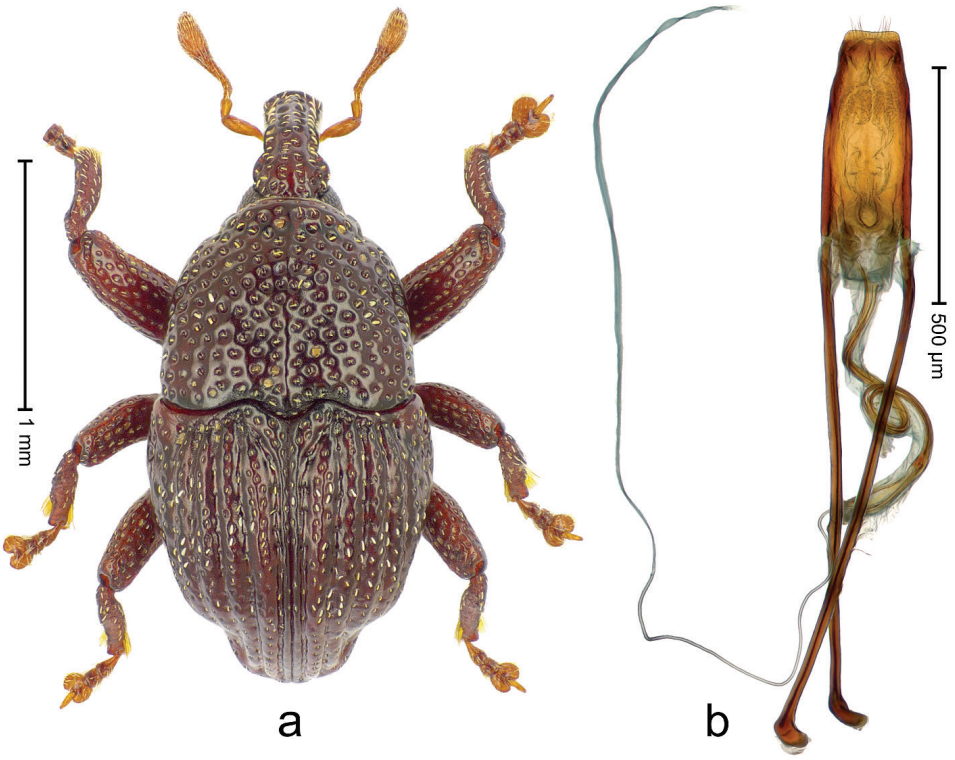

Figure 24. *Trigonopterus mossmanensis* sp. n., holotype; **a** Habitus **b** Penis.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet is an adjective based on the name of the type locality, Mossman.

25. *Trigonopterus oberprieleri* Riedel, sp. n.

http://zoobank.org/9E38DA44-1AD6-45FE-ACE9-FC4679E643D3

Diagnostic description. Holotype (Fig. 25a). Length 3.11 mm. Color black; antenna and legs ferruginous. Body subovate, with marked constriction between pronotum and elytron; in profile convex. Rostrum with median costa and pair of submedian costae; intervening furrows with rows of coarse punctures each containing one mesad directed seta; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with irregular ridge. Forehead coarsely punctate-rugose. Pronotum with subapical constriction; disk coarsely punctate; with median costa, bordered by pair of submedian longitudinal impressions. Elytra with striae deeply incised; intervals costate, microreticulate, punctate, with scattered recumbent white scales; base markedly bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus

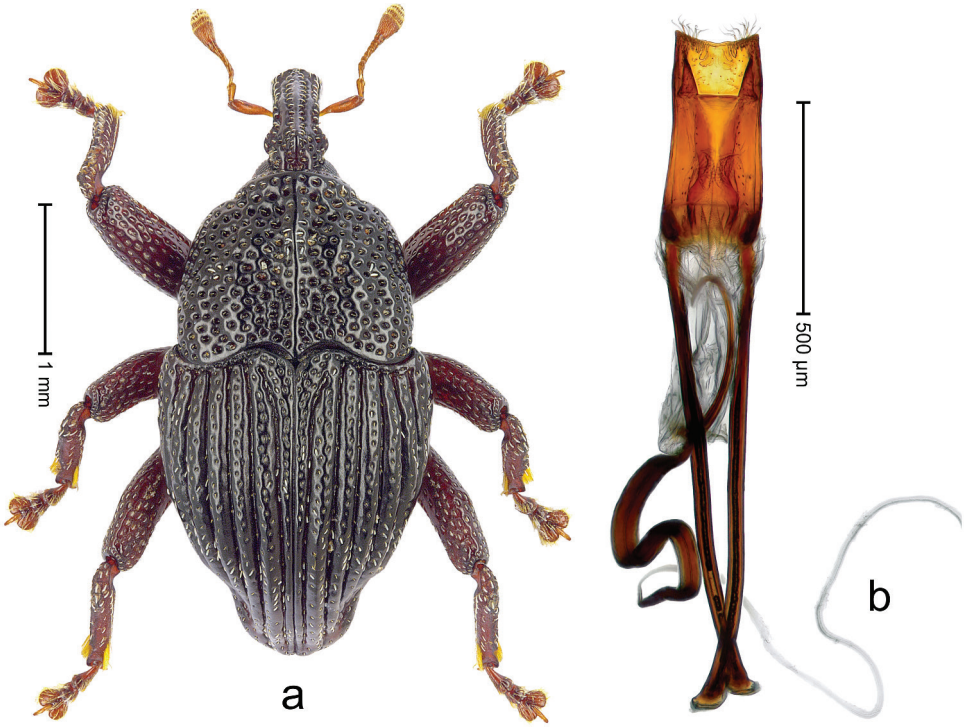

Figure 25. *Trigonopterus oberprieleri* sp. n., holotype; **a** Habitus **b** Penis.

anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia in apical third with blunt supranucal projection. Metaventrite and abdominal ventrites 1-2 laterally swollen, medially forming common cavity; metaventrite and abdominal ventrite 1 with dense erect setae, abdominal ventrite 2 with erect scales; ventrite 5 punctate, weakly concave. Penis (Fig. 25b) with sides of body subparallel, apex subtruncate, with weak median incision; transfer apparatus flagelliform, curved ventrad, subequal to body of penis; ductus ejaculatorius near insertion to transfer apparatus sclerotized, forming S-shaped ribbon longer than flagellum; without bulbus. **Intraspecific variation.** Length 2.55–3.14 mm. Female body more slender. Female rostrum dorsally somewhat flattened; median costa and pair of submedian costae subglabrous; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 punctate, concave.

Material examined. Holotype (QMBA): ARC3742 (EMBL # LN888224), Queensland, Cape Tribulation, Mt. Sorrow track, S16°04.579', E145°27.081', sample 6, 283 m, 10-IV-2014. Paratypes (QMBA, SMNK): Queensland: 2 exx, ARC3743 (EMBL # LN888225), ARC3744 (EMBL # LN888226), same data as holotype; 3 exx, Cape Tribulation, Mt. Sorrow track, S16°04.491', E145°26.873', sample 3, 343 m, 10-IV-2014; 1 ex, ARC3767 (EMBL # LN888244), 2,5 km W Mt. Hartley, near Rossville – Bloomfield-road, S15°47.393', E145°18.348',sample 3, 419 m, 01-V-2014; 1 ex, Daintree N.P.,Thompson Ck., S16°07', E145°25', FIT T01f, 10-I-12-II-1998.

Distribution. Queensland: Daintree N.P., Surroundings of Mt. Hartley.

Biology. Sifted from leaf litter in primary forest.

Etymology. This species is named in honor of Rolf Oberprieler, who made available for study the many *Trigonopterus* specimens in the ANIC.

Notes. *Trigonopterus oberprieleri* Riedel, sp. n. was coded as "*Trigonopterus* sp. 557".

26. *Trigonopterus robertsi* Riedel, sp. n.

http://zoobank.org/AB656BB2-7AB2-493B-B9E9-B39442D750DB

Diagnostic description. Holotype (Fig. 26a). Length 2.88 mm. Color ferruginous. Body subovate, with distinct constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges ending in apical third; intervening furrows with rows of coarse punctures each containing one mesad directed narrow scale; base dorsally protruding, markedly projecting from profile subangularly; epistome posteriorly with subangulate ridge. Forehead coarsely punctate-rugose. Pronotum with distinct subapical constriction; disk coarsely punctate-reticulate; with median costa; uneven, with weak swelling at center of disk; punctures each containing one narrow ochre scale. Elytra with striae deeply incised; intervals costate-carinate; with rows of narrow ochre scales and larger white scales; base markedly bisinuate. Legs. Femora densely punctate, with sparse ochre scales, with transverse band of larger white scales. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with dorsal angulation; metatibia with suprauncal tooth. Abdominal ventrites 1-2 laterally swollen, medially forming common cavity, with coarse punctures; ventrite 5 weakly concave, in basal half with ochre scales. Penis (Fig. 26b) with sides of body subparallel, with constriction in front of middle, continued subparallel to subangulate apex; transfer apparatus flagelliform, directed basad, its length subequal to body of penis; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.58–3.08 mm. Color ferruginous or almost black with only tarsi and antenna ferruginous. Female rostrum with median costa and pair of submedian costae; epistome simple. Female abdominal ventrites 1-2 medially flat; ventrite 5 flat.

Material examined. Holotype (QMBA): ARC3727 (EMBL # LN888209), Queensland, Mt. Finnigan, ascent from Shiptons Flat, S15°49.001', E145°16.853', 1075 m, sample 1, 28-IV-2014. Paratypes (QMBA, SMNK): Queensland: 5 exx, ARC3728 (EMBL # LN888210), ARC3729 (EMBL # LN888211), ARC3730 (EMBL # LN888212), same data as holotype; 1 ex, Mt. Finnigan, ascent from Shiptons Flat, S15°48.935', E145°16.669', 1048 m, sample 2, 28-IV-2014; 1 ex, Mt. Finnigan, site 4, S15°48', E145°17',1060 m, pitfalls, 04-XII-1990-17-I-1991; 1 ex, Finnigan summit, S15°49', E145°17', 1100 m, rainforest, stick brushing, Berlesate 979, 21-XI-1998; 1 ex, 4,0 km W of Cape Tribulation, site 8, 720 m, rainforest pitfall traps, sieved litter, 23-IX-7-X-1982; 1 ex, Mt. Hartley summit, S15°46', E145°19', 790 m, intercept trap, 08-XI-1995-16-I-1996; 2 exx, Mt. Hartley summit, S15°46', E145°19', 750 m, pitfall traps, 08-XI-1995-16-I-1996.

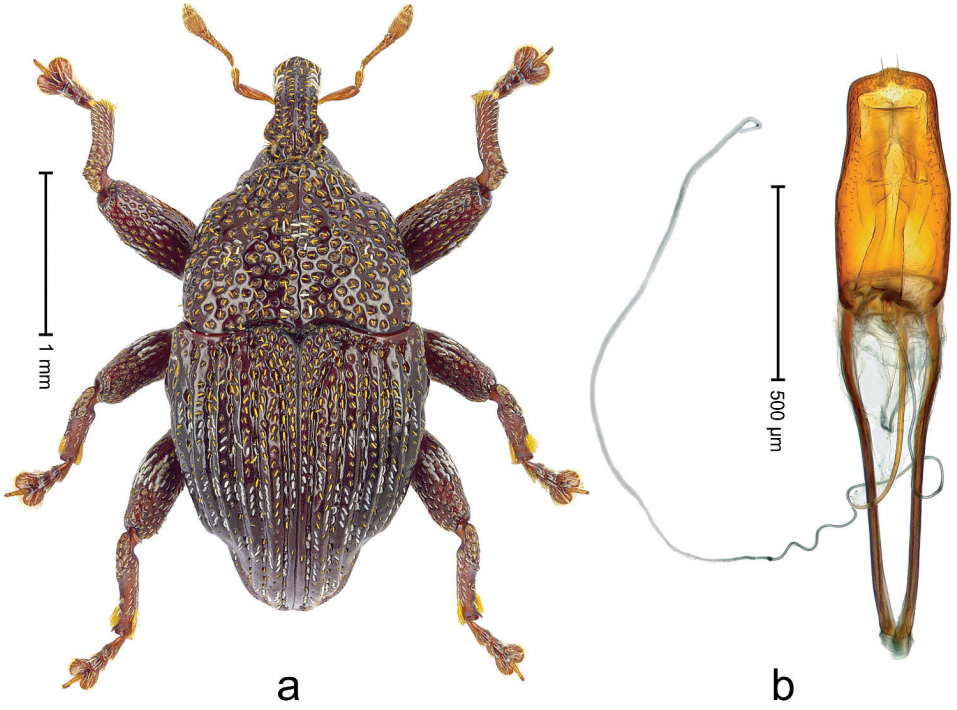

Figure 26. *Trigonopterus robertsi* sp. n., holotype; **a** Habitus **b** Penis.

Distribution. Queensland: W Cape Tribulation, Mt. Finnigan, Mt. Hartley.

Biology. Sifted from leaf litter in primary forest.

Etymology. This species is named in honor of the naturalist Lewis Roberts (Shiptons Flat), whose guiding help was essential for the discovery of this species.

Notes. *Trigonopterus robertsi* Riedel, sp. n. was coded as "*Trigonopterus* sp. 556".

27. *Trigonopterus rostralis* (Lea)

Idotasia rostralis Lea, 1928: 155–156.
Trigonopterus rostralis (Lea): Pullen et al. 2014: 271.

Diagnostic description. Lectotype (Fig. 27a). Length 3.81 mm. Color black; legs and antenna ferruginous. Body subovate; in dorsal aspect and in profile with constriction between pronotum and elytron. Rostrum slender, dorsally with glabrous median carina; in basal half clothed with mesad directed, white, spatulate scales; subapically subglabrous, punctate, sparsely setose. Eyes large, in dorsal position. Pronotum large; disk separated from sides by distinct edge; disk subglabrous, densely punctate with minute punctures, posterolateral and anterolateral corner clothed with white scales; sides in anterior 1/3 clothed with white scales. Elytra subglabrous, punctate with minute punc-

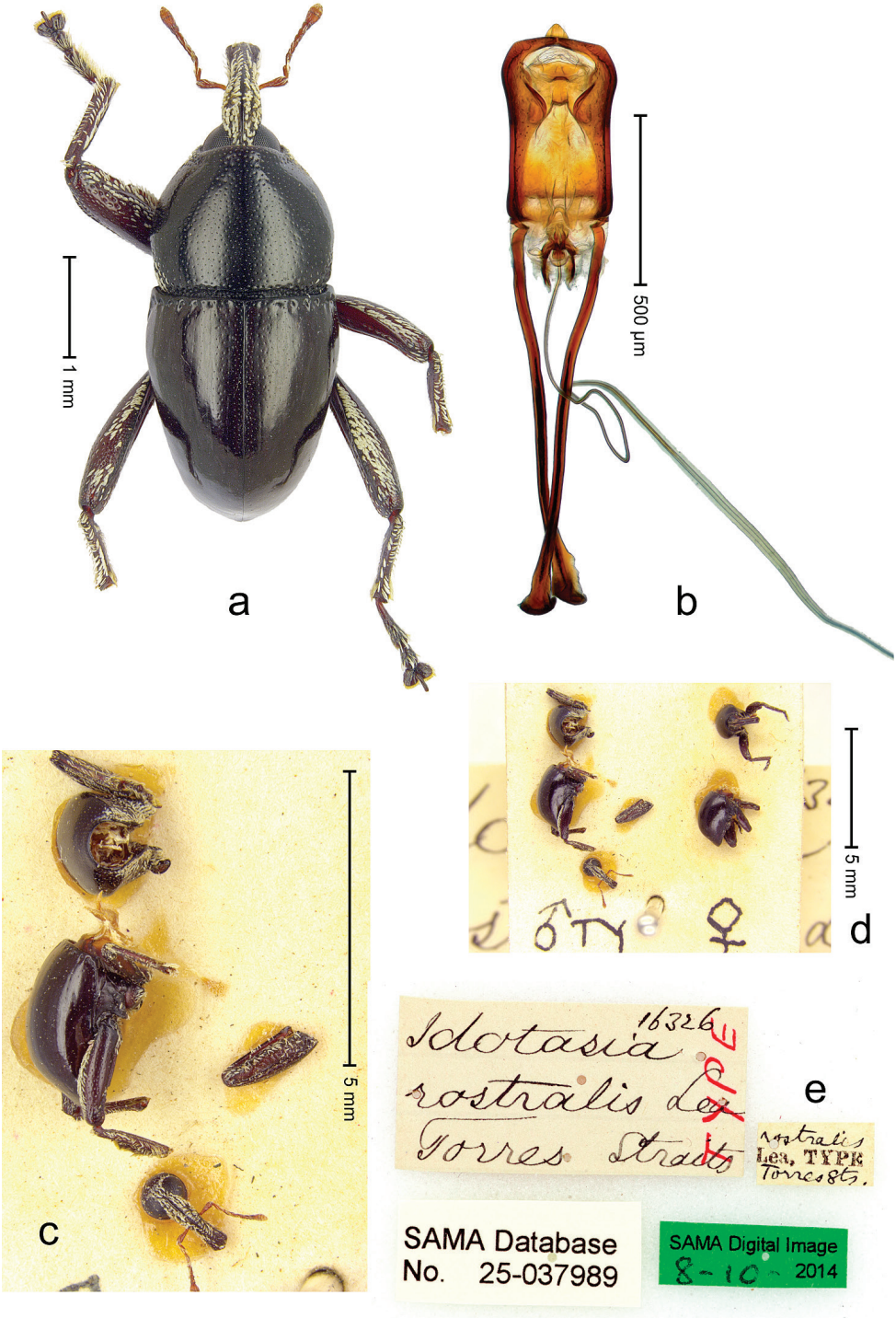

Figure 27. *Trigonopterus rostralis* (Lea), male lectotype; **a** Habitus **b** Penis **c** as mounted originally **d** original labels.

tures; basal margin bordered by row of large punctures continued behind humeri. Legs. Profemur large; anterior face with white scales. Mesofemur and metafemur dorsally densely squamose with white scales, with distinct dorsoposterior edge. Abdominal ventrite 5 flat. Aedeagus (Fig. 27b) with body in basal half subparallel, widened in apical half; extended into acute median process; ductus ejaculatorius subapically with weak bulbus. **Intraspecific variation.** Length 3.22–3.81 mm. Female rostrum dorsally largely subglabrous, with sublateral rows of minute punctures; in basal 1/5 punctate-rugose, sparsely clothed with white scales.

Material examined. Type specimens. Male, lectotype by present designation (SAMA): Queensland, Torres Straits (labels Fig. 27e), ARC4037 (PCR failed). Female, paralectotype (SAMA), same data as lectotype. Other specimens (QMBA, SAMA, SMNK): Queensland: 1 ex, 3 km ENE of Mt.Tozer, S12°44', E143°14', Malaise trap; 28-VI-04-VII-1986; 4 exx, 11 km ENE of Mt.Tozer, S12°43', E143°18', 5-10-VII-1986; 1 ex, 9 km ENE of Mt.Tozer, S12°43', E143°17', swept from undergrowth, 5-10-VII-1986; 4 exx, 9 km ENE of Mt.Tozer, S12°43', E143°17', 11-16-VII-1986; 2 exx, 9 km ENE of Mt.Tozer, S12°43', E143°17', Malaise trap, 11-16-VII-1986; 1 ex, 11 km ENE of Mt.Tozer, S12°43', E143°18', swept from undergrowth, 11-16-VII-1986; 1 ex, 11 km ENE of Mt.Tozer, S12°43', E143°18', ex yellow trays, 11-16-VII-1986; 2 exx, Claudie River, 4 km SW road junction, S12°44', E143°15', 04-XII-1986.

Distribution. Queensland: Torres Strait, Iron Range N.P.

Biology. Swept and beaten from forest undergrowth.

Notes. Lea's (1928) description is based on a male and a female specimen, and although Lea marked the male with a handwritten "TY" on its card, as he usually did to indicate the specimen he regarded to be the type, he did not designate it as the holotype in his description. This male is here designated as lectotype to ensure stability of nomenclature in case additional syntypes are discovered that belong to different species.

28. *Trigonopterus sculptirostris* (Lea)

Idotasia sculptirostris Lea, 1928: 154–155.
Trigonopterus sculptirostris (Lea): Pullen et al. 2014: 271.

Diagnostic description. Lectotype (Fig. 28a). Length 2.24 mm. Color black. Body subovate, almost without constriction between pronotum and elytron; in profile evenly convex. Rostrum with sharp median ridge and pair of sharp submedian ridges; intervening furrows with rows of white scales; apical 1/3 rugose-punctate. Eyes with dorsal margin bordered by furrow. Forehead punctate. Pronotum with disk densely punctate with small punctures; sides sparsely shallowly foveate. Elytra subglabrous, striae marked rows of small punctures; humeri laterally with row of large punctures. Legs with sparse white scales; anteroventral ridge of pro- and mesofemur with acute tooth, metafemur with blunt tooth. Metafemur dorsally with sparse white scales; posterior surface with furrow containing row of scales parallel to ventral edge, subdorsally with row of coarse

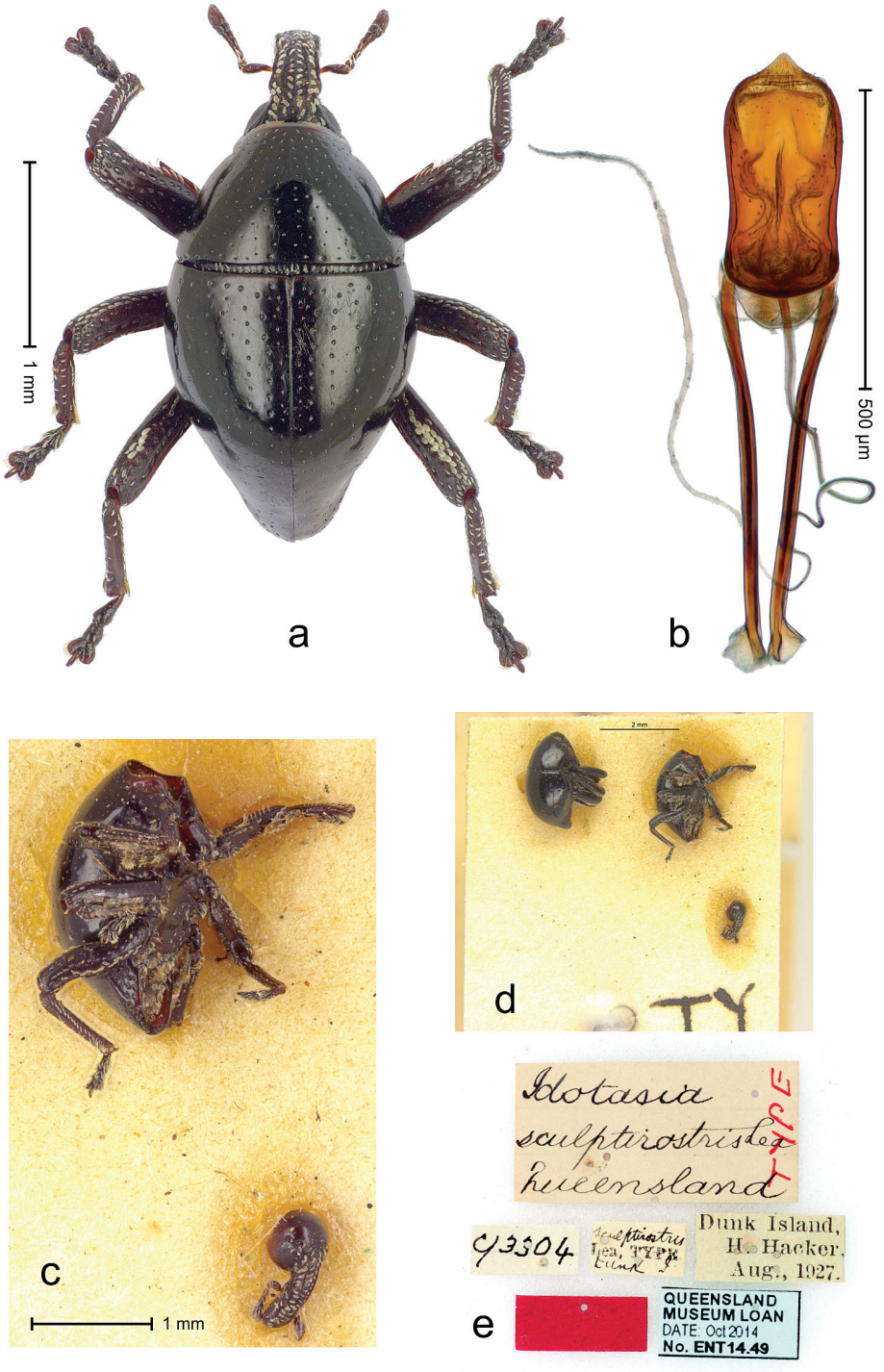

Figure 28. *Trigonopterus sculptirostris* (Lea), male lectotype; **a** Habitus **b** Penis **c** as mounted originally **d** original labels.

punctures. Tibial apex with uncus, without premucro. Abdominal ventrite 2 posteriorly costate resembling ventrite 3, anteriorly declivous to concave ventrite 1; ventrite 5 weakly concave, punctate, sparsely clothed with erect scales and setae. Penis (Fig. 28b) with sides of body subparallel, weakly concave; apex with median triangular extension confluent with outline of apex; transfer apparatus short, dentiform, supported by lyriform sclerite; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.14–2.80 mm. Female rostrum with dorsal ridges less distinct, only in basal half; apical 1/2 rugose-punctate. Female abdominal ventrites 1 and 2 medially flat; female abdominal ventrite 5 flat.

Material examined. Type specimens. Male, lectotype by present designation (Fig. 28) (QMBA): Queensland, Dunk Island, coll. H. Hacker, VIII-1927 (labels Fig. 28e), ARC4039 (PCR failed). Female, paralectotype (SAMA), same data as lectotype. Other specimens (ANIC, SMNK): Queensland: 10 exx, ARC3669 (EMBL # LN888170), ARC3670 (EMBL # LN888171), ARC3671 (EMBL # LN888172), Kuranda N.P., Saddle Mountain Road, S16°48.882', E145°38.870', to S16°48.559', E145°39.458', 380–475 m, 31-III-2014; 40 exx, ARC3681 (EMBL # LN888173), ARC3682 (EMBL # LN888174), ARC3683 (EMBL # LN888175), ARC3684 (EMBL # LN888176), Mission Beach, Clump Mt. N.P., Bicton Hill, S17°50.146', E146°06.023', to S17°50.499', E146°05.905', 36-240 m, 14-IV-2014; 5 exx, ARC3687 (EMBL # LN888177), ARC3688 (EMBL # LN888178), Djiru N.P., road between Mission Beach and El Arish, S17°52.053', E146°04.093', 75 m, 15-IV-2014; 2 exx, Julatten, edge of rainforest along creek, ex intercept trap, 20-X-21-XI-1987; 20 exx, ARC3756 (EMBL # LN888233), ARC3757 (EMBL # LN888234), ARC3758 (EMBL # LN888235), Daintree N.P., NW Mossman, Manjal Jimalji (Devils Thumb) trail, S16°23.653', E145°19.724', to S16°23.664', E145°18.531', 100-700 m, 20-IV-2014; 1 ex, Donovan Ck., S16°01', E145°27', 20 m, FIT D03F, 10-II-14-III-1998; 1 ex, ARC3861 (EMBL # LN888245), Mt. Finnigan, ascent from Shiptons Flat, S15°48.620', E145°16.329', to S15°49.043', E145°16.780', 700-1000 m, 28-IV-2014.

Distribution. Queensland: Mission Beach, Dunk Island; Kuranda, Julatten, Daintree N.P., Mt. Finnigan.

Biology. Beaten from foliage in rainforest.

Notes. Lea (1928) did not designate a holotype in the original description nor specify the number of specimens examined. The original description is based on more than one specimen. One pair with the male marked "TY" could be examined but other specimens may exist. The male is here designated lectotype to ensure stability of nomenclature in case additional syntypes are discovered that belong to different species.

29. *Trigonopterus squamosus* (Lea)

Idotasia squamosa Lea, 1928: 155.
Trigonopterus squamosus (Lea): Zimmerman 1992: 376.

Diagnostic description. Lectotype (Fig. 29a). Length 2.10 mm. Color ferruginous; integument partly covered with brown or white scales, partly abraded. Body

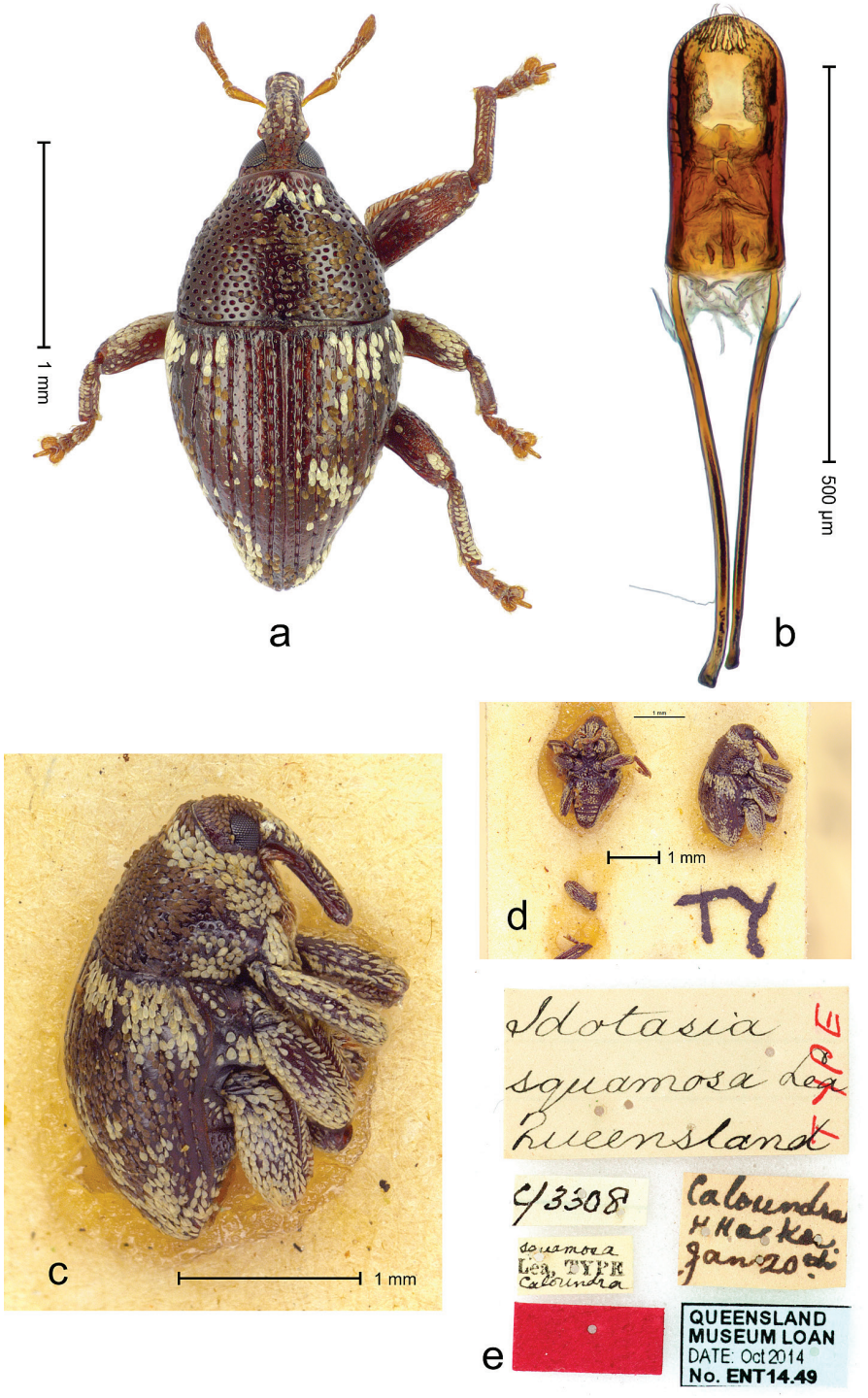

Figure 29. *Trigonopterus squamosus* (Lea), male lectotype; **a** Habitus **b** Penis **c** paralectotype **d** as mounted originally **e** original labels.

subrhomboid, with weak constriction between pronotum and elytron; in profile evenly convex. Rostrum with median ridge and pair of less distinct submedian ridges; covered with white scales. Eyes large, in subdorsal position. Forehead punctate, covered with brown scales. Pronotum coarsely punctate, covered with scales inserting at punctures, interspaces polished; disk clothed with brown scales, laterally and subapically with white scales. Elytra with striae deeply incised, narrow; intervals flat, each with two rows of scales largely covering surface, sutural interval with only one row; abraded scales leaving small punctures at point of insertion; subbasally and subapically clothed with white scales, remainder with brown scales and sparse white scales. Legs. Fore- and hind leg broken off and glued separately to card; largely covered with white scales except subglabrous posterior face of meso- and metafemur. Profemur with anteroventral ridge basally abruptly ending forming blunt angle; with subovate, slightly concave subbasal callus. Tibial apex with uncus and minute premucro. Abdominal ventrite 1-2 laterally swollen, medially concave. Penis (Fig. 29b) with sides of body subparallel to rounded apex; transfer apparatus simple, spiniform, supported by pair of small elongate sclerites; ductus ejaculatorius without bulbus. **Female paralectotype:** Length 2.40 mm. Body wider, rather subovate. Rostrum in apical half subglabrous, with sublateral sparse rows of scales. Abdominal ventrites 1 and 2 medially flat. **Intraspecific variation.** Length 2.00–2.40 mm.

Material examined. Type specimens. Male, lectotype by present designation (QMBA): Queensland, Caloundra, coll. H. Hacker, 20-I (labels Fig. 29e), ARC4036 (PCR failed). Female, paralectotype (SAMA), ARC4035 (PCR failed), same data as lectotype. Other specimens (QMBA, SMNK): Queensland: 7 exx, Fraser Isl., Lake Allom, S25°11', E153°13', ANZES Exped., XI-1992.

Distribution. Queensland: Caloundra, Fraser Isl..

Biology. Beaten from foliage of undergrowth in relatively dry forest.

Notes. Lea (1928) did not designate a holotype in the original description nor specify the exact number of specimens examined. One pair with the female marked "TY" could be examined but other specimens may exist. The male syntype is here designated lectotype. The diagnosis of this species is difficult, and E. C. Zimmerman (unpublished note in QMBS) and Pullen et al. (2014) considered its name to be synonymous with that of *T. striatipennis* (Lea). However, specimens collected at one locality of North Stradbroke Island fall into two highly divergent clusters based on CO1 sequences. These sequence clusters are correlated with relatively subtle differences in the male genitalia. One is identical to the species described from North Stradbroke Island by Lea (1928), i.e. *T. striatipennis*; the other is close to *T. squamosus*. There remains some uncertainty whether all populations of this complex belong to the same two sibling species or if additional cryptic species exist. Sequence data from specimens of additional localities need to be analyzed for a final clarification. The specimen illustrated by Zimmerman (1992, p. 377, plate 492) shows a specimen of *T. striatipennis* Lea.

30. *Trigonopterus striatipennis* (Lea), comb. n.

Idotasia striatipennis Lea, 1928: 155.

Diagnostic description. Holotype (Fig. 30a). Length 2.43 mm. Color ferruginous; integument partly covered with brown or white scales, largely abraded. Body subovate; with weak constriction between pronotum and elytron; in profile evenly convex. Rostrum in apical half with submedian rows of punctures, sparsely covered with white scales. Eyes large, in subdorsal position. Forehead punctate, covered with brown scales. Pronotum coarsely punctate, covered with scales inserting at punctures, interspaces polished; disk clothed with brown scales, laterally and subapically with white scales. Elytra with striae deeply incised, narrow; intervals flat, each with two rows of scales largely covering surface, sutural interval with only one row; abraded scales leaving small punctures at point of insertion; subbasally and subapically clothed with white scales, remainder with brown scales and sparse white scales. Legs. Left foreleg broken off and missing; largely covered with white scales except subglabrous posterior face of meso- and metafemur and where abraded. Profemur with anteroventral ridge basally abruptly ending forming blunt angle; with subovate, slightly concave subbasal callus. Tibial apex with uncus, without premucro. Abdominal ventrites 1-2 medially flat. Terminalia (Fig. 30b). **Male** (ARC3663, Fig. 30e). Male rostrum with median ridge and pair of submedian ridges; covered with white scales. Abdominal ventrites 1-2 laterally swollen, medially concave. Penis (Fig. 30f) with sides of body slightly diverging to widened, rounded apex; transfer apparatus simple, spiniform, supported by single Y-shaped sclerite; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 2.32–2.53 mm. One specimen (ARC3666) with conspicuous pair of protrusions behind eyes, apparently a rare aberration.

Material examined. Type specimens. Female, holotype by monotypy (QMBA): Queensland, Stradbroke Island, coll. H. Hacker, 17-IX-1915 (labels Fig. 30d), ARC4034 (PCR failed). Other specimens (ANIC, QMBA, SMNK): Queensland: 5 exx, ARC3663 (EMBL # LN888167), ARC3665 (EMBL # LN888168), ARC3666 (EMBL # LN888169), North Stradbroke Isl., 3,5 km SW Point Lookout, Fishermans Road, 105 m, S27°26.507', E153°30.353', 24-III-2014, beaten from forest understorey; 8 exx, North Stradbroke Isl., track to Blue Lake, on *Pteridium*, 11-IX-1984; 7 exx, North Stradbroke Isl., track to Blue Lake, on *Pteridium*, 02-IX-1983; 3 exx, N Stradbroke Isl. Enterprise, S27°33', E153°28', Blackbutt #1, 90 m, 09-I-2002, sweeping 50934.

Distribution. Queensland: North Stradbroke Island.

Biology. Beaten from foliage of undergrowth in relatively dry forest.

Notes. Lea (1928) stated in his description that the "type" was a "unique" specimen, and it therefore has to be regarded as the holotype. Regarding the distinction of this species from *T. squamosus* (Lea), see the remarks above.

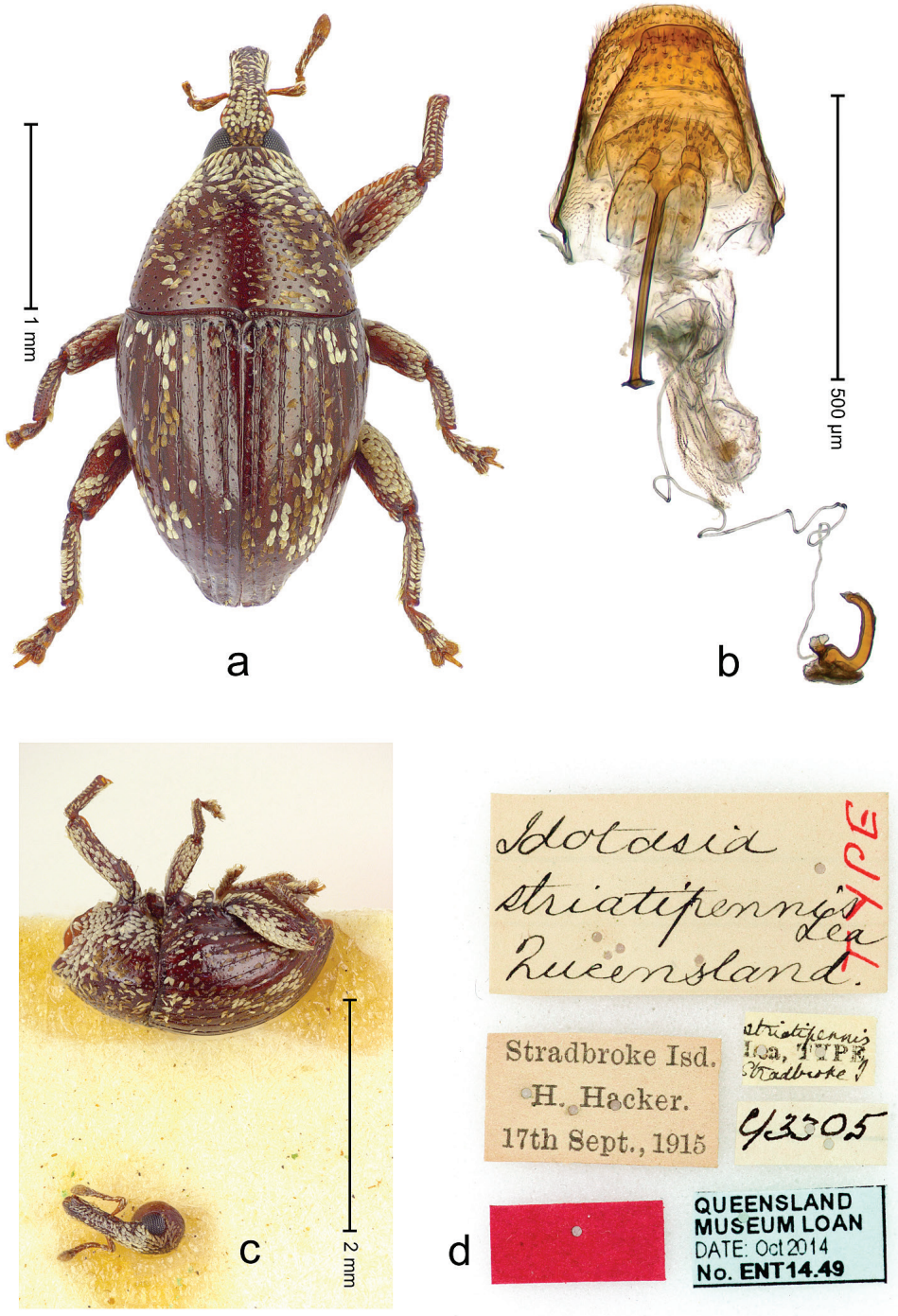

Figure 30a–d. *Trigonopterus striatipennis* (Lea), female holotype; **a** Habitus **b** terminalia **c** as mounted originally **d** original labels.

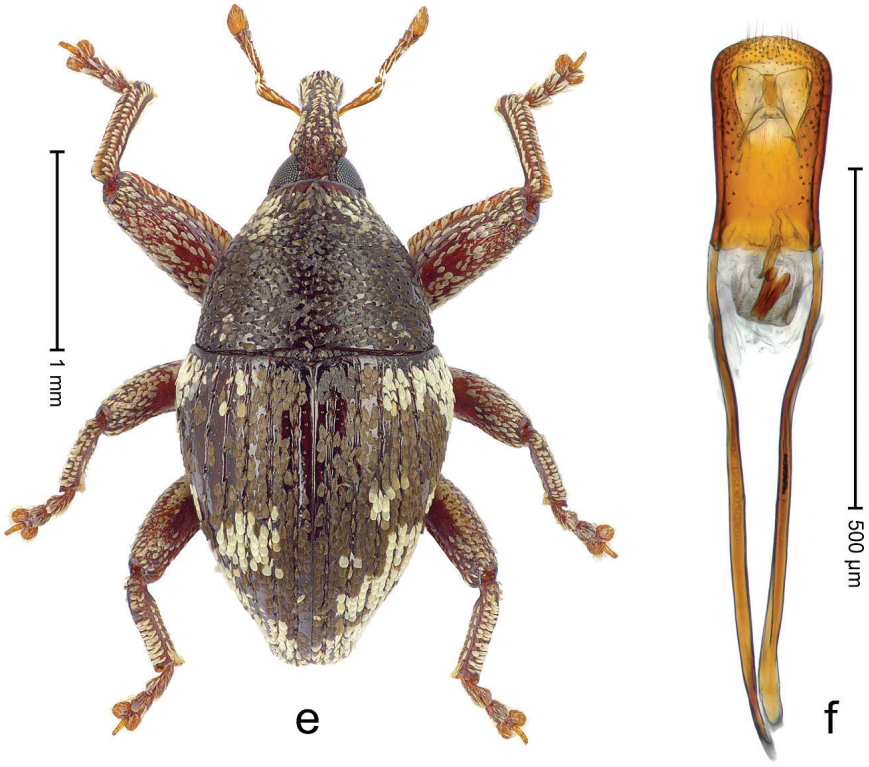

Figure 30e–f. *Trigonopterus striatipennis* (Lea), male; **e** Habitus **f** Penis.

31. *Trigonopterus terraereginae* Riedel, sp. n.
http://zoobank.org/C801E410-1A73-4BBA-BDB1-60706499D224

Diagnostic description. Holotype (Fig. 31a). Length 2.50 mm. Color black; antenna and legs ferruginous. Body subovate, in dorsal aspect with marked constriction between pronotum and elytron; in profile convex. Rostrum with median ridge and pair of submedian ridges; intervening furrows with rows of coarse punctures each containing one mesad directed scale; epistome posteriorly with curved ridge. Forehead coarsely punctate-rugose. Pronotum with sides subparallel, anteriorly abruptly rounded to distinct subapical constriction; irregularly foveate-reticulate; each fovea containing one inconspicuous seta. Elytra with striae deeply incised, with coarse punctures; intervals costate-carinate; subglabrous, sparsely punctate, with sparse scales; base bisinuate. Legs. Femora densely punctate. Profemur with subbasal callus anteriorly projecting. Tibiae subbasally with acute tooth; metatibia with supranucal tooth. Abdominal ventrite 1 concave; abdominal ventrite 2 posteriorly transversely costate. Penis (Fig. 31b) with sides of body subparallel, apex subangulate, medially rounded; orifice with pair of curved sclerites; transfer apparatus short, dentiform; ductus ejaculatorius subapically with weak bulbus.

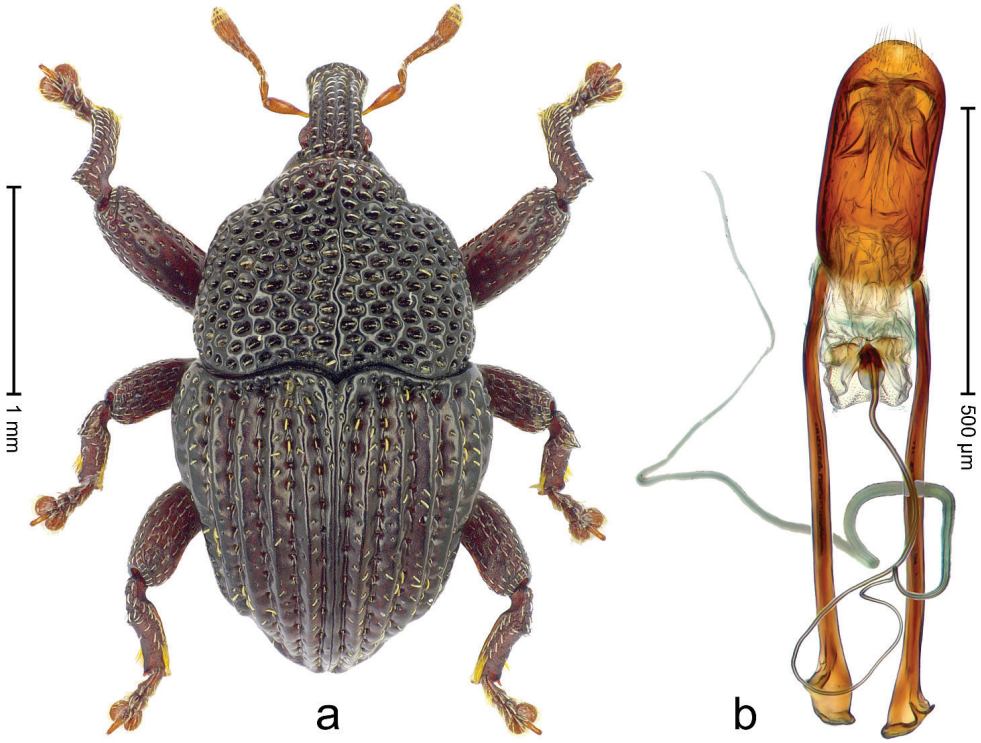

Figure 31. *Trigonopterus terraereginae* sp. n., holotype; **a** Habitus **b** Penis.

Material examined. Holotype (ANIC): ARC4242 (PCR failed), Queensland, Mt. Cook N.P., S15°29', E145°16', rainforest litter, ANIC Berlesate No. 732, 10-12-V-1981.

Distribution. Queensland: Mt. Cook.

Biology. Sifted from leaf litter in primary forest.

Etymology. This epithet refers to Queensland (*Terra Reginae*).

32. *Trigonopterus yorkensis* Riedel, sp. n.

http://zoobank.org/2D448C5C-AA72-486A-BF59-2AE27383D75E

Diagnostic description. Holotype (Fig. 32a). Length 1.84 mm. Color black, antenna and tarsi ferruginous. Body subrhomboid, without constriction between pronotum and elytron; in profile evenly convex. Rostrum punctate-rugose, with sparse white scales, median ridge indistinct. Eyes large, in subdorsal position. Forehead punctate, with scattered brown scales. Pronotum coarsely punctate, interspaces between punctures polished; with sparse narrow brown scales inserting in punctures. Elytra

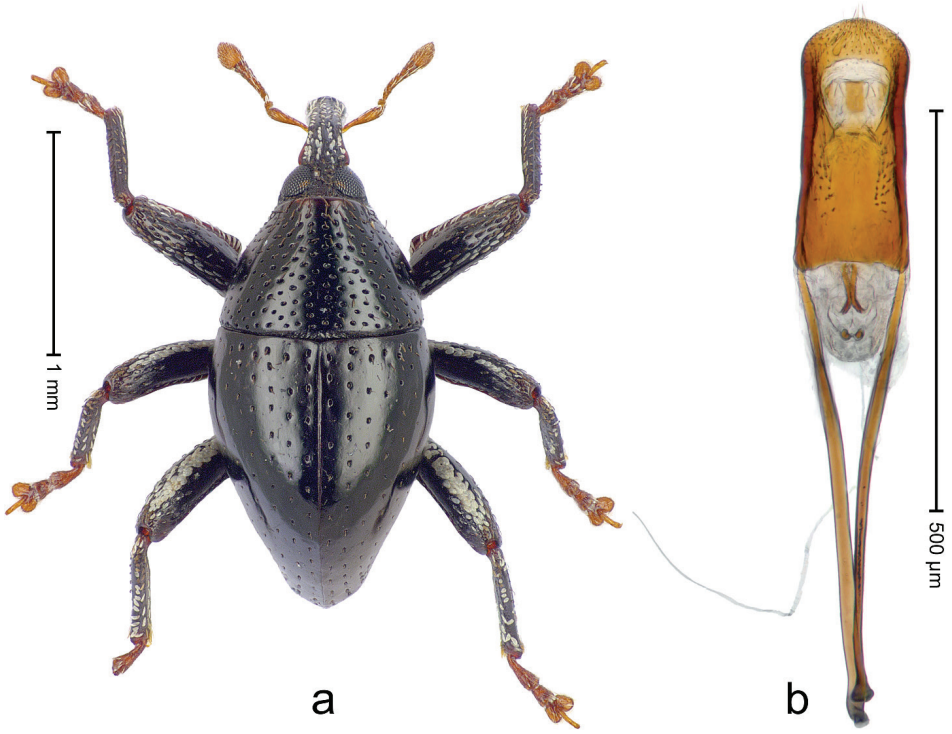

Figure 32. *Trigonopterus yorkensis* sp. n., holotype; **a** Habitus **b** Penis.

subglabrous; striae marked by indistinct rows of minute punctures each containing minute narrow brown scale; at apical margin with few white almond-shaped scales. Legs. Femora dorsally clothed with white scales; anteroventral furrow with sparse row of white scales. Profemur with anteroventral ridge basally abruptly ending forming blunt angle; with somewhat indistinct subbasal callus. Tibial apex with uncus, without premucro. Abdominal ventrites 1-2 laterally swollen, medially concave; ventrite 5 coarsely punctate, at middle concave. Penis (Fig. 32b) with sides of body subparallel to subangulate apex; transfer apparatus simple, elongate, with pair of small basal sclerites; ductus ejaculatorius without bulbus. **Intraspecific variation.** Length 1.70–1.96 mm. Female rostrum with sparse small punctures, with sparse recumbent setae, only basally with few scales. Female abdominal ventrites 1-2 medially flat; ventrite 5 flat.

Material examined. Male, holotype (QMBA): ARC3707 (EMBL # LN888189), Queensland, W Bloomfield, Mt. Misery, S15°52.706', E145°13.383',750-850 m, 30-IV-2014. Paratypes (QMBA, SMNK): Queensland: 5 exx, ARC3706 (EMBL # LN888188), ARC3708 (EMBL # LN888190), ARC3709 (EMBL # LN888191), same data as holotype; 1 ex, Mt. Misery, summit, 15°52', S 145°14', E, 850 m, 03-I-1991, Pyrethrum knockdown; 1 ex, Massey Ra., 6 km NW of Bellenden Kerr, 17°14', S 145°48', E, 1150 m, 11-X-1991.

Distribution. Queensland: Mt. Misery, Massey Range.

Biology. Beaten from foliage in relatively dry forest.

Etymology. This epithet is an adjective based on the Cape York Peninsula, where the type locality is located.

Notes. *Trigonopterus yorkensis* Riedel, sp. n. was coded as "*Trigonopterus* sp. 552".

Discussion

The most recent description of an Australian *Trigonopterus* species prior to this study was by Lea in 1928, reflecting a general taxonomic neglect of Australian Cryptorhynchinae, and in particular of the small sized *Trigonopterus*. The hitherto described species are found on foliage, whereas all the edaphic species dwelling in the leaf-litter are undescribed – a result agreeing with observations on other groups of tropical insects (Stork et al. 2008). Many of the new edaphic species are endemic to small areas of tropical forest on mountains of the Cape York Peninsula. Most likely, wingless weevils are sensitive to environmental changes, e.g. a warming climate (Staunton et al. 2014), and, considering their high level of endemism, they should be of concern to conservation.

The Australian *Trigonopterus* fauna is divided into a few species-groups, each restricted to geographical areas and specific life-styles: the edaphic fauna inhabiting leaf litter is shared among the *T. australis* and *T. bisinuatus*-groups. The former ranges with three species from Cooktown to the Iron Range, whereas the 16 species of the latter occur between Mission Beach and the Mt. Finnigan area. A few less diverse species-groups found on foliage are restricted to the northern Cape York, i.e. the *T. nasutus*-group (a single species from the Iron Range) and the *T. illitus*-group (three species in the area north of Cooktown). The *T. politus* and the *T. squamosus*-groups are relatively widespread and can be found on foliage in coastal areas ranging from northern New South Wales to the Cape York Peninsula. The taxonomy of these two species groups is problematic and could not be dealt with adequately herein, because male genital as well as external characters are relatively uniform among different species. This situation is unfortunate as the *T. politus*-group comprises the greatest ecological band width of the Australian *Trigonopterus* — its numerous species occur in wet rainforests as well as savannah habitats. Furthermore, the *T. politus*-group represents the largest portion of Australian *Trigonopterus* specimens stored in collections; in many cases these are incorrectly identified, if identified at all. Therefore, identification records of *T. aequalis* Pascoe, *T. albidosparsus* Lea and *T. evanidus* Pascoe should be treated with caution. Presumably a dense sampling of specimens with molecular data covering the east coast of Queensland and northern New South Wales would be the most efficient way to delineate species boundaries reliably. Thus, a solution of these taxonomic problems mainly depends on freshly collected material suitable for DNA sequencing. The geographical ranges and ecologies of these "difficult species" will become sufficiently clear with such a study, hopefully allowing the safe identification of all the unnamed specimens stored in museum collections.

Preliminary key to the *Trigonopterus* species of Australia

1 Species found on foliage; elytral striae distinct or indistinct, but never deeply incised **2**

– Species found in the litter layer; elytral striae deeply incised **14**

2(1) Eyes in lateral position; forehead as wide as, or wider than rostrum. (*T. politus*-gr.) **9**

– Eyes in dorsolateral position; forehead narrower than rostrum **3**

3(2) Elytra ferruginous, densely squamose unless partly abraded **4**

– Elytra black, nude (or almost nude with sparse inconspicuous scales inserted in punctures in *T. yorkensis* Riedel, sp. n.) **5**

4(3) Penis parallel-sided, rounded at apex. ..... ***T. squamosus* Lea**

– Penis with sides weakly diverging from base to rounded apex. ..... ***T. striatipennis* Lea**

5(3) Elytra subglabrous except for row of punctures at base and humeri, never with scales. Tarsi black **6**

– Pronotum and elytra punctate; punctures each with one narrow brown recumbent scale. Tarsi ferruginous ..... ***T. yorkensis* Riedel, sp. n.**

6(5) Prothorax dorsolaterally with distinct edge; near procoxa with patch of white scales. Body size large, 3.22–3.81 mm ..... ***T. rostralis* Lea**

– Prothorax evenly rounded towards sides, near procoxa without patch of white scales. Body size smaller, 1.96–3.47 mm 7

7(6) Pronotum dorsally with coarse punctures (Fig. 19a) ..... ***T. laetus* (Lea)**

– Pronotum dorsally with minute punctures (Figs 4a, 25a) **8**

8(7) Body size larger, 2.98–3.47 mm. Rostrum in male basally markedly swollen. Prothorax in front of procoxa with acute process. ..... ***T. australinasutus* Riedel, sp. n.**

– Body size smaller, 2.16–2.68 mm. Rostrum in male basally simple. Prothorax in front of procoxa simple ..... ***T. allaetus* Riedel, sp. n.**

9(2) Rostrum with sharp median and pair of submedian ridges. Profemur dentate ..... ***T. sculptirostris* (Lea)**

– Rostrum dorsally flat or with low costae, never carinate. Profemur edentate. **10**

10(9) Elytra ferruginous. In montane habitats of Mt. Spurgeon and Mt. Finnigan .... ***T. finniganensis* Riedel, sp. n.**

– Elytra black. Usually in lowland habitats **11**

11 (10) Apex of mesotibia in male with two separate teeth, i.e. outer uncus and inner premucro **12**

– Apex of mesotibia in male with only one relatively wide tooth, apically simple or bifid **13**

12(11) Elytra with fine but distinct striae. Pronotum and elytra between punctures microreticulate ..... ***T. aequalis* Pascoe**

– Elytra with striae invisible from most directions. Pronotum and elytra between punctures not microreticulate ..... ***T. evanidus* Pascoe**

13(11) Pronotum uniformly densely punctate with relatively large punctures, dorsally and laterally of almost equal size. Apex of mesotibia in male with apically bifid tooth ..... ***T. cooktownensis* Riedel, sp. n.**

– Pronotum dorsally with minute punctures, laterally with large punctures. Apex of mesotibia in male with one apically simple tooth. ..... ***T. albidosparsus* Lea**

14(1) Elytral intervals irregularly costate-carinate; sutural interval basally swollen; rostrum in apical third with median denticle ..... ***T. australis* Riedel, sp. n.**

– Elytral intervals costate or flat; sutural interval basally simple. Rostrum at most along apical margin with denticles, but simple further behind..... **15**

15(14) Base of rostrum in profile with distinct angulation..... **19**

– Base of rostrum in profile without distinct angulation; with shallow constriction or evenly convex to forehead..... **16**

16(15) Pronotum without or with indistinct subapical constriction. Elytral intervals costate without forming sharp prominent ridges..... **17**

– Pronotum with distinct subapical constriction. Elytral intervals costate-carinate, forming sharp and/or prominent ridges..... **18**

17(16) Body black with elytra cuneiform and pronotum subquadrate (Fig. 11a), Length ca. 2.98 mm..... ***T. deplanatus* Riedel, sp. n.**

– Body largely ferruginous, subovate (Fig. 23a); smaller, 1.92–2.20 mm..... ..... ***T. mossmanensis* Riedel, sp. n.**

18(16) Elytra ferruginous. Epistome posteriorly with 4 denticles..... ..... ***T. fraterculus* Riedel, sp. n.**

– Elytra black. Epistome posteriorly with curved ridge..... ..... ***T. terraereginae* Riedel, sp. n.**

19(15) Pronotum subtrapezoidal, with sides markedly converging from base to apex; disc densely foveate-reticulate, without median costa..... **20**

– Pronotum with sides subparallel or weakly converging to preapical constriction; disk always with median costa **21**

20(19) Elytral intervals flat to weakly costate. Penis (Fig. 22b) with shorter, spiniform transfer apparatus..... ***T. monteithi* Riedel, sp. n.**

– Elytral intervals costate. Penis (Fig. 16b) with longer, flagelliform transfer apparatus..... ***T. basenpuschi* Riedel, sp. n.**

21(19) Body small, pronotum plus elytron 1.90–2.40 mm, relatively compact; elytral striae weakly incised or marked by rows of isolated punctures, intervals weakly costate..... **22**

– Body larger, pronotum plus elytron 2.42–3.28 mm, more elongate; elytral striae deeply incised, intervals distinctly costate or carinate..... **23**

22(21) Elytral striae anteriorly marked by rows of large punctures. Pronotum with interspaces between punctures polished ..... ***T. hartleyensis* Riedel, sp. n.**

– Elytral striae weakly incised, without large punctures. Pronotum with interspaces between punctures dull, with silky luster ..... ***T. boolbunensis* Riedel, sp. n.**

23(21) Metaventrite and abdominal ventrite 1 with dense erect setae, abdominal ventrite 2 with erect scales. Ductus ejaculatorius near insertion to transfer

apparatus sclerotized, forming S-shaped ribbon longer than flagellum .... ***T. oberprieleri*** **Riedel, sp. n.**

– Metaventrite and abdominal ventrite 1 at most sparsely setose with recumbent setae. Ductus ejaculatorius near insertion to transfer apparatus membranous; if sclerotized, slender, not ribbon-shaped **24**

24(23) Pronotum with pair of patches of sparse yellow scales. Elytra basally almost nude, in apical half with scattered scales. Penis subapically with lateral subangular extensions (Figs 6b, 15b, 18b) **30**

– Pronotum and elytra without patches of yellow scales; if sparse patches of scales present, color of scales white. Penis in apical 1/3 without lateral extensions (e.g., Figs 7b, 10b, 20b) **32**

30(29) Body (Fig. 15a) broader, with marked constriction between pronotum and elytra. Penis with flagellum shorter (Fig.15b) ..... ***T. garradungensis*** **Riedel, sp. n.**

– Body (Figs 6a, 18a) more slender, with shallow constriction between pronotum and elytra. Penis with flagellum longer (Figs 6b, 18b) **31**

31(30) Metatibia in apical third with blunt suprauncal projection. Flagellum ca. 3.0× longer than body of penis (Fig. 18b) ..... ***T. kurandensis*** **Riedel, sp. n.**

– Metatibia in apical third simple, without supprauncal projection. Flagellum ca. 1.5× longer than body of penis (Fig. 6b). Daintree N.P. and Windsor Tableland ..... ***T. bisignatus*** **Riedel, sp. n.**

32(24) Elytra cuneiform, from broad humeri converging to narrow apex **33**

– Elytra subovate or subparallel **34**

33(32) Body more slender (Fig. 7a). Pronotum coarsely sculptured, submedially interspaces confluent forming irregular wrinkles besides median ridge. From Atherton Tablelands southwards to Wooroonooran N.P. .... ***T. bisinuatus*** **Riedel, sp. n.**

– Body broader (Fig. 10a). Pronotum densely punctate-reticulate, with simple median costa. Daintree N.P. ..... ***T. daintreensis*** **Riedel, sp. n.**

34(32) Body subovate (Figs 20a, 26a), with sparse vestiture dominated by narrow ochre-colored scales. Elytral intervals costate-carinate throughout **35**

– Body parallel-sided (Figs 3a, 21a), with sparse vestiture dominated by white scales. Elytral intervals in basal half partly transversely confluent **36**

35(34) Penis (Fig. 20b) with large X-shaped sclerite and complex transfer apparatus.... ..... ***T. lewisensis*** **Riedel, sp. n.**

– Penis (Fig. 26b) with flagelliform transfer apparatus.... ***T. robertsi*** **Riedel, sp. n.**

36(34) Elytral striae with coarse punctures; intervals weakly carinate. Penis (Fig. 21b) with widened, subangulate apex; transfer apparatus with pair of triangular sclerites ..... ***T. montanus*** **Riedel, sp. n.**

– Elytral striae with punctures less distinct; intervals costate. Penis (Fig. 3b) with subtruncate apex; transfer apparatus subrotund .... ***T. athertonensis*** **Riedel, sp. n.**

Catalogue of species groups of *Trigonopterus* Fauvel in Australia

***T. australis*-group:** *T. australis* sp. n., *T. fraterculus* sp. n., *T. terraereginae* sp. n.
***T. politus*-group:** *T. aequalis* (Pascoe), *T. albidosparsus* (Lea), *T. cooktownensis* sp. n., *T. evanidus* (Pascoe), *T. finniganensis* sp. n., *T. sculptirostris* (Lea)
***T. nasutus*-group*:** *T. australinasutus* sp. n.
***T. squamosus*-group:** *T. squamosus* (Lea), *T. striatipennis* (Lea), *T. yorkensis* sp. n.
***T. illitus*-group*:** *T. allaetus* sp. n., *T. laetus* (Lea), *T. rostralis* (Lea)
***T. bisinuatus*-group:** *T. athertonensis* sp. n., *T. bisignatus* sp. n., *T. bisinuatus* sp. n., *T. boolbunensis* sp. n., *T. daintreensis* sp. n., *T. deplanatus* sp. n., *T. garradungensis* sp. n., *T. hasenpuschi* sp. n., *T. hartleyensis* sp. n., *T. kurandensis* sp. n., *T. lewisensis* sp. n., *T. montanus* sp. n., *T. monteithi* sp. n., *T. mossmanensis* sp. n., *T. oberprieleri* sp. n., *T. robertsi* sp. n.

*note: the *T. illitus*-group was not distinguished from the *T. nasutus*-group by Riedel et al (2013b); however, based on recent analysis of molecular data, it represents a separate lineage.

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